Technical Report for CBRS Temporary PAL Channel Reassignment

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CBRS PAL Channel Reassignment Technical Report

1 Introduction

The Citizens Broadband Radio Service (CBRS) allows a novel three tier spectrum sharing scheme for mobile broadband users deploying Citizens Broadband Radio Service Devices (CBSD). Priority Access Licenses (PAL) represent Tier 2 users (PAL Holders) that are entitled to receive interference protection from Tier 3 GAA on their assigned PAL channels.

Currently, with the collective SASs' semi-static PAL channel assignments process of planning the channel assignments, these 'bumped' Tier 2 PAL Holders and their CBSD radios are now only offered other GAA channel(s) to replace the "bumped" PAL channel grant(s) by their Managing SAS. This effectively means that the protected status that the PAL Holders' CBSDs had on the PAL channel(s) is lost. While on the originally assigned PAL channel(s), the Managing SAS determines and enforces a PPA by forcing all other co-channel users a significant minimum distance away, so as to preserve the threshold of -96 dBm/10MHz interference level within the PPA.

The requirements in WInnForum Release 1 TS-0112 specification [1] have been updated in WINNF-TS-1020 to enable the SASs to support temporary PAL channel reassignment during DPA activation.

This Technical Report provides a guideline as recommendation for development of technical specifications necessary for enabling temporary PAL Channel reassignment, allowing the Priority Access Licensees to use their PALs even in the presence of tier-1 incumbent federal radar operations.

2 Scope

The scope of this Technical Report is to provide guidelines as recommendations for development of technical specifications necessary for enabling temporary PAL Channel reassignment in accordance with Section 4.5.1. of WINNF-TS-1020 [9]. In particular, the document focuses on the coordination process among SAS Administrators to temporarily reassign a PAL impacted by DPA activation to another PAL channel and protect the PAL operation.

3 References

[1]	WINNF-TS-0112 – CBRS Operational and Functional Requirements,

	"https://groups.wirelessinnovation.org/wg/SSC-WG1/document/17362"
[2]	WINNF-SSC-008 – WinnForum Coordinated Periodic Activities Among SASs, "https://winnf.memberclicks.net/assets/CBRS/WINNF-SSC-0008.pdf"
[3]	WINNF-SSC-003 – WinnForum CBRS Traceability Matrix, "https://winnf.memberclicks.net/assets/CBRS/WINNF-SSC-0003.xlsx"
[4]	WINNF-TS-3002 – Extensions to SAS-CBSD Interface Technical Specification (Release 2), "https://winnf.memberclicks.net/assets/CBRS/WINNF-TS-3002.pdf"
[5]	WINNF-TS-3003 – Extensions to SAS-SAS Interface Technical Specification (Release 2), "https://winnf.memberclicks.net/assets/CBRS/WINNF-TS-3003.pdf"
[6]	WINNF-TS-1001 – CBRS Release 2 Operational and Functional Requirements, "https://winnf.memberclicks.net/assets/CBRS/WINNF-TS-1001.pdf"
[7]	WINNF-SSC-0010 – WinnForum Recognized Grouping Information, "https://winnf.memberclicks.net/assets/CBRS/WINNF-SSC-0010.pdf"
[8]	WINNF-TS-0016 - SAS to CBSD Technical Specification, "https://winnf.memberclicks.net/assets/CBRS/WINNF-TS-0061.pdf"
[9]	WINNF-TS-1020 Post Initial Certification Revisions to WINNF-TS-0112-V1.9.1
[10]	WINNF-TS-4010 Post Initial Certification Revisions to WINNF-TS-0061-V1.5.1
[11]	WINNF-SSC-0011 V1.0.0, SSC Abbreviations and Definitions
[12]	WINNF-TS-0096 V1.3.2 SAS-SAS Protocol Technical Specification
[13]	WINNF-SSC-0002-V10.0.0 - WInnForum Registered CBRS Air Interfaces and Measurements
[14]	WINNF-SSC-0011-V1.0.0 SSC Abbreviations and Definitions

4 Abbreviations and Definitions

For the purposes of the present document, the abbreviations given in [11] and the following apply

4.1 Abbreviation

ACAS: Aperiodic Coordinated Activities among SASs
API: Application Programming Interface
CUP: Channel Unoccupied by PAL
DL: DownLink
FWA: Fixed Wireless Access
HB: Heartbeat
KPI: Key Performance Indicator
LTE: Long Term Evolution
MNO: Mobile Network Operator
MSO: Mobile Service Operator
NR: New Radio
P_LTE: Private LTE
P_PPM: Permanent PAL Protection Method
SDL: Supplemental DL
SON: Self-Organizing Network
SUL: Supplemental UL
T_PPA: Temporary PAL Protection Area
T_PPM: Temporary PAL Protection Method
UL: Uplink

4.2 Definitions

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

Not available for this version of this technical report.

ACAS Exchange Message: an array of objects that are exchanged by the managing SAS with all other SASs at the beginning of the ACAS process.

5 Background

5.1 General

The top bidders in the FCC's CBRS Auction 105 purchased over $3.9 billion worth of Priority Access License (PAL) spectrum rights. The size of these bids indicates the value of such spectrum rights. Many other operators and service providers also participated in FCC's Auction 105 to purchase significant numbers of PAL licenses across the US for a total of $4.54 billion[1], collectively purchasing about 22,000 individual PAL licenses. These PAL licenses represent spectrum in the ten 10 MHz channels in the 3550-3650 MHz portion that the FCC designated for Tier 2 PAL Priority Access use.

Priority Access represents interference protection that PAL channels assigned to PAL Holders' CBSDs receive and that Tier 3 General Authorized Access (GAA) channels do not. In every county within the United States, CBRS offers up to seven PAL channels, depending on the number of licenses sold, within these ten channels, such that every county maintains (at least) three 10 MHz channels that are available for PAL uses but that are not committed to the (up to) seven PAL auction winners. In theory, at least three channels in every county could be available to permit Tier 2 users (PAL) to be reassigned to these channels due to incumbent use on their assigned channels. Also, note that these three or more unassigned or unused PAL channels in 3550-3650 MHz frequency range can be used by GAA users opportunistically when not in use by Tier 1 and 2 users.

Most importantly, the FCC's Part 96 rules also have a provision in §96.59(c) that allows any SAS to temporarily reassign PALs to different channels. The language reads "An SAS could temporarily assign PALs to different channels (within the frequency range authorized for Priority Access use) to protect Incumbent Access Users or if necessary to perform its required functions." This authorized frequency range refers to the ten 10 MHz PAL channels in the 3550-3650 MHz range. Incumbent Access Users refers to the Tier 1 incumbents. This rule plus the FCC's provision that (at least) three PAL channels remain unsold, allows the SASs to rearrange PAL channel assignments. When Dynamic Protection Areas (DPAs) are activated by Tier 1 Incumbents for Naval radar uses (or other Tier 1 Incumbents make use of channels in 3550-3650), one or more PAL channels could be removed from Tier 2 uses in coastal (or other) areas "to protect Incumbent Access Users" and hence these initial PAL channels assigned to Tier 2 PAL Holders become unavailable. This is often called "channel bumping" where the initial PAL channel grants given to the Tier 2 users (PAL Holders) are not renewed, and instead expire within 300 seconds, forcing these PAL Holders' CBSDs off of their initially assigned PAL channels.

Currently, with the collective SASs' semi-static PAL channel assignments process of planning the channel assignments, these 'bumped' Tier 2 PAL Holders and their CBSD radios are now only offered other GAA channel(s) to replace the "bumped" PAL channel grant(s) by their Managing SAS. This effectively means that the protected status that the PAL Holders' CBSDs had on the

[1] The FCC website for Auction 105: https://www.fcc.gov/auction/105

PAL channel(s) is lost. While on the originally assigned PAL channel(s), the PAL Holder could claim a PPA protected contour, forcing all other co-channel users a significant minimum distance away so as to preserve the -96 dBm interference level for the PAL Holder's CBSDs within the PPA within that PAL(s). This is the definition of Tier 2 Priority Access.
However, when the PAL is impacted by DPA activation (i.e., the PAL Grant is in the DPA Move List), the PAL Grant is either suspended or terminated by the managing SAS. In both cases, the Managing SAS could suggest the CBSD to request a GAA Grant in a different frequency range from the PAL Grant, and so the corresponding PPA with guaranteed -96 dBm/10MHz interference level is lost. This means the PAL Holder's CBSDs operate under GAA rules, with equivalent spectrum rights to all other GAA CBSDs in the local area, namely forced to accept interference from all other co-channel GAA users. As per Part 96 rules, GAA deployment is not entitled to receive interference protection from other users and so it is susceptible to interference. For many MSO and MNO deployments and applications, the certainty of PAL interference protection is critical for radio access network coverage.

As described in Section 5.4, the PAL Holders request that SASs take advantage of 96.59(c) to the extent feasible so that during interruptions triggered by incumbent operations, new PAL channels can be assigned to the PAL Holders' CBSDs operating as PAL if needed. This is important to maintain the guaranteed interference protection levels that PAL channel use affords.

Temporary reassignment of PAL(s) to different channels requires a number of new features to be implemented by SASs, as follows.
requires a number of features to be implemented.

1. The Managing SAS needs to identify the best candidate available PAL channel(s) for reassignment(s) and have a consistent methodology to do so, as defined in Section 7.

2. The Managing SAS needs to have a methodology to determine interference effects to other PAL co-channel users. These could be aggregate interference calculations similar to those now used in the current overnight CPAS process or other methodologies that are simpler, easier and faster to evaluate.

3. The Managing SAS needs to have a methodology to decide whether to reassign new channel(s) to the PAL Holder's CBSDs impacted by DPA activation and other CBSDs using the same PAL channel in the vicinity but are not impacted by either whole-county PAL re-assignment, or partial-county reassignment as described in Section 6.

4. The Managing SAS needs to have a defined methodology to report and communicate the new PAL channel assignments in a timely manner to all other SASs.

5. All the other SASs need to have a defined methodology to receive this new PAL channel assignment report and to

- Conduct assessments of all nearby co-channel GAA users' CBSDs and their possible interference or aggregate interference contributions to the newly assigned PAL channel,
- Identify those GAA users that need to be bumped off of their current GAA assigned channels to accommodate the newly reassigned PAL channel,
- Communicate a GAA channel grant termination (or not renew such GAA grants) to these other user GAA CBSDs in order to clear the co-channel GAA users off the newly granted PAL reassigned channel.

6. These new features need to be tested to show interoperation among SAS Administrators. Note that subsequent PAL reassignments and bumping does not impact incumbent users, as these channels have already been accommodated, and these methods have already been Certification Tested.

5.2 PAL Uses

This section describes PAL uses and the significance of PAL for mobility and fixed wireless networks in the context of LTE and 5G NR technology. Similar principles apply to proprietary technologies (such as Cambium technology [13]). The PAL channel reassignment procedure described in this document applies to all radio technologies. In this subsection only the impact on 3GPP LTE operation is discussed as an example.

Many of the MNO, MSO, and FWA service providers use PAL channels in coastal areas and other areas near DPAs to provide wireless voice and data services to customers in high density urban areas. These channels could be used for carrier aggregation as either a primary component carrier or secondary component carriers. Primary use of an LTE channel means the CBRS uplink (UL) and downlink (DL) channels themselves carry both user traffic and also system control information. Secondary (or SDL) LTE use means the CBRS uplink (SUL) and/or downlink (SDL) channels carry only supplemental user traffic information. Another LTE channel (a primary channel within another licensed, protected band) is used along to carry the system control information and the traffic information. The SDL or SUL channel in the CBRS band is used only to carry (add) supplemental downlink and/or uplink traffic to expand capacity via the use of Carrier Aggregation.

Primary uses of radios allow indoor uses and other uses that are not coordinated (not Carrier Aggregation coordinated) with an operator's macro coverage network (which requires a separate primary network upon another uncoordinated licensed band). This is optimal for picocells or indoor cells that need not be coordinated with the macro-cellular coverage of the wireless network provider. These could even be private LTE (P_LTE) radios, which inherently cannot be coordinated with an MSO's or MNO's own coverage network. These CBRS coverage cells and types of usage are not supported nor backed up by coverage from another co-area cell from the service provider. For most Private LTE users, this Primary, 'stand-alone' use is a requirement.

Secondary (or Supplemental Use, with Carrier Aggregation) uses of radios allows outdoor or indoor uses that are closely coordinated (and collocated) with a wireless network operator's own macro/micro coverage network. These CBRS cells then are macro or microcells that are closely coordinated and Carrier Aggregated with existing other-band coverage cells. If these 'supplemental use' CBRS band radios lose use of a CBRS channel, the capacity of the system could suffer, but other non-CBRS and licensed channels will take over and continue to maintain coverage and provide radio service and provide traffic capacity.

Specifically, in the cases of Primary uses, the need for constant availability and adequate performance of a PAL protected CBRS channel is paramount for the usability of such a primary cell. If the Primary CBRS radio loses use of a primary channel, the coverage, capacity, and control of the system is terminated, and radio service is lost. Thus, for such Primary cell CBRS PAL Holders, the capability for PAL channel re-assignment on the part of the Managing SAS is critical for interference free operation and continuity (availability) of radio service. Deploying a Primary cell on a GAA channel leaves the control channel unacceptably vulnerable to such GAA-to-GAA interference.

For improved capacity, a CBRS-band-only architecture could use both PAL and GAA channels, where the PAL channel(s) are Primary (for control that is interference protected), and where the GAA channel(s) are used as supplemental channels to improve the radio's data capacity. But again, it is critical that the Primary (control) channel be on a PAL protected channel so that it is not vulnerable to GAA-to-GAA interference.

Therefore, the Managing SAS's PAL Channel Re-Assignment capability under §96.59(c) is critically important.

5.3 Impact of DPA Activation

The coastal areas of the US (east coast, west coast, gulf coast, Hawaii and Alaska) cover a very large proportion of high-density markets and overall population. These coastal areas are vulnerable to CBRS Tier 1 offshore DPA activation, where PAL channels could be temporarily suspended or reassigned to other channels. For service continuity (availability statistics) in these coastal areas, especially close to the coast and especially where primary cells are deployed or desired, it is critical that PAL channel operations are preserved by means of channel re-assignment.

PAL channel suspension or replacement of a PAL channel with a GAA channel is not adequate for primary use cases. This is especially true if a new PAL channel assignment can only be accomplished during an overnight CPAS procedure among the SAS Administrators. Waiting many hours for the CBSD radio(s) to obtain new PAL channel assignment(s) destroys the viability of many desirable use cases for the CBRS band (primary cell network, Private LTE, FWA).

Again, the Managing SAS's PAL Channel Re-Assignment capability under §96.59(c) is critically important.

5.4 PAL Holders Preferences

A PAL user's Managing SAS can initiate a PAL channel reassignment process at the time of a DPA activation affecting the PAL channel. The Managing SAS can offer such services to its customers. All SAS administrators are required to protect any PAL channels reassigned if and when requested by other Managing SASs. This is required to protect the PAL users whose PAL channels have been re-assigned (moved) to new channels, which could have been occupied by GAA users in the vicinity. This PAL reassignment methodology must include protecting all PAL operations that are moved from their previously assigned PAL channels. The moved PAL operations must be protected from all GAA co-channel operations that could cause interference from within the county, as well as other PAL co-channel operations in adjacent counties.
PAL channel reassignment requirements, as compiled by some PAL Holders, are given below, not in any prioritized order.

PAL Holders prefer that the temporary PAL channel reassignment process is designed as follows:

- Consider one of the following options for selection of CBSDs to move to new PAL channel, when available (See Section 6):
    - Option 1: Move all PAL CBSDs of the affected PAL Holder within the PPA together to a new channel.
        - This option is beneficial for operations requiring end user mobility, which involves handoff between cells. Inter-frequency handovers are not as simple as intra-frequency handovers. Channel contiguity within a PPA during handoff is desirable in the same way as channel contiguity across license areas is considered desirable.
    - Option 4: Move only those CBSDs that were impacted by the Move List.
        - This option has the least impact on GAA CBSDs that may be using the new channel. Only those GAA CBSDs are impacted that affect the PAL CBSDs on the Move List.
    - Option 2: Establish some threshold (for example 80 %) and if more than 80% of the PAL Holder's CBSDs within the PPA cluster are impacted by the Move List, then reassign all (100%) of the PAL Holder's CBSDs to the newly assigned channel. Otherwise, reassign only the CBSDs that are on the Move List
        - This option strikes a balance between the two options, allowing flexibility for PAL Holders.
- Strive to reduce the impact to GAA users as much as possible: For example,

  - Suspend only those GAA CBSDs' grants that need to be suspended to avoid interference to PAL CBSDs that are reassigned on the same channel due to DPA activation, or
  - Suspend only those GAA CBSDs' grants that are too close to the PAL Holder's reassigned CBSDs to cause interference.

- Strive to create and assign new PAL channel grants within the 300 second FCC channel shutdown mandate interval, in order to appear seamless to PAL Holders. PAL channel evaluations, reassignments, and subsequent channel bumping (of GAA users off the newly assigned PAL channel) would all occur within this 300 second interval.

- Consider one of the following options for returning reassigned CBSDs to their original PAL channels (See Section 8.4):
  - Option 1: Return the PAL Holder's CBSDs to their originally assigned grants as soon as possible, after the DPA has been deactivated. This retains the PAL Holder's original channel plan as much as possible, or
  - Option 2: Leave the PAL Holder's CBSDs on the reassigned PAL channels even after the DPA has been deactivated until the next CPAS, as this reduces the PAL CBSD's grant changes,
  - Option 3: Leave the PAL Holder's CBSDs on the reassigned PAL channels indefinitely, as this reduces the PAL CBSD's grant changes.

- Maintain the PAL Holder's CBSDs' channel contiguity and area contiguity. Choosing new PAL channels (where possible) that maintain PAL channel-to-channel contiguity (use adjacent PAL channels for wider carriers of 20, 30 or 40 MHz) and area-to-area contiguity as much as possible.

- Establish messages (CBSD-to/from-SAS and inter-SAS) to coordinate PAL channel reassignment and allow the CBSDs to be informed of available PAL channels and allow the CBSDs themselves to coordinate, if possible.

The Managing SAS promptly publishes the SAS Administrators' 'channel map' so that PAL Holders can understand the current PAL channel map (map to user assignments), to avoid stale maps and databases.

6 Reassignment Area

6.1 Motivation

Voice and Data networks are typically deployed in specific geographic areas driven by traffic demands, mobility considerations and availability of installation locations. Deployments typically cover sometimes large geographic areas for voice and data services on narrow band macro transceivers in the sub 2 GHz frequencies and deployed as small cells with large bandwidths in frequencies above 3.5 GHz.

Typically, transceiver deployments are planned, deployed, constructed, and brought into service in coordinated groups called Clusters. Such coordinated deployments allow a service provider to build a consistent user experience across mobility boundaries and meet Indoor coverage objectives.

A service provider can use both PAL and GAA frequencies in its CBSD deployments. PAL channels are guaranteed interference protection under FCC Part 96 rules from GAA as well as other PAL Holders. The protection is defined by means of PPAs, which are geographic areas around CBSDs using PAL channels, and are created by the managing SAS and PPA information is exchanged with participating SASs.

A PPA could comprise a cluster of Category A or Category B small cells used for capacity needs, or a cluster of Cat B macro cells used for providing coverage, or a mixture of the two. PPAs could have different sizes and can span anywhere from a small portion of a county to possibly an entire county. They could also traverse county boundaries in the scenario where an operator has PALs in multiple adjoining counties.

6.2 Approach

A PAL licensee is granted one or more “steady state” channels assigned by the SAS that it can use to operate the CBRS network and serve its end users. In case of DPA activation, a service provider will strive to minimize the disruption to its end customers and look to operational methods to manage DPA disruptions. As stated earlier, PPAs vary in size from a small area with a small number of CBSDs to an area that could span the entire county (or counties) with a large number of CBSDs. Continued availability of PAL channels is critical for the operation of the networks. In cases where PAL grants are disrupted due to DPA activation, it is critical that the Managing SAS assign alternative temporary grants to PAL CBSDs as soon as possible while ensuring continued protection to the extent feasible.

The provision of temporary PAL channel grants to CBSDs can either be addressed at the county level, PPA level or CBSD level. An operator needs to consider operational aspects to minimize disruptions to CBSD configuration and management systems, minimize EUD communications and minimize inter frequency handovers between CBSDs. An operator has to balance the operational

load due to configuration changes and SON (Self-organizing Network) procedures within the Radio Access Network management system or manage the over the air communication to EUDs to guide them for access and mobility messaging. Network availability is a key operational KPI that every service provider values for multiple reasons, e.g., public safety and emergency services.

A list of options is proposed below to provide tradeoffs for the volume of messaging, end user impact, and network availability. A service provider could choose one or more of the below options to communicate to its managing SAS the scope of CBSDs that the SAS could consider for assignment of temporary PAL channels. These options could be communicated in the CBSD to SAS protocol.

The List of Options is shown with descriptions shown below the list.

Option 1: Full County Reassignment

Option 2: Threshold Based PPA Reassignment

Option 3: Operator-Defined Contour-Based Reassignment

Option 4: Impacted CBSD Reassignment

Note: The SASs exchange information on PPAs during CPAS across all the SASs. A Managing SAS communicates the PPA information of its PAL CBSDs to all other SASs in references of *"Zone_ID"* and *ppaInfo* as defined in WINNF-TS-0096 [12].

Impacts on the managing SAS that supports PAL Channel Reassignment:

Opt-in: used to enable the PAL Channel Reassignment. Managing SAS can reassign the PAL channels only if the PAL Holder opts-in

- **PPA-based Move Threshold**:

  PPA-based Move Threshold is defined as the percentage threshold for the SAS to make the determination of whether to move the entire PPA or only the impacted CBSDs. The PAL Holder can be allowed to configure Move Thresholds on an individual PPA basis with the managing SAS, using offline communication. The managing SAS can move all the CBSDs in the PPA to a new channel if the impacted CBSD percentage meets the configured Move Threshold for that PPA. If the Move Threshold is not met, only the impacted CBSDs are moved to the new channel. See Section 6.2.2 for detailed behavior.

  This PPA-based Move Threshold value can be updated by the PAL Holder, but the managing SAS can apply the new values when feasible.

- **PAL Holder defined PPA**:

Managing SAS can support PPA definition by a PAL Holder. The PAL Holder defined PPA can be smaller or equal in size but cannot exceed the PPA boundary defined by the SAS. The PPA defined by PAL Holder is updated by managing SAS to include the complete 2 arc second pixels in the grid at the PPA boundary. The max EIRP of the PAL CBSDs in the PAL Holder defined PPA is not impacted by the PPA size.

To support Option 2 and Option 3 below, the managing SAS is required to support PAL Holder defined PPAs.

6.2.1 Option 1: Full County Reassignment

In this option, when a DPA activity causes suspension of one or more PAL steady state channels belonging to a service provider in a given county, the SAS assigns all CBSDs using the steady state channels within the county to temporary channels. In this case, the SAS directs all the CBSDs with impacted PAL channel grants to retune to the alternate PAL channel, whether the CBSDs were on the move list or not.

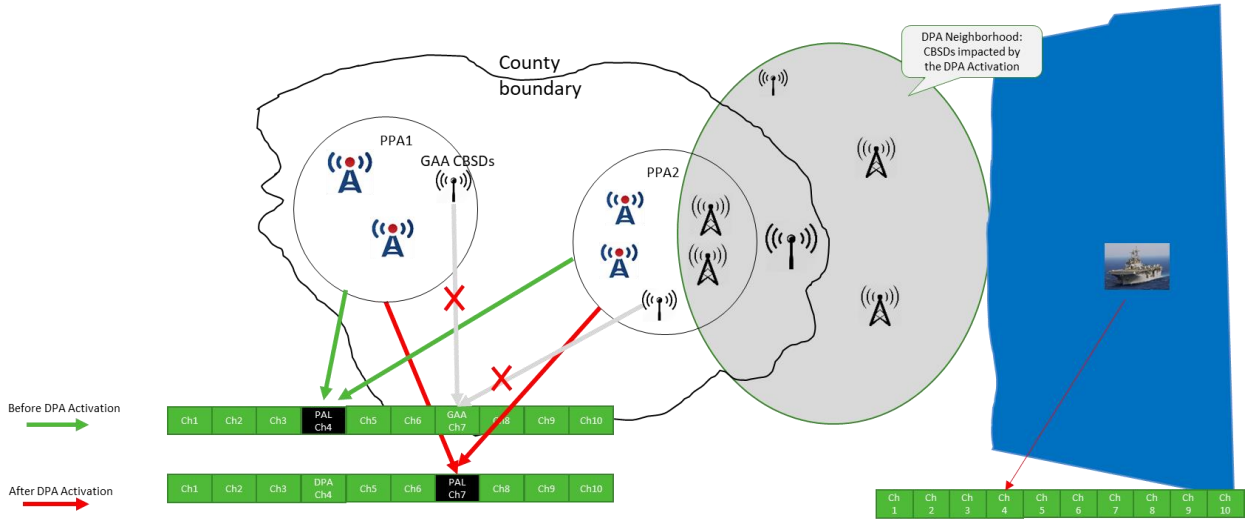


Figure 6-1: Full County Reassignment

6.2.1.1 Expected Operation:

An ESC belonging to the managing SAS (or the DPA portals) informs the SAS of DPA activity on a particular set of PAL channels belonging to one or more service providers. The managing SAS directs the CBSDs that are on the move list to cease operations and optionally provides a recommended channel in the Heartbeat Response. In addition, the managing SAS could report the new PAL channel in the Spectrum Inquiry Response as a PAL grant, if requested by impacted CBSDs.

The managing SAS calculates the alternate solution for the impacted PAL channel(s) and directs all the CBSDs in the county to re-tune to a new frequency or frequencies.

Move only if the operator opted in for PAL Channel Reassignment. Move the whole county if the percentage of impacted CBSDs is greater than a threshold configured for the county, otherwise move only the impacted CBSDs. The threshold could be configured by the operator for each county, independently.

6.2.1.2 Advantages and Disadvantages

This option serves to be the most advantageous from a computation point of view for the SASs. In this case the managing SAS can assign the same secondary PAL channel for all the PAL CBSDs registered and operating with the impacted channel grants within a county. This exercise of assigning an alternate secondary PAL channel grant will be very similar to the exercise of assigning a steady state PAL channel grant. This option is also the quickest in finding a PAL secondary channel and communicating it to the CBSDs. However, this option causes all the PAL CBSDs to change their channel and communicate to end users (EUDs) about such channel change.

This option causes the most impact on network management systems and could cause a signaling overload on both upstream and downstream systems. The overhead processing in management systems extends to processes such as cell unlock, cell rebuild, SON re-calculations, backend system changes among other things. The metrics and KPIs tied to such processes reflect the wide scale impact of the disruption and impact on the Network Availability and Reliability indices. Given the extent of the CBSDs impacted across the entire county, this impact is estimated to be highest for the Network Availability KPI.

This option has the highest impact on channel availability for GAA users as all CBSDs using the affected PAL channels need to move regardless of whether they are on the move list or not for the DPA.

6.2.2 Option 2: Threshold Based PPA Reassignment

This option requires the SAS to support PPA definition by a PAL Holder which can be smaller but does not exceed the PPA defined by the SAS.

In this option, whenever a DPA activation causes suspension of one or more PAL steady state channels belonging to an Operator, the SAS will temporarily re-assign either the impacted_PAL CBSDs within the applicable PPA or the entire PPA with the impacted CBSDs. The SAS reassigns (relocates) the CBSDs within that PPA to channels that are not currently occupied by PAL CBSDs. The SAS possesses knowledge of the PPA. In this option, the SAS either relocates only the CBSDs within the applicable PPA that are impacted by the DPA activation or relocates the entire set of CBSDs within the PPA.

See Section 7 for the Secondary Channel Assignment Process, and Section 8.4 for the Return to Primary Channel process.

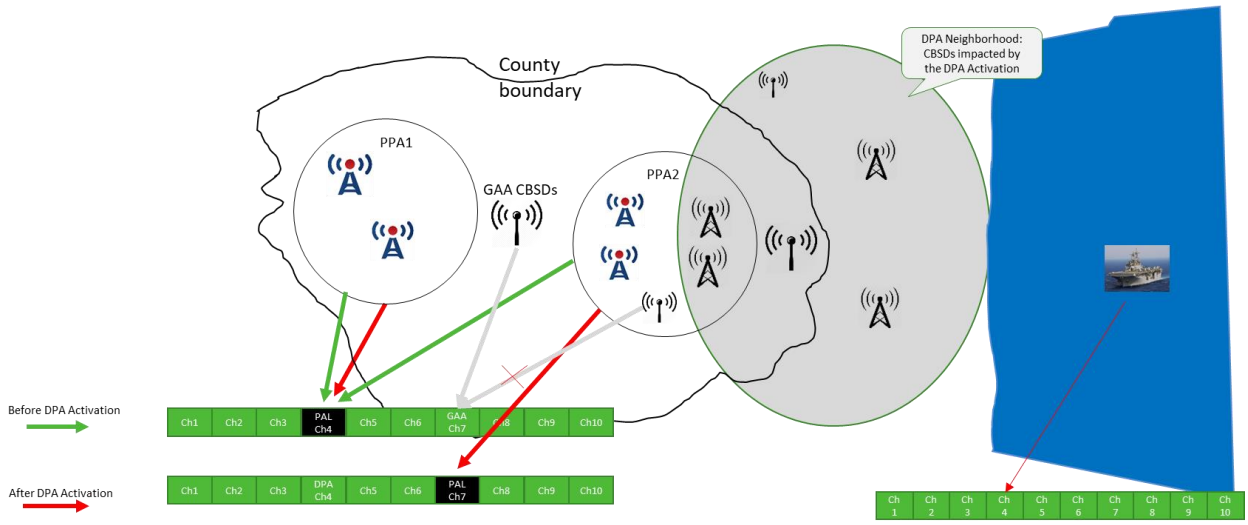


Figure 6-2: PPA-based Reassignment

6.2.2.1 Expected Operation:

An ESC belonging to the managing SAS (or the DPA Portal) informs SAS about the DPA activation on a PAL channel or channels. The managing SAS directs the CBSDs/Grants that are in the move list to cease operations on the impacted channel(s) or optionally reassign to a channel (or channels) recommended by the managing SAS in the Heartbeat Response.

To determine whether the entire PPA is reassigned or only the impacted CBSDs are reassigned, a parameter, PPA-based Moved Threshold, is defined in Section 6.2.2. If the percentage of CBSDs in the PPA that are impacted is greater than the parameter, the entire set of CBSDs within the PPA is reassigned, regardless of whether or not they are on the move list; if the percentage of CBSDs within the PPA that are impacted is less than or equal to the parameter only the impacted CBSDs are reassigned (i.e., those on the move list). Note that if the threshold parameter is set to 100%, only the impacted CBSDs will be reassigned.

How to manage the threshold when the PAL License is leased is FFS. Table 6-1 contains several examples of relocation scenarios.

Table 6-1: Example Relocation Scenario Examples

# CBSDs in PPA	% Threshold	# CBSDs impacted	% CBSDs impacted	# Moved	Description of result
100	50%	60	60%	100	Move entire PPA
100	50%	50	50%	50	Move only impacted CBSDs
100	50%	40	40%	40	Move only impacted CBSDs
100	100%	100	100%	100	Move only impacted CBSDs
100	100%	90	90%	90	Move only impacted CBSDs
100	100%	20	20%	20	Move only impacted CBSDs
100	100%	10	10%	10	Move only impacted CBSDs

6.2.2.2 Advantages and Disadvantages

This option takes a slightly different approach to striking a balance between the ease of finding a rapid PAL secondary channel versus lessening the extent of processing and signaling impact on the overall system. This option provides the advantage of permitting the operator to set the conditions for whether to move just the impacted CBSDs or the entire PPA. This approach has the advantage of flexibility in determining the amount of signaling within the network based upon the network design. Another advantage of this option is that only the PAL CBSDs within the impacted PPA (either the entire PPA or only the impacted CBSDs) change their channel and communicate to end users (EUDs) about the channel change. The remaining CBSDs in all other PPAs within the counties are not impacted and even if they are impacted, then the SAS applies the default Release 1 behavior of pausing transmission on the incumbent impacting CBSDs.

GAA channel availability impact is less than option 1. There is no need for the service provider to determine partial counties and share this information with managing SAS, nor is there inter-SAS sharing of this information.

6.2.3 Option 3: Operator-defined Contour-based Reassignment

In this option, whenever a DPA activity causes suspension of one or more PAL steady state channels belonging to a service provider, the SAS will reassign the PAL CBSDs only within a geographically defined subset of the applicable PPA. The SAS reassigns a subset of CBSDs within that PPA to alternate channel frequencies with no PAL operations. This way the service impact to the end customer is limited to the subset of the PPA. This enhances the network availability metric of the service provider.

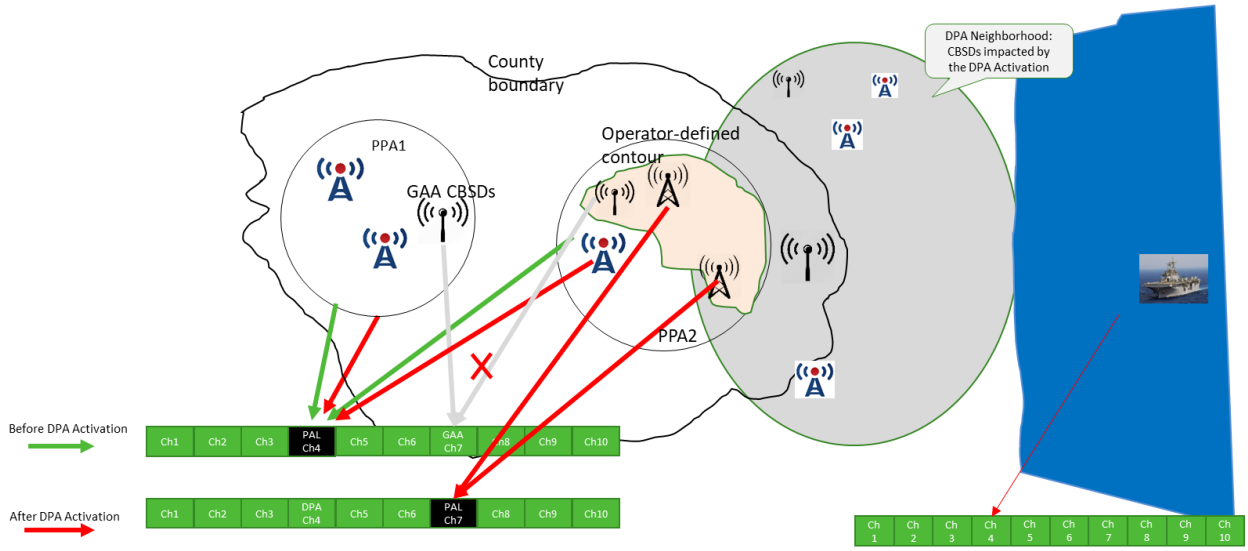


Figure 6-3: Operator-defined Contour-based Reassignment

6.2.3.1 Expected Operation:

An ESC belonging to the managing SAS (or the DPA Portal) informs SAS about the DPA activation on a PAL channel or channels. The managing SAS directs the CBSDs/Grants that are in the move list to cease operations on the impacted channel(s) or optionally reassign to a channel (or channels) recommended by the managing SAS in the Heartbeat Response.

Move only if the operator opted in for PAL Channel Reassignment. The managing SAS calculates the alternate solution for the impacted PAL channel(s) and directs all the CBSDs in the operator

defined contour region to return to a new frequency, if the number of impacted CBSDs meet the configured threshold for the operator defined contour region. If the configured threshold is not met, only the impacted set of CBSDs are returned to a new frequency.

6.2.3.2 Advantages and Disadvantages

This option builds upon Option 2 and strives to further refine the number of CBSDs affected by carving out geographic regions within a PPA based on traffic and mobility considerations as well as DPA move list impact that have to be moved together. An advantage of this option is that it reduces the impact on overall operations and signaling overhead between CBSDs and EUDs. Since the number of CBSDs affected is lower, this yields an improvement of network availability and reliability KPIs. GAA channel availability is improved compared to Options 1-2.

While this option reduces the impact overhead, it requires the service provider to manage and communicate partial PPAs to the Managing SAS. In turn, the Managing SAS also will have to communicate the new PAL secondary channel at the operator defined contour level to peer SASs for PAL protection. The service provider needs to determine how to create operator defined contours and convey this information to its managing SAS. When directional antennas are used, move list impact can generally not be contained to geographic areas as it depends on antenna direction.

6.2.4 Option 4: Impacted CBSD reassignment

In this option, whenever DPA activity causes suspension of one or more PAL steady state channels belonging to a service provider, SAS reassigns only the impacted CBSDs (the CBSDs on the move list for the DPA) to alternate channels. In this option the SAS does not rely on any geographic considerations for which CBSDs to move to alternate channels.

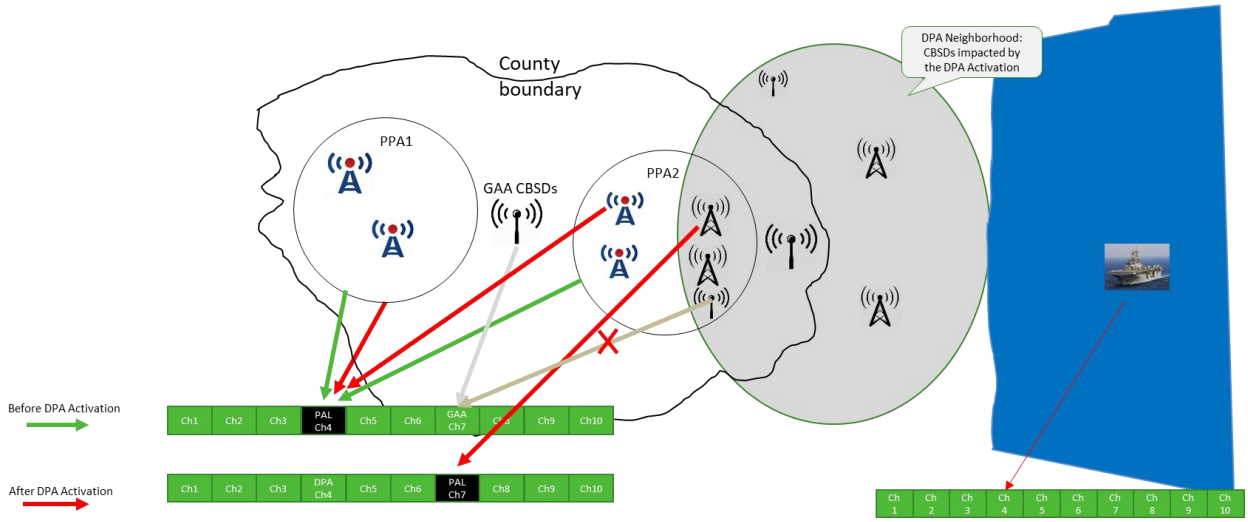


Figure 6-4: Impacted CBSDs Reassignment

6.2.4.1 Expected Operation:

An ESC belonging to the managing SAS (or the DPA portal) informs the SAS of the DPA activity on a particular set of PAL channels belonging to one or more service providers. This service provider could either be PAL or GAA users. The managing SAS directs the CBSDs that are on the move list to cease operations and optionally provides a recommended channel in the Heartbeat Response. The Managing SAS communicates such a decision to other participating SASs.

6.2.4.2 Advantages and Disadvantages

This option has the advantage of being the least impacting when it comes to operator network signaling and operational overhead. It involves only the CBSDs that are part of the move list and have been communicated by the Managing SAS to pause transmission per Part 96 rules. This option also has the least impact on GAA channel availability as only the required CBSDs are moved from PAL channels to alternate channels, which could be occupied by GAA users.

Move only if the operator opted in for PAL Channel Reassignment. While this option has the least signaling overhead for the CBSD to EUD, there could be a higher impact at the EUD level when the EUD has to move from one CBSD to another due to inter-frequency handover situations when these CBSDs operate on different channels.

6.2.5 Conclusion

Option 2 is the recommended option for reassignment. The initial default threshold is set to 80% of the number of CBSDs within the affected PPA (Column 2 in Table 6-1). However, a PAL owner could revisit the default threshold along with their managing SAS and change it based on their operational experience (See PAL Holders Preferences in Section 5.4).

6.3 BTS-CBSD and CPE-CBSD treatment

Any relocation of BTS-CBSD to a new channel will result in relocation of associated CPE-CBSDs as well, regardless of if the CPE-CBSDs are inside the PPA or not. Moreover, CPE-CBSDs could only be reassigned in four scenarios:

a. along with BTS-CBSD,
b. reassigned to a different channel used by the same BTS-CBSD,
c. reassign to a channel used by a different BTS-CBSD at which the CPE-CBSD is already associated, or
d. change its association to a different BTS-CBSD.

Except scenario “a”, all other scenarios could require the CPE to move to a specific channel determined by what the BTS-CBSD is using. Such a change in channel could not follow the algorithm captured in Section7.2 and is outside the scope of this document. Moreover, the scenarios “c”, and “d” might require additional coordination among SASs that are beyond the coordination defined in Section 8.3.

It could be further noted that scenario “d” requires CPE-CBSD to request changing the association to a new BTS-CBSD and therefore it is not guaranteed that this relocation can happen at the time of DPA activation.

The same limitation applies to CBSDs that are required to use the same operational frequency (ies).. In other words, all members of such groups are either reassigned to a new channel together, or not moved[2].

[2] Release 1 WinnForum Specifications have not specified groups for such CBSDs. However, in Release 2, several groups are defined in [6] to address such requirements. Example of such groups are Principal-Subordinate Single Frequency Group, Interdependent Single Frequency Group, Separable Single Frequency Group, and Passive DAS Group [6].

7 PAL Secondary Channel Assignment Process

7.1 Background

When a SAS receives notification from the ESC that a DPA needs protection on certain frequencies, the SAS applies the mechanism defined in R2-SGN-24 in [1] to identify CBSDs that need to be suspended or moved to another frequency to protect that particular frequency or channel. PAL Holders could have CBSDs with active grants on those frequencies that need to be suspended or moved to another frequency to protect the DPA. The reassignment of PAL channel Grants to a temporary channel within the PAL frequency range need to be coordinated across different SAS Administrators. This section proposes a rule-based method on how SAS determines dynamically the temporary channels for PAL CBSDs impacted by the DPA activation. Since all SASs apply the same rule-based method the reassignment of the PAL channel is consistent and coordinated across SASs.

The method to find temporary PAL channels when a CBSD operating on a PAL channel is suspended due to DPA protection needs to be applied for each county independently. Suspended PAL channels will be reassigned dynamically to a Channel Unoccupied by PAL (CUP). Within a county, all physical channels within the first 100 MHz that have not been mapped to a PAL licensee for primary allocation and all physical channels where licensee (or any lessee) has not established a PPA corresponding to their license, is considered a candidate channel for PAL reassignment for that county. These candidate channels are termed Channels Unoccupied by PAL (CUP).

All subsequent sub-sections here are described under the scope of within a county unless otherwise stated explicitly.

7.2 Temporary PAL channel identification for PAL reassignment

SAS(s) need to apply a deterministic set of rules to identify PAL channels among the CUPs for the suspended PAL channels to be reassigned temporarily as described in this section. If "*M"* PAL channels belonging to the same user are suspended in a DPA activation event, while "*N*" CUPs are available, then the algorithm looks for temporary reassignment of *min(M, N)* channels. A search is conducted for each channel to be reassigned to a temporary channel in the order defined in Section 7.3. Two independent algorithms are proposed here for identifying CUPs for reassignment.

The pre-determined "*secondaryChannel*" field in PAL Database is not used for the purpose of PAL channel Reassignment for the following reasons:

1- Infeasibility of determining the a-priori "*secondaryChannel*" for permutation of PAL channel allocations.
2- Depending on the number affected channels, using a pre-determined assignment results in channel availabilities for some PAL Holders.

7.2.1 Algorithm 1

The rules are designed to address the following objectives in order as much as possible: (i) after reassignment, the PAL channels of the moved CBSDs of a given operator are contiguous in frequency, (ii) impact to GAA users is minimized. Objectives (i) and (ii) correspond to Criteria 1 and 2 given below, respectively. Criterion 3 is used as a tie-breaker in case of a tie. A search is conducted jointly for all channels to be reassigned.

The motivation for Objective (i) comes from FCC Part 96 and operator interest in getting operators contiguous frequency assignments for high channel bandwidths. The motivation for Objective (ii) comes from the consideration of minimizing impact to GAA users using CUPs, which is also beneficial to PAL Holders who could want to use GAA channels opportunistically. Moreover, with less impact to GAA CBSDs, PAL CBSDs are better protected against interference from GAA use in their vicinity during the temporary protection phase (Section 8.3, Step 8) reassignment process.

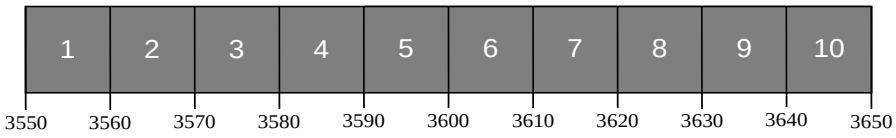


Figure 7-1: PAL Frequencies

Let *"I"* be the set of indices of active (non-suspended) PAL channels for a PAL Holder; *"C"* be the set of indices of CUPs available in the county; "*R*" be a candidate set of indices selected from "*C*" for reassignment; and "*S*" be the union of sets "*I*" and "*R*", i.e. a set of combined indices. Criteria 1, 2, and 3 are applied in order. Criterion 2 is used in the case of a tie using Criterion 1 or if Criterion 1 is not met. Criterion 3 is used in the case of a tie using Criterion 2 or if Criterion 2 is not met.

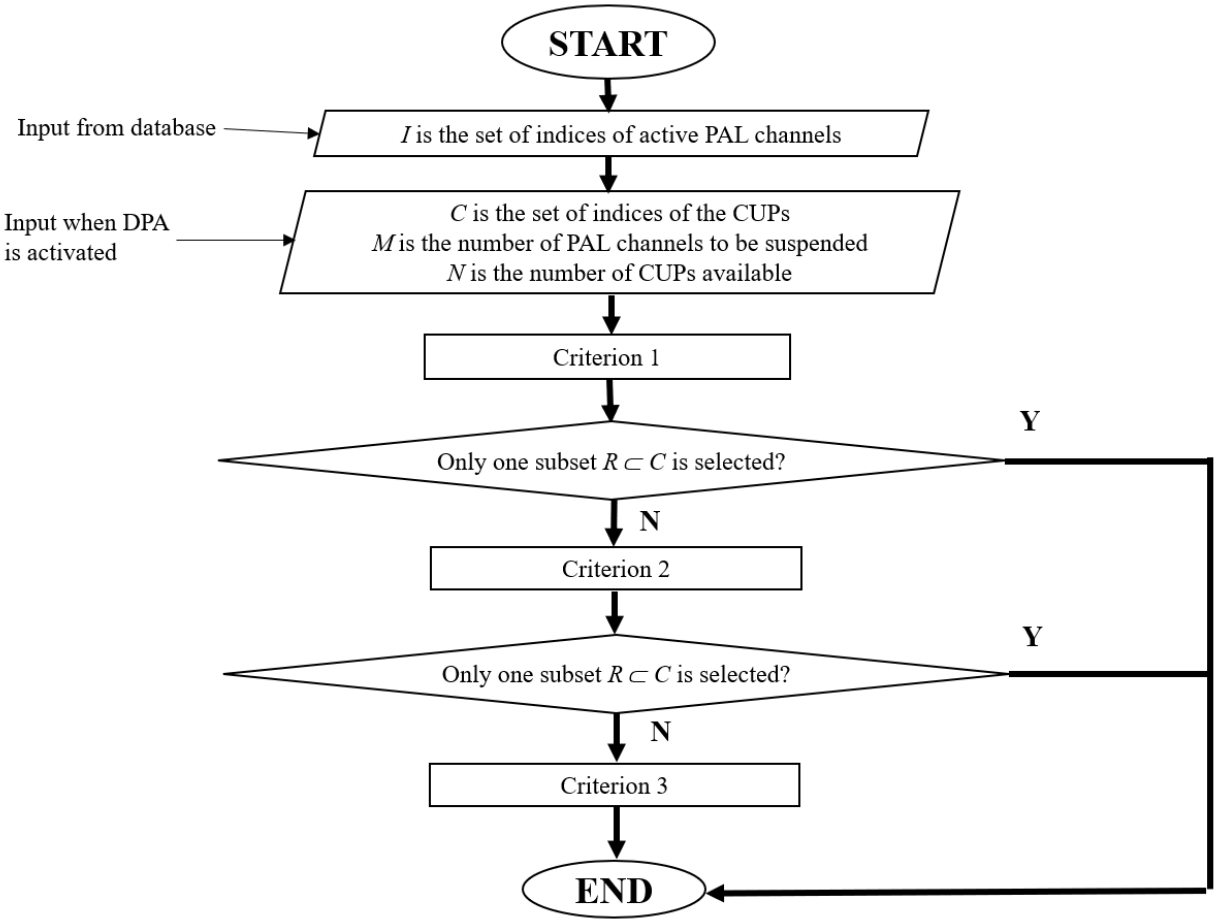


Figure 7-2: Algorithm 1

Criterion 1: Temporary channel indices *r* are picked from the set *R* such that they result in the largest string of contiguous indices in the combined set *S*.

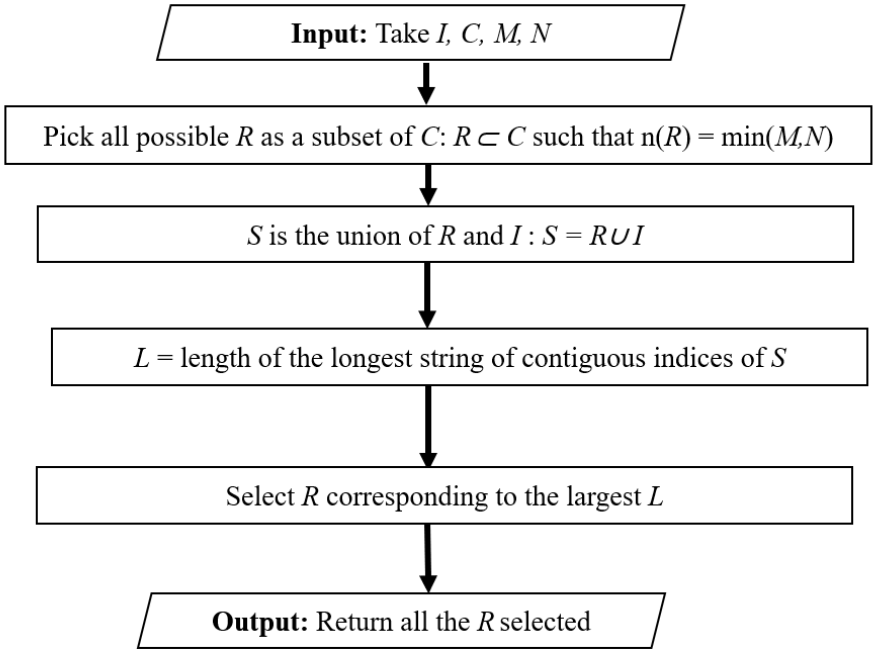
Steps:

1. Pick a candidate set of indices *R* to be assigned jointly from the set *C*
2. Form the set *S* of combined indices by taking the union of the sets *R* and *I*
3. Find the longest string of contiguous indices in the set *S* and determine its length *L*
4. Repeat Steps 1-3 for all possible choices of indices taken from the set *C*
5. Pick the set(s) of indices *r* that maximize *L* (there could be a tie)

For example, suppose that a PAL Holder is operating on PAL Channels 4, 5, and 6. Channels 5 and 6 are suspended. CUPs 1, 2, 3, 7, 8 and 9 are available. The algorithm will pick channels {2,3} because they form a set of 3 contiguous channels in the combined set *S*={2,3,4}, as compared to a set of 2 contiguous channels if channels 7 and 8 were picked, i.e. *S*={4,7,8}.

Alternatively, suppose that only channel 5 was suspended, then there is a tie between CUPs 3 and 7 as both form a set of 2 contiguous channels in the combined set S={3,4,6} or {4,6,7}. Or suppose that only channel 5 was suspended and only CUPs 1, 2, 8, and 9 are available. In this case, none of the CUPs result in a set of contiguous channels in the combined set S. There is a tie between channels 1, 2, 8 and 9.

Now suppose that a PAL Holder is operating on PAL channels 4 and 5. Both channels are suspended. CUPs 2, 3, 6 and 7 are available. In this case, there is again a tie between channels {2,3} and {6,7} as they both result in a set of 2 contiguous channels in the combined set S.



***Note: n(*R*) is the cardinality of the set *R*

Figure 7-3: Criterion 1

Criterion 2: Temporary channel indices *r* are picked from the indices identified with a tie in Criterion 1 to minimize GAA impact. GAA impact on each CUP is determined by counting the total number of GAA CBSDs in the county or the total number of GAA CBSDs located within the contour of all suspended PPAs operating on the CUP.

For example, suppose that a user is operating on PAL Channels 4, 5, and 6. Channel 5 is suspended in two full PPAs but not in a third PPA within a county. CUPs 2, 3, 7, and 8 are available. There is a tie between CUPs 3 and 7 using Criterion 1. In this case, the total number of GAA CBSDs operating on CUP 3 within the contours of the first two PPAs is counted and compared to the total number of GAA CBSDs operating on CUP 7. The CUP used by the lowest number of GAA CBSDs is selected for temporary reassignment.

Alternatively, suppose that a PAL Holder is operating on PAL channels 4 and 5. Both channels are suspended. CUPs 2, 3, 6 and 7 are available. In this case, there is a tie between channels {2,3} and {6,7} using Criterion 1. In this case, the total number of GAA CBSDs operating on CUPs {2,3} within the contours of the first two PPAs are counted and compared to the total number of GAA CBSDs operating on CUPs {6,7}. The CUPs used by the lowest total number of GAA CBSDs are selected for temporary reassignment.

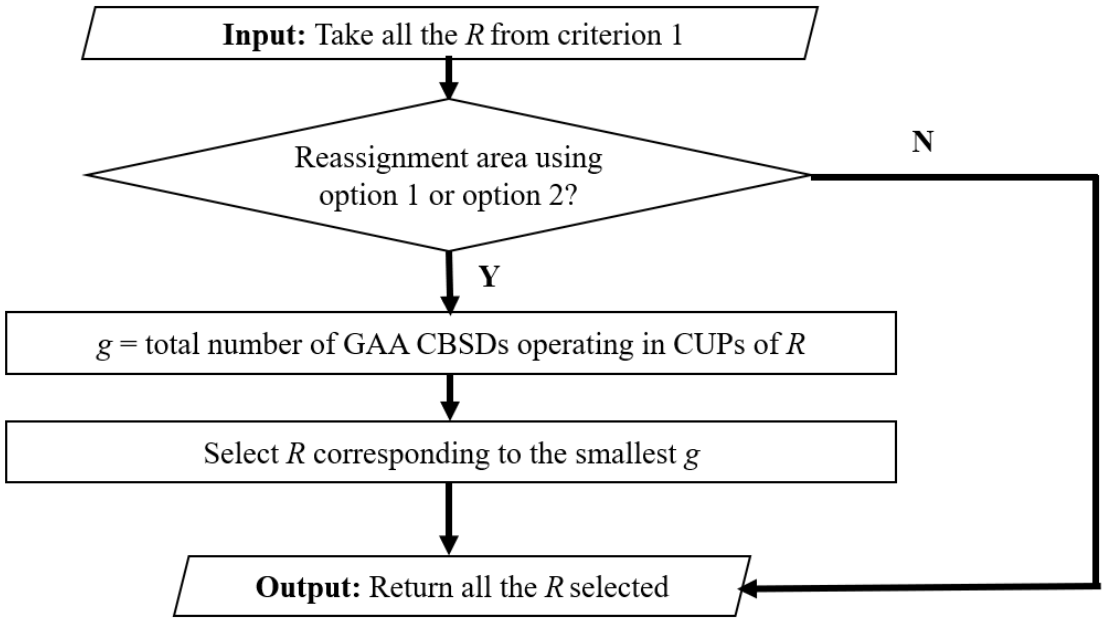


Figure 7-4: Criterion 2

Note that Criterion 2 does not fully address impact to GAA users in order to allow low-complexity and low-latency SAS implementations. Future enhancements can look into consideration of the actual number of GAA CBSDs using CUPs affected by reassignment inside and outside of the reassignment area.

Criterion 3: Temporary channels indices *r* are selected from the indices identified in Criteria 1-3 in the same order as used for processing the suspended PAL channels in the county (Section 7.3)

If there is a tie between multiple CUPs after using Criteria 1, 2 and 3, the lowest channel index (or indices) are selected from the CUPs if the predetermined order of processing of suspended PAL channels is left to right, i.e. lowest order to highest order, or vice versa.

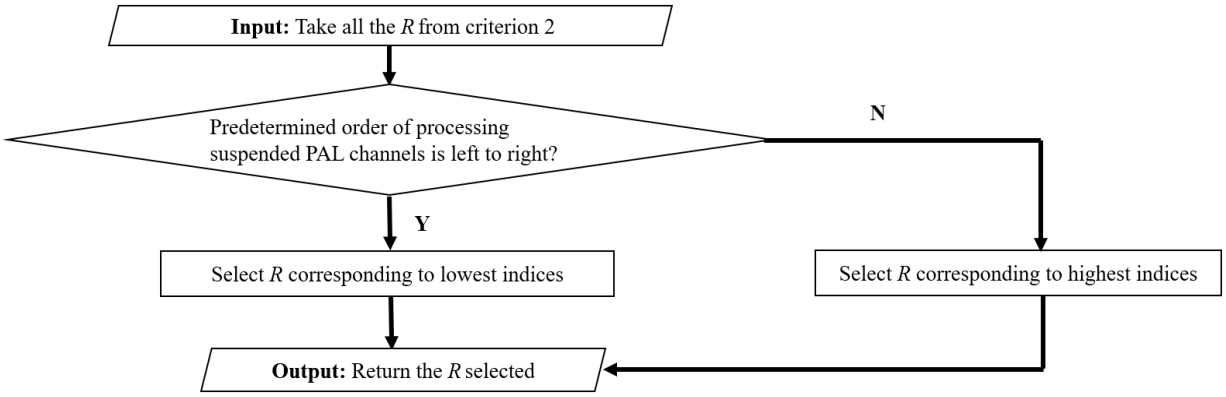


Figure 7-5: Criterion 3

7.2.2 Algorithm 2

If out of ten (10) PAL channels, the *j*-th channel, where *j* is the index of the channel set shown in Figure 7-1 above, is suspended and *R* is the set of indices of CUPs then the channel index, *r*, where $r \varepsilon R$, for relocation for the suspended channel *j*, will be such that $|r - j|$ is the minimum over all elements of *R*. If there are two solutions for *r*, then one of the channels will be selected based on a-priori configuration of selecting channels from the left or right in relation to the suspended *i-th* channel.

If a pair of PAL channels belonging to a single PAL owner, *j* and *j+1*, get suspended then a pair of channels *r* and *r+1* that meet the above condition will be selected for relocation.

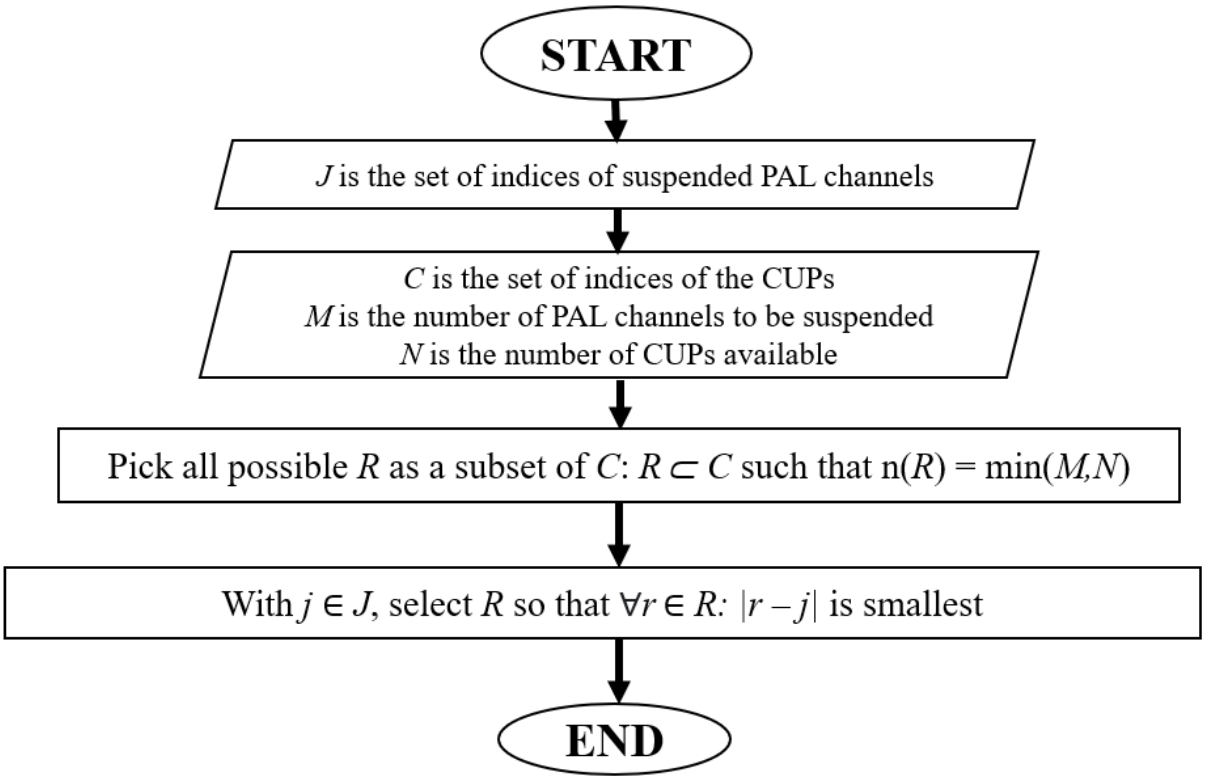


Figure 7-6: Algorithm 2

7.2.3 Conclusion

Option A preserves PAL channel contiguity whenever possible, while Option B provides the lowest SAS complexity. The preferred option is yet to be decided.

7.3 Order of processing suspended PAL channels for temporary reassignment

As suspended PAL channels are reassigned dynamically to temporary PAL channels, if multiple PAL channels within a county are suspended at the same time due to DPA protection, SASs need to know the order in which PAL channels can be selected for reassignment from among the CUP. This is especially relevant when there are more PAL channels impacted than there are CUPs. All SASs need to follow the same order in finding a reassignment for the plurality of suspended channels within a county. The following provides two options for determining the order of PAL channel reassignment.

7.3.1 Option A: A-Priori Random Order

If more than one PAL channel is suspended, within a county, due to DPA activation, then the order of reassignment needs to be chosen in order of the indices of channels from lower frequency to higher frequency or from higher frequency to lower frequency. Each county can be randomly chosen to either follow indices from lower frequency to higher frequency or from higher frequency to lower frequency. To avoid the same order being repeated for a given county every time, a random order has to be adopted for each county individually. The a-priori order for each county needs to be changed periodically.

Figure 7-7 shows Option A reassignment for a three-operator case with 2, 4 and 1 PAL channels in a given county. Four PAL channels are impacted by DPA, while only three are available. Suppose that the order selected for this county was low to high frequency. Option B calls for reassignment of Channels 6, 7, and 8 belonging to the blue-highlighted operator. Channel 9 of the yellow-highlighted operator is not reassigned.

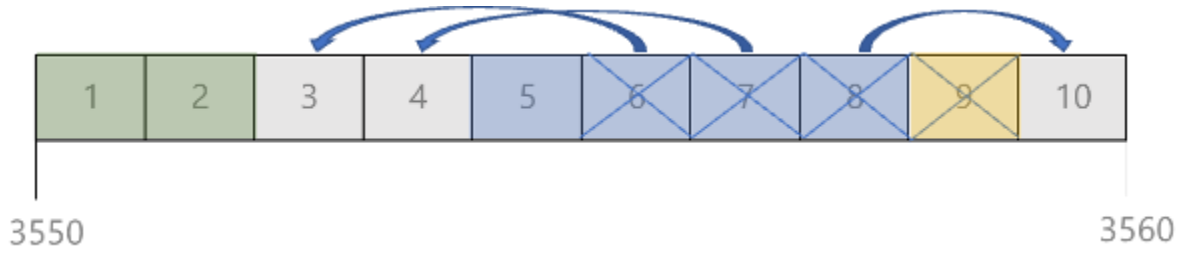


Figure 7-7: Option A Reassignment

7.3.2 Option B: Order to minimize impact across PAL Holders

In this option, the order depends on the impact and outage caused by DPA activations on PAL Holders in a given county.

- If #PAL channels affected ≤ #CUP channels (channels unoccupied by PAL in lower 100 MHz), select all affected channels for reassignment.
- If #PAL channels affected > #CUP channels, determine impact and outage for each operator as follows:

  Impact = No. of PAL channels affected
  Outage = No. of PAL channels affected / No. of PAL channels licensed
- Stage 1: Select the first channel to reassign from the PAL channels of the operator with the highest impact (first criterion), highest outage (second criterion in case of a tie). Recalculate impact & outage for the above operator after removing the selected PAL channel.

- Stage 2: Select a second channel to reassign from the (remaining) PAL channels of the operator with the highest (re)calculated impact / outage. Recalculate impact & outage for the above operator after removing the selected PAL channel.
- Stage 3, 4, … : Repeat until all available (CUP) channels have been assigned
- Ties resolved by a tie breaker, such as based on the odd/even status of the lowest DPA activated.

Figure 7-8 shows Option B reassignment for the same three-operator scenario as in Figure 7-7. Option B calls for reassignment of two channels of the blue-highlighted operator (higher impact: 3 channels affected of blue operator vs. one channel of yellow operator, 2 channels affected of the blue operator vs one channel of yellow operator). Option B also calls for the reassignment of the only channel of the yellow-highlighted operator (equal impact: 1 channel affected for both operators; higher outage: 100% for yellow operator vs 25% outage for blue operator). If Option A was used with low to high order of reassignment, then the blue-highlighted operator would have had all three of its channels reassigned and the yellow-highlighted operator would have been left with no channel, i.e., 100% outage.

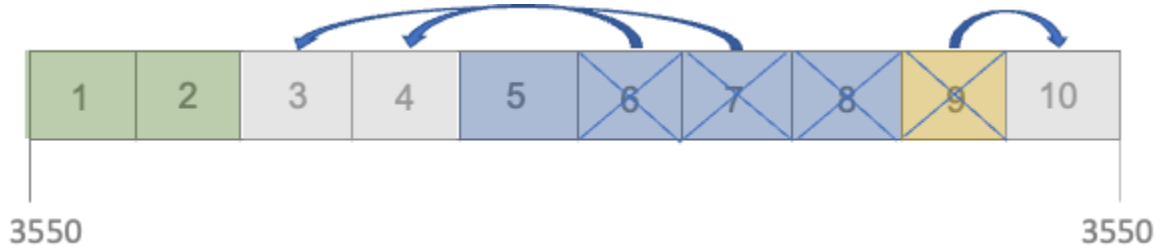


Figure 7-8: Option B Reassignment

7.4 Conclusion

In general, field data shows that DPA activation impacts two contiguous PAL channels at a time. Therefore, the first DPA activation in a county will generally impact two channels, both of which can be reassigned, assuming at least three CUPs are available in the lower 10 channels. Reassignment order doesn't matter; Options A and B are the same in this case. A subsequent DPA activation could impact two additional PAL channels, while only one CUP could be available. Reassignment order could make a difference in this case if the two PAL channels belong to two different operators. Option A calls for a predetermined or random order, while Option B calls for minimizing outage among the two operators. Option A is proposed as the preferred option due to lower SAS complexity.

8 Aperiodic Coordinated Activities among SASs (ACAS)

8.1 Background

According to Part 96 and WInnForum Release 1 specifications, SASs are required to coordinate with each other to apply aggregate interference protection to PAL operation. As a result, PPAs are exchanged among SASs once per day during Coordinated Periodic Activities among SASs (CPAS), conventionally agreed to occur every day. The information about PAL licenses used by licensees is shared through Full Activity Dump (FAD) exchange at the beginning of CPAS (See Section 8.2). The PAL information shared among SASs includes the following:

- The PAL ID, captured in a public database, which conveys the primary frequency channel allocated to the particular license.
- PPA Cluster List, which includes the CBSD IDs of all CBSDs using the particular PAL channel.
- PAL Protection Area (PPA), a contour created by the managing SAS that mainly encompasses the union of coverage areas of all CBSDs.

All SASs perform the Iterative Allocation Process (IAP) to keep the aggregate interference from all CBSDs with any grant overlapping with the PAL channel, at any point on or inside the PPA contour below -80 dBm/10MHz.

8.2 Release 1 CPAS

To achieve synchronous power allocation among all SASs, all SASs perform a procedure called Cooperative Periodic Activities among SASs (CPAS), which is a periodic process performed by all SASs synchronously. The CPAS is a process performed at a certain time by all SAS Administrators and aims to facilitate the required file exchange and coordinated aggregate interference calculation to all incumbents. CPAS is performed on a daily basis, and currently SAS Administrators have agreed to start the process T1 in the following process. The process includes the following steps as depicted in Figure 8-1.

1. At Time T_1: All SAS Administrators prepare FAD files to be shared with all other SAS Administrators. Each FAD file includes the following information.
    a. All CBSDs with at least one active Grant
    b. All existing active Grants

c. All PPAs

d. Location, antenna characteristics, and protection levels of all ESC sensors

2. At Time T_2: SAS Administrators pull FAD from other SASs and perform synchronization with information retrieved from FCC Databases

3. Upon completion of Step 2, SAS Administrators perform Pre-IAP filtering, including the following steps:

   a. Resolving grant conflicts among SASs

   b. Terminating all grants (whether belonging to managing SAS or other SASs) used by CBSDs located inside the following exclusion zones with overlapping frequency ranges:

      i. PPA,

      ii. GWPZ

      iii. Part 90 subpart Z (GWBL stations within 150 km of FSS operating within 3650-3700 MHz),

      iv. Exclusion Zone for the Inland federal radars

   c. Performing FSS Purge List

4. Upon completion of step 3, all SASs perform the following activities independently:

   a. IAP: to protect all non-Federal incumbents (GWPZ, FSS Co-channel, FSS blocking, PPAs and ESC sensors),

   b. Create the DPA Move Lists for all offshore and inland DPAs, and out of band inland radar DPAs.

5. At Time T_3 and beyond: Enforce the results of IAP and DPA Move list for activated DPAs.

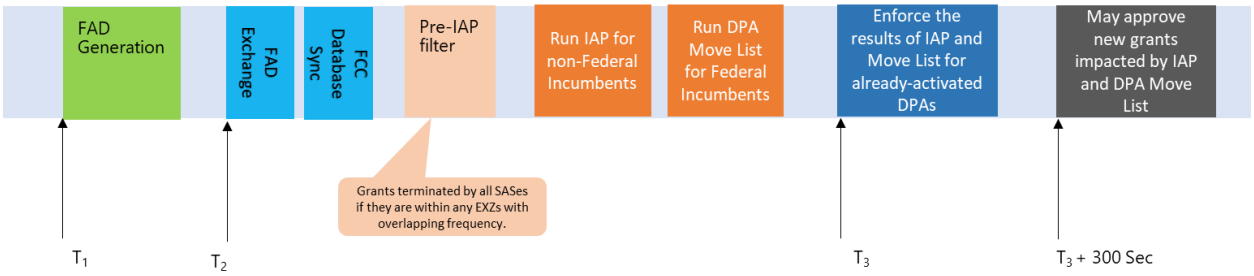


Figure 8-1: Release 1 CPAS

8.3 ACAS

PAL protection coordination among SAS Administrators occurs once daily at CPAS time. Since DPA activation could occur anytime during the day and according to Part 96 rules) within 5 minutes of the ESC network detecting DPA activities, the impacted CBSDs need to either terminate or move from existing channels, some level of coordination is required among SAS administrators at the time of DPA activation to provide protection for the reassigned PAL CBSDs. In this section, this unplanned coordination among SASs is defined Aperiodic Coordinated Activity among SASs (ACAS), as opposed to Coordinated Periodic Activities among SASs (CPAS). The purpose of this coordination is for the SASs to coordinate to apply the same interference protection to the CBSDs and their coverage area using the secondary PAL channel by performing the following functions:

a. The Managing SAS triggers the temporary PAL Channel reassignment process for all PAL Grants that are impacted by the DPA activation.
b. SASs coordinate to synchronize determination of the secondary PAL channel(s)
c. SASs coordinate the list of CBSDs and PAL grants that are expected to switch to the secondary PAL channel.
d. SASs coordinate to apply the same aggregate interference protection to the CBSDs and their coverage area using the secondary PAL channel.

Note that the time window between T1 and T3 in Figure 8-1 is considered an uncertainty duration at which SASs are performing IAP process and DPA Move List calculation. Therefore, if an DPA activation occurs during this time window, SASs need to avoid relocation of PAL channels.

As described in Section 8.4, the ACAS process could also be used to return to the original PAL Primary channel upon DPA deactivation. A flag defined in Section 8.3.3, and Table 8-3 defines the usage of this flag. In this Section, we assume the ACAS is used for DPA activation.

Figure 8-2 describes the processes involved in ACAS. The following describes the steps.

Step 1- Coverages are calculated for all PAL CBSDs included in the Move List (ML): After determination of the ML for each DPA in each 10 MHz channel during CPAS, the managing SAS could record the coverage area of each CBSD using a particular 10 MHz PAL channel that is within the ML of any DPA within the same 10 MHz channel. Since the managing SAS has already calculated the coverage areas of every CBSD included in a PPA cluster list, in theory, no new calculation is needed by the SAS, and this might only require retrieving such information.

Step 2- The managing SAS determines activation of the DPAs impacting its managed PPAs

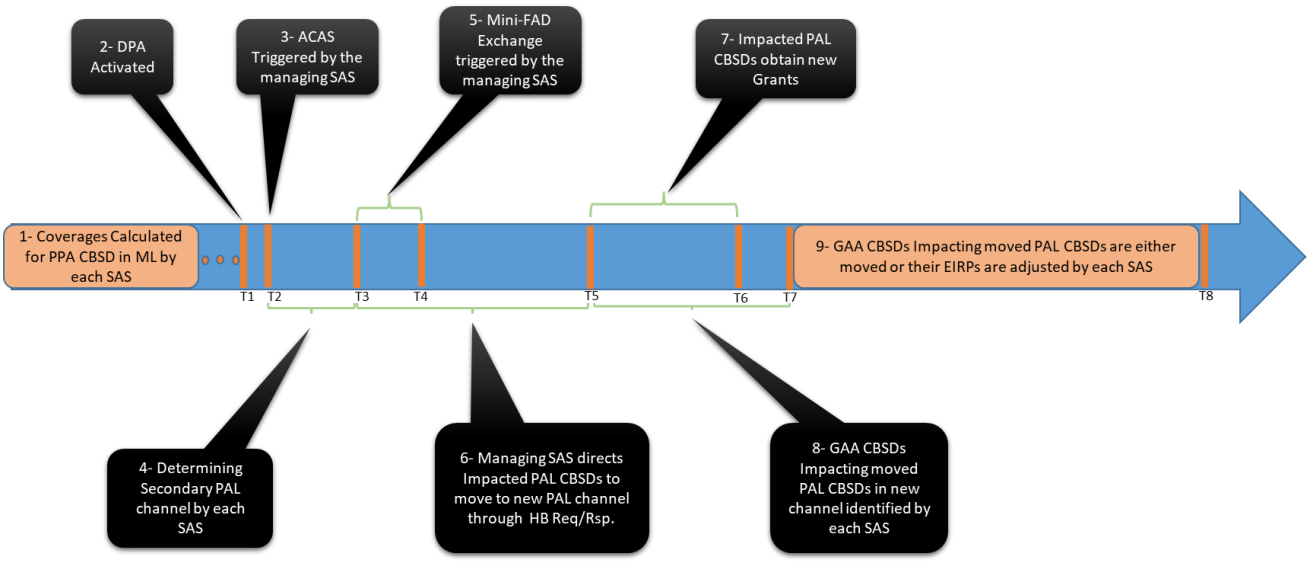


Figure 8-2: ACAS for DPA Activation

Step 3- Using the process defined in Section 8.3.3, the managing SAS triggers the start of the ACAS process, as a result of notification of a DPA activation either by ESC sensors or other means

Step 4- The managing SAS performs the process described in Section 7 to determine the secondary PAL channel for each PPA.

Step 5- Each SAS creates and shares the ACAS Exchange Message with all other SASs. The content of ACAS Exchange Message is defined in Section 8.3.2.

Step 6- The managing SAS recommends the impacted CBSDs to move to the new secondary PAL channel using the *operationParam* in the HB Response message. Managing SASs are required to suspend the original PAL grant, rather than termination of the grant. It is up to the CBSD to decide whether to keep or relinquish the old PAL grant. The HB Response message that suspends the old grant and contains the recommended PAL channel need to indicate this new recommended channel as a PAL grant. For the time being, the only way to support this feature in the HB Response message is to use *ResponseData* field.

Note that CBSD could send *SpectrumInquiryRequest* message. The managing SAS needs to report the new PAL channel in the *SpectrumInquiryResponse* as a PAL grant.

Step 7- Impacted CBSDs could decide to stay suspended. However, if they decide to move to the new PAL channels, they could send *grantRequest* to the managing SAS including the PAL secondary channel, according to the suggested "*OperationParam*" provided by Managing SAS through *heartbeatResponse* message. One possible reason that CBSDs could decide not to move to the new PAL channel is if the new channel is not adjacent to any other grants used by the CBSD. Even though PAL channel adjacency is a criterion in the PAL channel assignment algorithms described in Section 7, it is not guaranteed that channel adjacency could be achieved in all cases.

Step 8- For all impacted CBSDs that have requested the grant for the new PAL channel, the Managing SAS determines all CBSDs that are using the secondary PAL channel as a GAA grant and are either located inside the coverage area or their coverage areas overlap with the coverage area of those impacted CBSD. This enables every SAS to protect the new PAL operation without the need to perform IAP in a coordinated way with other SASs. The DL coverage of reassigned PAL CBSDs and GAA CBSDs are determined based on a default value of -96 dBm/10MHz signal strength close to the border of the coverage area but could be configured by the Managing SAS. The area threshold to determine such overlapping GAA CBSDs could be either a predetermined, fixed, and a common value among all SASs. Alternatively, the SAS could determine the threshold according to the number of GAA CBSDs impacting the new PAL coverage. In this case, the threshold is not unique and coordinated among SASs. The area that will be protected by this mechanism is termed Temporary PAL Protection Area (T_PPA) and the mechanism is called Temporary PAL Protection Method (T_PPM).

Note: Alternatively, the managing SAS could choose not to provide the list of CBSDs. Rather, in step 9, it will provide the collective coverage of those impacted CBSDs (the union of all CBSD coverages).

Step 9- If any GAA CBSD is located inside the coverage area of any impacted PAL CBSD, the GAA might be either suspended, or moved to a different GAA channel. Other GAA CBSDs having coverage overlap with the impacted PAL CBSDs, could be treated in any of following three approaches:

- They are suspended
- they are moved to new GAA channels
- their EIRPs are adjusted so that the coverage overlap falls below the threshold defined in Step 8

Alternatively, a SAS could decide to apply aggregate interference protection to the new PAL Area (T_PPA) to protect against all GAA CBSDs managed by the same SAS. The default protection threshold is -80 dBm/10 MHz, but could be adjusted by the Managing SAS.

8.3.1 Time Budget for ACAS

As described in Section 8.3, If DPA activation occurs within the time window between T1 and T3 in Figure 8-1 (SAS calculations during CPAS process), SASs need to avoid relocation of PAL channels.

Beyond that, this Section provides the details of ACAS time budget:

Depending on the process to trigger ACAS, the time required for Steps 3 is considered to be less than or equal $t_{trigger}$ minutes.

Since Step 4 (determination of secondary PAL channels) and Step 5 (exchanging min-FAD) could be automated, they might happen fairly quickly.

Completion of Step 6 requires the exchange of Heartbeat request and response between the managing SAS and impacted PAL CBSDs, requiring at least one Heartbeat duration.

Step 7 requires reassigned PAL CBSDs to request a grant for their new PAL channels and send the first Heartbeat request message to successfully activate the new grants. Let's assume PAL CBSDs take $t_{request}$ to make the request and successfully complete the grant process. They need to send the first Heartbeat request message and receive a successful response from the SAS. The time budget $t_{request}$ includes the time required by CBSDs to complete Spectrum Inquiry process, if they choose to do so. Assuming the time required for one Heartbeat exchange is t_{HB}, Step 7 requires a time budget at least equivalent to $t_{request} + t_{HB}$.

In Step 8, all SASs identify the GAA grants operating inside the new PAL CBSD coverage areas. In addition, all SASs identify other GAA CBSDs whose coverage areas overlap with the PAL CBSD coverage areas. We assume the time required to perform Step 8 is t_{GAA}. Note that this step could be performed in parallel with Step 7.

Step 9 is performed by each SAS individually, however the time T8 represents the end of the time period for Step 9 used by each SAS Administrator. In this step, the GAA CBSDs identified in Step 8 are either terminated, moved to new GAA channel grants, or their EIRPs are reduced using the Heartbeat process. Time T8 is the time when the new PAL channels are expected to receive protection from other GAA users. The total time required to perform Step 9 is considered to be $t_{GAA\text{-}Move}$. This time includes at least one t_{HB} for each GAA CBSD grant.

Note that the move of GAA CBSDs is expected to happen after the PAL CBSDs have requested the new PAL grants. Therefore Step 9 needs to start after the completion of Step 7. However, Step 9 can be perfomed partially parallel along with Step 8.

Table 8-1 summarizes the time budget for each step. Note that each Heartbeat process takes five minutes that includes four minutes for the Heartbeat duration and one minute for the CBSDs to reassign the channels.

Table 8-1: Potential ACAS Time Budget Elements

Step	Function	Parallel with	Time Budget
3	ACAS Trigger	N/A	$t_{trigger}$
4	PAL Secondary Channel allocation	N/A	*Negligible*
5	Exchange of ACAS Exchange Messages	N/A	*Negligible*
6	Inform Impacted PAL CBSDs to move to secondary PAL channels	N/A	t_{HB}
7	Impacted PAL CBSDs request grant for secondary PAL channels	Step 8	$t_{request} + t_{HB}$
8	Impacted GAA CBSDs identified	Step 7	t_{GAA}
9	Impacted GAA CBSDs moved, terminated or power reduced	Partially with Step 8	$t_{GAA\text{-}Move}$

The total time required for complete ACAS process is:

$$Total\ Time\ till\ PAL\ Protection\ (T_8) \approx t_{trigger} + t_{HB} + Max\ (t_{request} + t_{HB}\ ,\ t_{GAA}\ ) + t_{GAA\text{-}Move}$$

The above time limits represent the limit required by SAS-CBSD protocol. However, the actual time budget requires additional processing time for SASs to determine GAA channels, ensure the Tier 1 incumbents and Tier 2 users in other counties are not interfered with, and CBSDs plan to request new grants. Therefore, the practical time budget might be longer than the time represented above.

8.3.2 ACAS SAS-SAS Exchange

ACAS Exchange Message is an array of objects that is exchanged by the managing SAS with all other SASs at the beginning of the ACAS process. Each object includes the following information:

- PPA ID impacted by DPA activation
- The channel used by the PPA prior to DPA activation.
- The secondary PAL channel determined in Step 4.

- The list of PAL CBSDs moved to the secondary PAL channel. For an explanation of such a list, please refer to Section 6.
    - Note: Alternatively, the managing SAS could choose to only provide the collective coverage of those impacted CBSDs (Union of all CBSD coverages), rather than the list of impacted CBSDs

Table 8-2 depicts the contents of ACAS Exchange Message.

Table 8-2: Proposed ACAS Exchange Message Content

Field	Data Type	Field Definition
id	String	ACAS instance Identifier
SasId	String	· **Format**: sas_admin/$ADMINISTRATOR_ID · **$ADMINISTRATOR_ID**: a unique SAS administrator identifier
name	String	Human-readable local significant string. The name of the SAS Administrator.
palId	array of string	List of one or more PAL Database record IDs upon which the PPA is based.
ppaRegionType	String	This field describes the region type of the PPA to be used in calculating the path loss for PPA protection. The field needs to be set to one of the following values: · "URBAN" · "SUBURBAN" · "RURAL"

primaryPalChannel	object: FrequencyRange	This parameter defines the 10 MHz used by the PPA prior to DPA activation
secondaryPalChannel	object: FrequencyRange	This parameter defines the 10 MHz secondary PAL channel for impacted CBSDs.
cbsdReferenceId	array of string	List of one or more CBSD Reference IDs that are impacted by DPA activation and are moved to *secondaryPalChannel*.
newPPAzone	object: GeoJSON	geometry description of the coverage area of CBSDs impacted by DPA activation and are moving to *secondaryPalChannel*.

8.3.3 ACAS Triggering

The ACAS process could be used by a SAS for two purposes:

1. To trigger a coordinated process to reassign some or all CBSDs belonging to a PPA from an activated PAL channel to a secondary PAL channel.
2. To trigger a coordinated process to return the reassigned PAL CBSDs belonging to a PPA from the secondary PAL channel to their Primary PAL channel or receive aggregate interference protection.

A flag *activationTrigger* is included in ACAS information to distinguish the purpose of the ACAS trigger. If the flag is TRUE, the ACAS is used for triggering the DPA activation, and if the flag is FALSE, the ACAS is used to trigger the return of the PAL CBSDs to their original PAL Primary channel or receive aggregate interference protection.

If a SAS detects activation of a DPA that impacts some or all of the CBSDs included in the cluster list of a PPA, the SAS could trigger the ACAS process by informing other SASs that CBSD grants using that PAL channel are being reassigned.

In order to inform other SASs about the activated DPA, the message used for ACAS triggering by a managing SAS includes the following information, tabulated in Table 8-3.

- *activationTrigger* Flag to distinguish DPA activation versus deactivation
- Information regarding activated DPA (s)
- Activated channels
- Activated channels at PAL customers are impacted
- PPA ID (s) impacted by DPA activation

Table 8-3: Proposed ACAS Triggering Content

Field	Data Type	Field Definition
id	String	· **Format**: sas_admin/$ADMINISTRATOR_ID · **$ADMINISTRATOR_ID**: a unique SAS administrator identifier
name	String	Human-readable local significant string. The name of the SAS Administrator.
activationTrigger	boolean	A flag to indicate the purpose of the ACAS process. If TRUE, it indicates the DPA activation. If FALSE, it indicates the DPA deactivation.
DPAId	array of string	List of one or more DPA identifiers that are activated or deactivated. The IDs are obtained from NTIA KML files listed in the NTIA site.
ImpactedChannels	object: array of *FrequencyRange*	This parameter defines the activated 10 MHz channel(s) on which DPA is (are) activated, and PAL customers are impacted.

ppaID	array of string	List of one or PPA Identifiers, equivalent to the parameter “id” in the object ZoneData defined in Table 10 Section 7.4 in [5].

The approaches described in Sections 8.3.3.1 to 8.3.3.6 could be used to trigger ACAS.

8.3.3.1 Criteria for ACAS Triggering

Regardless of the approach taken to trigger the ACAS process, and to non-necessary ACAS triggering, the SASs could only trigger the ACAS if meets the following conditions:

1. DPA activation(s) is (are) detected by the ESC supporting the SAS operation or is informed by the P-DPA portal.
2. The SAS has PAL CBSDs operating in the neighborhood of activated DPA or DPAs
3. Some or all of the CBSDs/grants using the same activated DPA channel as a PAL grant, and are impacted (are within the DPA move list created for the DPA at the PAL channel)
4. The PAL Holder (licensee or lessee) has not opted out of the PAL channel reassignment process.

In other words, even if the SAS has PAL Holders in the neighborhood of the activated DPA(s), it cannot initiate the ACAS process, unless some or all of the CBSDs using impacted PAL channel(s) are in the move list(s) of activated DPA(s), and the PAL customers have not opted out of the process.

However, to avoid simultaneous multiple triggering of ACAS, a fifth condition might be added as follows:

5. No other SAS administrator has triggered any ACAS process, involving the same activated DPA(s) within the past 30 seconds.

The objective of PAL channel reassignment is to make sure PAL owners can be protected during DPA activation, and then under the above five conditions, the managing SAS triggers the ACAS process when a DPA is activated. However, if the radio frontend of an ESC sensor is overloaded, or for any other reason, all ESCs covering all ten PAL channels are not operational, DPAs for all ten channels get activated. In this case, no PAL channel reassignment procedure can ensure PAL operation continuity.

Another scenario at which PAL operation continuity is not feasible is when there is no CUP channel available for PAL channel reassignments. For example, when all ten channels within 3550-3650 MHz are either used as PAL channels as a result of the previous PAL channel reassignment process or have active DPAs. Therefore, under the following conditions, ACAS could not be triggered by the managing SAS:

- All ten channels are occupied.
- When no CUPs are available for PAL channels to reassign

8.3.3.2 Approach 1: Push-based trigger

In this approach each SAS will expose a webhook or API endpoint for triggering ACAS. When the managing SAS detects a DPA activation, it will trigger the API endpoint exposed by all peer SASs, if they have an API endpoint implemented.

Pros:

- The trigger is invoked as soon as the DPA is activated, potentially allowing fast protection for reassigned PAL channels.

Cons:

- Multiple triggers from different peer SASs for the same DPA activation could arrive at different times. The question is how long can SAS have to wait before triggering another ACAS?

Questions:

- If the managing SAS sends DPA activation triggers at different times for the same DPA event due to their implementation limitations what happens? Do we trigger ACAS each time?
- A SAS could have difficulty running actual “on-demand” ACAS. For example, a new PAL reassignment notification could be received during an ACAS.

8.3.3.3 Approach 2: Centralized SAS push trigger

This is an extension of Approach 1. In this approach, only one SAS will act as the centralized SAS and will detect the DPA activation. Each peer SAS will expose a webhook or API endpoint for triggering ACAS. When the centralized SAS detects a DPA activation it will trigger the API endpoint for all other peer SASs, if they have an API endpoint implemented.

Pros:

- No timing issue for the same DPA activation event.

Cons:

- One SAS is responsible for detecting DPA activation. This could be an issue not only for other SASs but also for the centralized SAS (as their DPA notification implementation will be known and others are not). To prevent it, we could switch which SAS acts as a centralized SAS every month or based on some other criteria.
- The reliability of this approach depends on how the centralized SAS detects DPA activation. In other words, there is a possibility that the centralized SAS does not detect a DPA activation, and therefore does not trigger ACAS, but another SAS detects the DPA activation and is required to perform PAL channel reassignment.

8.3.3.4 Approach 3: Scheduled polling trigger

In this approach, each SAS will poll their peer SASs for a DPA activation event at a fixed interval (e.g., every 30 minutes or one hour). The SAS will trigger an ACAS depending on how we define the DPA activation trigger condition. Once a PAL CBSD is notified of a channel reassignment, an ACAS will be executed by all SASs at a predefined time.

Pros:

- The possibility of multiple ACAS/CPAS for the same DPA activation event is reduced.
- Pull based method is consistent with current SAS-SAS communication.

Cons:

- Frequent polling from multiple SASs is needed,
- There is a delay in the trigger being invoked after a DPA activation. In other words, protection time of the reassigned PAL channel depends on the polling frequency.

8.3.3.5 Approach 4: External Database of Reassignment Notification

Once the managing SAS detects DPA activation and needs to trigger the ACAS, it posts the PAL channel reassignment information to an external database. All SASs read from the external database regularly.

Pros:

- The possibility of multiple ACAS/CPAS for the same DPA activation event is reduced.

- A SAS doesn't have to pull the PAL channel reassignment information from all SASs immediately. A SAS only needs to read the external database periodically.

Cons:

- Frequent polling of the external database is needed.
- There is a delay in the trigger being invoked after a DPA activation. In other words, protection time of the reassigned PAL channel depends on the polling frequency.
- There need to be an external entity that hosts and maintains the database securely and reliably.
- A read/write interface with a new database is required.

8.3.3.6 Possible Solution

One acceptable solution is to combine approaches 2 and 4. In other words a centralized SAS plays the role of the external database of the reassignment notifications and all other SASs poll that particular SAS regularly. The polling frequency determines how quickly SASs can re-assign and protect the new PAL channels. The SAS Administrators need to define a process for selecting the centralized SAS . One simple solution is to use a round robin selection of the centralized SAS Administrator in an area with a predetermined time period.

8.3.4 Resolving ACAS triggering Conflicts

For ESC-monitored DPAs, the activation time of the DPA depends on when the maximum energy level at the sensor's radio front-end exceeds -89 dBm/MHz. Depending on the sensors' radio design within different ESC vendors, the timing of DPA activation might be different among multiple SASs. Therefore, it is important to avoid race conditions when multiple PPAs belonging to different SASs are impacted by activated DPAs.

To that end, it is critical to prevent repetitive triggering of ACAS by multiple SAS administrators. Referring to Figure 8-2, If a SAS admin receives the notification to start ACAS process at time T2 (the time at which the managing SAS triggers ACAS), and receives DPA activation for the same DPA, there is no need for the receiving SAS to initiate a new ACAS process, as long as it receives the notification before time T5 (the time at which impacted PAL CBSDs start moving to new PAL channels). However, it is required for the receiving SAS to exchange its own ACAS Exchange Messagewith other SASs.

8.4 Return to Primary PAL Channel

When DPA deactivates, the managing SAS can provide an indication to other SASs to restore the protection of PAL operation in the original channels. The impacted GAA CBSD grants on the

reassigned channels can also be restored (i.e., unsuspended or returned to original EIRP). Except if DPA deactivation occurs at CPAS time, this would require a second ACAS process in the middle of the day to protect PAL operations in the original channels. This ACAS process would ideally require a coordinated IAP to restore PAL protection. The complexity of performing IAP in the middle of the day would create added computation and delay in SAS operation.

To address the above concerns, we have considered two approaches. In one approach, PAL continues to operate in the temporary channels after DPA deactivation until the next scheduled CPAS. The original PAL operation is restored at CPAS, similar to when PAL protection is coordinated via IAP in case of a new PPA. In the second approach, PAL returns to the original channels at DPA deactivation. SASs trigger the second ACAS process but hold off doing the coordinated IAP until CPAS. During this period PAL is protected on the original channels independently by each SAS.

The following subsections describe two options requested by PAL Service providers, depicted in Figure 8-3 through Figure 8-6. In these figures, X indicates the original PAL channel used by the operator before DPA activation, and Y indicates the secondary PAL channel as a result of DPA activation. Moreover, A is the whole PPA using channel X before DPA activation, A1 is the area defined by the set of CBSDs who stayed on the original PAL channel X, and A2 is the area defined by the set of CBSDs whose PAL channel is reassigned to Channel Y. In these figures, T_PPM refers to the protection criteria described by Steps 8 and 9 in Section 8.3 and Section 9, and P_PPM (Permanent PAL Protection Method) refers to the aggregate interference PPA protection performed in coordinated IAP by all SAS Administrators during the CPAS process [1, 2]. Note that the T_PPM could include the alternative solution, when a SAS applies aggregate interference protection to the new PAL Area (T_PPA) to protect against all GAA CBSDs managed by the same SAS.

It is noted that the *ppaID* parameter in ACAS triggering information (Table 8-3) indicates the PPA, the *cbsdReferenceId* parameter included in the ACAS Exchange Message (Table 8-2) indicate the set A2. The remaining CBSDs in the PPA cluster list indicate the set A1.

8.4.1 Return at the Next CPAS

Some PAL Holders could request their managing SAS to allow CBSDs with reassigned PAL channels to continue operating on the reassigned channel Y beyond DPA deactivation and return to the original PAL channel (X) at the next CPAS process. In this option, SAS Administrators are not required to perform ACAS at the time of DPA deactivation.

Figure 8-3 and Figure 8-4 depict the first option for returning to primary PAL channel, wherein Figure 8-3 describes the process when DPA activation time does not cross a CPAS process, but Figure 8-4 assumes DPA activation continues throughout at least one CPAS process.

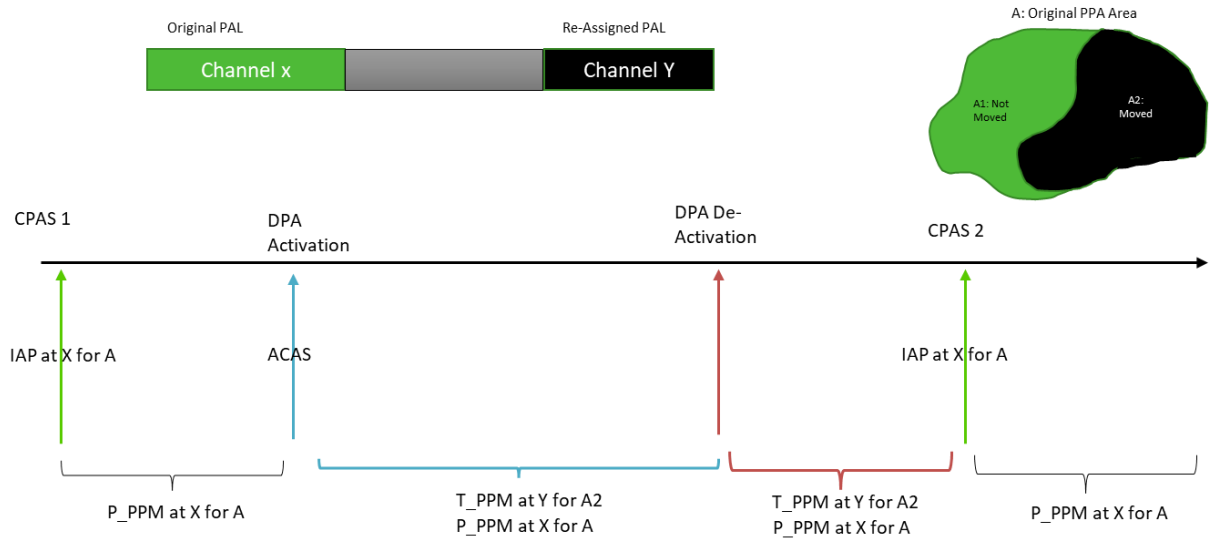


Figure 8-3: Option 1, Return to Primary PAL with no CPAS during DPA Active period.

Since there is no opportunity for the SAS Administrators to coordinate to update the PPA protection, it is assumed that after the ACAS performed at the time of DPA activation, aggregate interference protection (P_PPM) continues to be applied to the whole PPA area A at the original PAL channel X. However, the CBSDs moved to the newly reassigned PAL channel Y are protected using T_PPM.

If the DPA deactivation occurs before the next CPAS (See Figure 8-3), the protection methods as described in the previous paragraph for both A and A2 are continued even beyond DPA deactivation, until the next CPAS. The reassigned CBSDs are not returned to their original PAL primary channel X until the next CPAS process. The coordinated IAP performed at the next CPAS restores the whole PPA protection at the original primary PAL channel X.

Figure 8-4 describes the scenario, wherein there is at least one CPAS process between the times at which DPA activation and DPA deactivation occur. Similar to Figure 8-3, before the first CPAS after DPA activation, aggregate interference protection (P_PPM) continues to be applied to the whole PPA area A at the original PAL channel X, and the CBSDs moved to the newly reassigned PAL channel Y are protected using T_PPM.

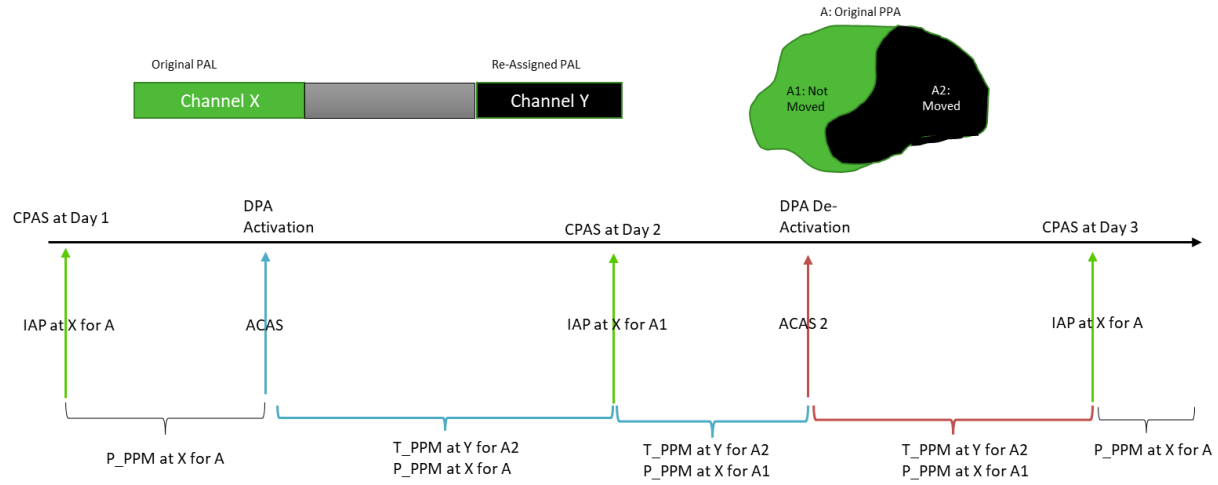


Figure 8-4: Option 1, Return to Primary PAL with CPAS during DPA Active period.

At every CPAS process between the times of DPA activation and DPA deactivation, SAS Administrators perform IAP to apply aggregate interference protection to the remaining non-moved CBSDs (A1) at channel X. Beyond this time, P_PPM is applied to A1 at channel X. Moreover, T_PPM is continued to be applied at the reassigned channel Y for all moved CBSDs (A2).

At the time of DPA deactivation, the protection methods described in the previous paragraph (i.e., T_PPM at channel Y for A2, and P_PPM at channel X for A1) are continued until the next CPAS. Therefore, SAS Administrators are not required to perform the ACAS process at the time of DPA deactivation. The reassigned CBSDs (A2) are not returned to their original PAL primary channel X until the next CPAS process. The coordinated IAP performed at the next CPAS revives the whole PPA protection at the original primary PAL channel X.

8.4.2 Return at DPA Deactivation

Some PAL Holders could request their managing SAS to return their CBSDs to the original PAL channel soon after DPA deactivation, without waiting for CPAS. To achieve this goal, SAS Administrators are required to perform ACAS at the time of DPA deactivation. As described in Section 8.3, the value of *activationTrigger* provided during the ACAS process is set to FALSE in this case.

Figure 8-5 and Figure 8-6 depict the second option for returning to primary PAL channel, wherein Figure 8-5 describes the process when DPA activation time does not cross a CPAS process, but Figure 8-6 assumes DPA activation continues throughout at least one CPAS process.

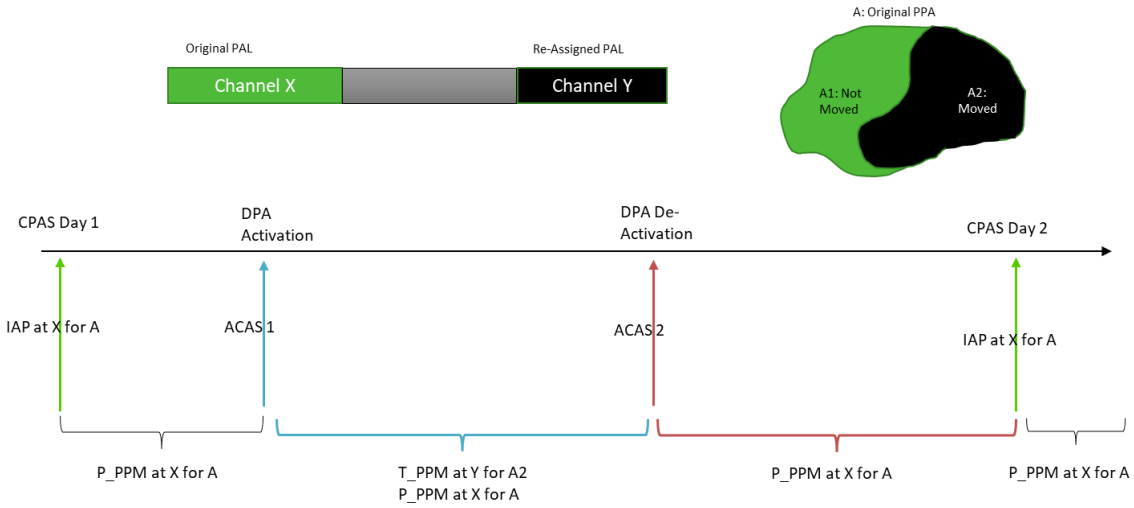


Figure 8-5: Option 2, Return to Primary PAL with no CPAS during DPA Active Period.

Since there is no opportunity for the SAS Administrators to coordinate to update the PPA protection, it is assumed that after the ACAS performed at the time of DPA activation, aggregate interference protection (P_PPM) continues to be applied to the whole PPA area A at the original PAL channel X. However, the CBSDs moved to the newly reassigned PAL channel Y are protected using T_PPM. If the DPA deactivation occurs before the next CPAS time, an ACAS is performed at the time of DPA deactivation (See Figure 8-5: ACAS2). Right after completion of ACAS2, SAS Administrators request all CBSDs to return to the original primary PAL channel, and use the result of previous CPAS to perform P_PPM to protect the whole area A at the original channel X. It can be noted that any new CBSD within the activated DPA neighborhood will not be able to get transmit authorization on the original PAL channel as any new grant request during DPA activation is suspended. In the less likely case, some CBSDs outside the DPA neighborhood can get a channel grant on the original PAL channel during the DPA activation period. However, upon the return of CBSDs to the original PAL channels the newly granted GAA channel on the original PAL channel could be suspended or assigned a lower EIRP to protect the original PAL channel. The coordinated IAP performed at the next CPAS revives the whole PPA protection at the original primary PAL channel X.

Figure 8-6 describes the scenario, wherein there is at least one CPAS process between the times at which DPA activation and DPA deactivation occur. Similar to Figure 8-5, before the first CPAS after DPA activation, aggregate interference protection (P_PPM) continues to be applied to the whole PPA area A at the original PAL channel X, and the CBSDs moved to the newly reassigned PAL channel Y are protected using T_PPM.

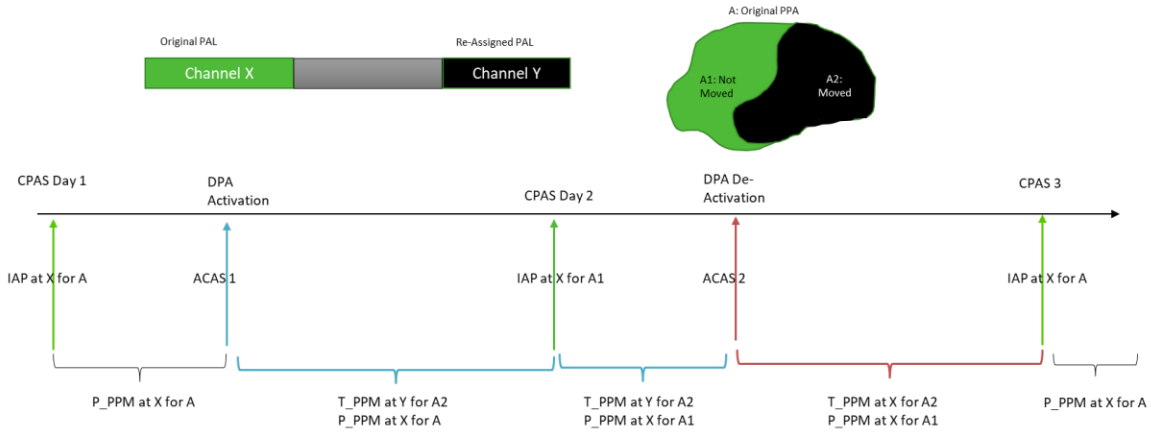


Figure 8-6: Option 2, Return to Primary PAL with CPAS during DPA Activation.

At every CPAS process between the times of DPA activation and DPA deactivation, SAS Administrators perform IAP to apply aggregate interference protection to the remaining non-moved CBSDs (A1) at channel X. Beyond this time, P_PPM is applied to A1 at channel X. Moreover, T_PPM is continued to be applied at the reassigned channel Y for all moved CBSDs (A2).

At the time of DPA deactivation, SAS admins perform an ACAS process to return all CBSDs to the primary PAL channel X right after the DPA deactivation, without waiting for the next CPAS (See Figure 8-6: ACAS2). Since SAS Administrators had not had any chance to coordinate to perform the IAP process for the reassigned CBSDs, the reassigned CBSDs are protected using T_PPM at the original PAL primary channel X. The non-moved CBSDs (A1) continue receiving aggregate interference protection (P_PPM) at channel X. Moreover, since the DPA is activated at the original PAL Primary, any new upcoming GAA grant during DPA activation is either rejected or goes into the DPA move list directly (and therefore suspended). The coordinated IAP performed at the next CPAS revives the whole PPA protection at the original primary PAL channel X.

8.4.3 Comparison of Return Options

Table 8-4 and Table 8-5 summarize the difference between the two options, with and without CPAS between DPA activation and deactivation, respectively.

Table 8-4: Summary of differences with no CPAS between DPA activation and deactivation

Items	Option 1	Option 2
ACAS at Deactivation	No	Yes
Return to original PAL Channel X	CPAS after DPA de-activation.	At the time of DPA de-activation.

Whole PPA area protection/channel after DPA activation. (Area A)	P_PPM using CPAS1 IAP X	P_PPM using CPAS1 IAP X
Whole PPA area protection/channel after DPA de-activation (Area A)	P_PPM using CPAS1 IAP X	P_PPM using CPAS1 IAP X
Non-Moved PAL CBSD protection/channel after DPA activation. (Area A1)	No additional Protection beyond P_PPM at X for Area A	No additional Protection beyond P_PPM at X for Area A
Non-Moved PAL CBSD protection/channel after DPA de-activation (A1)	No additional Protection beyond P_PPM at X for Area A	No additional Protection beyond P_PPM at X for Area A
Moved PAL CBSD protection/channel after DPA activation. (Area A2)	T_PPM at Channel Y	T_PPM at Channel Y
Moved PAL CBSD protection/channel after de-activation (Area A2)	T_PPM at Channel Y	No additional Protection beyond P_PPM at X for Area A

Table 8-5: Summary of differences with CPAS between DPA activation and deactivation

Items	Option 1	Option 2
ACAS at Deactivation	No	Yes
Return to original PAL Channel X	CPAS after DPA de-activation.	At the time of DPA de-activation.
Whole PPA area protection/channel after DPA activation. Before CPAS (Area A)	P_PPM using CPAS1 IAP X	P_PPM using CPAS1 IAP X
Whole PPA area protection/channel after CPAS (Area A)	Protection split between T_PPM at A2 and P_PPM at A1	Protection split between T_PPM at A2 and P_PPM at A1
Whole PPA area protection/channel after DPA de-activation (Area A)	Protection split between T_PPM at A2 and P_PPM at A1	Protection split between T_PPM at A2 and P_PPM at A1

Non-Moved PAL CBSD protection/channel after DPA activation. Before CPAS (Area A1)	No additional Protection beyond P_PPM at X for Area A	No additional Protection beyond P_PPM at X for Area A
Non-Moved PAL CBSD protection/channel after CPAS (A1)	P_PPM using CPAS2 IAP X	P_PPM using CPAS2 IAP X
Non-Moved PAL CBSD protection/channel after DPA de-activation (A1)	P_PPM using CPAS2 IAP X	P_PPM using CPAS2 IAP X
Moved PAL CBSD protection/channel after DPA activation. Before CPAS (Area A2)	T_PPM at Channel Y	T_PPM at Channel Y
Moved PAL CBSD protection/channel after CPAS (Area A2)	T_PPM at Channel Y	T_PPM at Channel Y
Moved PAL CBSD protection/channel after de-activation (Area A2)	T_PPM at Channel Y	T_PPM at Channel X
Operation at CPAS	IAP for A1 at X	IAP for A1 at X

9 Reassigned PAL Protection Methodology

This section describes how a PAL Holder is protected in channels reassigned in the lower 100 MHz during DPA activation.

- At CPAS, the SAS managing a PAL Holder's CBSDs (Managing SAS) shares a list of the PAL Holder's CBSDs on the move list for each DPA with other SASs (Receiving SAS). The managing SAS could also compute and share the PPA of the PAL Holder's CBSDs on the move list for each DPA.
- When a DPA activates, Managing SAS indicates to Receiving SASs in an ACAS the PAL CBSDs (or the corresponding PPAs) that are affected and their new channel assignment.
- The new EIRP for the reassigned CBSDs is based on the existing CBSD grant on the old channel, except it is reduced when the new channel assignment impacts a Tier-1 user or a Tier-2 (PAL) user in an adjoining county.
- All Receiving SASs protect PAL in one of two ways:
    - If the Managing SAS shared the list of PAL CBSDs affected
        - The receiving SAS computes the coverage contour of the PAL CBSDs using -96 dBm/10MHz DL signal strength at the border of coverage area, and its GAA CBSDs located in the neighborhood of the PAL CBSDs using the channels to be reassigned. The signal strength could be configured by the managing SAS.
        - The receiving SAS determines the coverage overlap of each PAL CBSD with its GAA CBSDs. The coverage overlap is compared to a threshold.
        - If the overlap is less than a threshold, then the GAA CBSD spectrum grant is unaffected. Otherwise, the grant is suspended or the EIRP is reduced to make the overlap smaller than the threshold.
        - The threshold could depend on the number of GAA CBSDs overlapping PAL CBSD coverage contour.
    - If Managing SAS shared PPAs affected
        - Receiving SAS performs IAP to protect the PPA from its GAA CBSDs on the reassigned channels.
- When DPA deactivates, the process defined in Section 8.4 is used.

10 Policy and Certification Impact

The following FCC rules are relevant to PAL channel reassignment:

§ 96.3 Definitions.

…

Priority Access License (PAL). A license to operate on a Priority Access basis, consistent with subpart C of this part.

Priority access licensee. A holder of one or more PALs. Priority Access Licensees shall be entitled to protection from General Authorized Access Users and other Priority Access Licensees within the defined temporal, geographic, and frequency limits of their PAL, consistent with the rules set forth in this part.

…

§ 96.11 Frequencies.

(a) The Citizens Broadband Radio Service is authorized in the 3550-3700 MHz frequency band.

(1) General Authorized Access Users may operate in the 3550-3700 MHz frequency band.

(2) Priority Access Users may operate in the 3550-3650 MHz frequency band.

…

47 CFR 96.25(b) PALs have the following parameters:

(1) ***Geography:*** Each PAL consists of a single License Area.

(i) ***Contiguous geographic areas:*** An SAS must assign geographically contiguous PALs held by the same Priority Access Licensee to the same channels in each geographic area, to the extent feasible. The SAS may temporarily reassign individual PALs held by the same Priority Access Licensee to different channels, so that geographical contiguity is temporarily not maintained, to the extent necessary to protect Incumbent Users or if necessary to perform its required functions under subpart F of this part.

(2) ***Channels:*** Each PAL consists of a 10 megahertz channel within the frequency range set forth in § 96.11. Channels must be assigned by the SAS. Priority Access Licensees may request a particular channel or frequency range from the SAS but will not be guaranteed a particular assignment.

(i) ***Contiguous channels:*** An SAS must assign multiple channels held by the same Priority Access Licensee to contiguous channels in the same License Area, to the extent feasible. The SAS may temporarily reassign individual PALs to non-contiguous channels to the extent necessary to protect Incumbent Users or if necessary to perform its required functions under subpart F of this part.

47 CFR 96.59(b): Consistent with the requirements of § 96.25, an SAS shall assign geographically contiguous PALs held by the same Priority Access Licensee to the same channels in each geographic area, where feasible. The SAS shall also assign multiple channels held by the same Priority Access Licensee to contiguous frequencies within the same License Area, where feasible.

47 CFR 96.59(c): An SAS may temporarily assign PALs to different channels (within the frequency range authorized for Priority Access use) to protect Incumbent Access Users or if necessary to perform its required functions.

10.1 Policy Impact

Generally speaking, the FCC rules envision temporary reassignment of PAL channels due to incumbent events. Even if displaced due to incumbent activity, PALs cannot operate in the 3650-3700 MHz range with PAL protection. They can operate in that range as GAA while reassigned, but do not receive any special consideration over any other GAA.

The concept of partial license area reassignment, in which a licensee's CBSDs in one part of a license area are reassigned to different PAL channels due to incumbent activity while other CBSDs belonging to the same licensee remain on their regular PAL channel, is not explicitly envisioned by the FCC's rules. Whether this situation conforms with the rules is to be determined.

10.2 Impact on SAS Certification

PAL channel reassignment was not tested in the SAS certification process under WInnForum Release 1 standards. To the extent that any modification to Release 1 standards to accommodate PAL channel reassignment, or to make it mandatory for SASs, need not to create a significant burden on SASs, such as re-certification through the NTIA/ITS laboratory process. It also need to not impact the certification process for Wave 2 SAS Administrators.

11 GAA Considerations

11.1 Potential Impact to GAA CBSDs

When DPA activates and multiple channels are impacted by the incumbent activity, any user with deployments in the DPA protection neighborhood, using those channels, could be equally impacted even if it operates as PAL or GAA. The impacted users will have to vacate the channels used by incumbents and find new available channels to operate in.

In addition, when the impacted PAL grants are reassigned to new channels and the T_PPAs are activated for the PAL protection, GAA grants in those channels could be further impacted. From the GAA CBSD user perspective, the impact is the same regardless of direct impact by the incumbent activity or by the PAL relocation.

The main difference between a “normal” PPA activation and a DPA activation followed by PAL relocation and T_PPA activation is the transitory nature of DPA/T_PPA activation and the need to revert to the original “steady” state once the DPA is deactivated. A framework is introduced to help CBSDs handle channel relocation, including reverting back to the original state.

For deployments done inside the DPA protection neighborhoods, the GAA CBSDs can avoid the impact caused by DPA activations and PAL relocation by using grants in the upper 50 MHz of the CBRS band, from 3650 MHz to 3700 MHz, but the upper portion of the band can become crowded which can lead to higher level of interference. A GAA coexistence approach would be a useful tool for managing interference, and CBSD users are encouraged to work with their SAS administrators to determine potential GAA coexistence solutions.

11.2 Common PAL and GAA Framework to Handle Channel Relocation

The overall framework for this channel relocation is the same for GAA and PAL. The CBSD grants that are in the move list will be suspended by the SAS, not terminated. When the grants are suspended, the SAS might provide a recommendation of the channel where CBSD could attempt to request a new grant.

There are three main approaches how the CBSD can handle the grant suspension due to incumbent activity:

1. The CBSD receives a recommendation from SAS, in the HB response message that suspends the original grant, of an available channel and then proceeds immediately to request a grant in the recommended channel.

2. The CBSD receives the HB message that suspends the original grant, then the CBSD triggers a Spectrum Inquiry where all the available channels are reported, including the PAL reassigned channels that are marked as PAL channels; then the CBSD selects which channels are the most appropriate for its use and proceeds to trigger grant requests in those channels.

3. The CBSD receives the HB message that suspends the original grant, then it decides to wait until the incumbent will finish its activity and the original grant will be restored. The CBSD will continue to heartbeat the suspended grant until the grant will become authorized again and at which point it will resume its operation in that channel.

Since the SAS has limited knowledge of the business case that the CBSD user is trying to fulfill, flexibility is needed for the CBSD to be able to choose which channel to move to when the suspension happens. The trivial example is if the CBSD is using a 20 MHz cell that is mapped to two 10 MHz grants, the CBSD needs to find two other 10 MHz adjacent channels before it can resume operation.

The three main approaches above can also be used in combination, for example if the CBSD attempts to find another grant to move to but it fails to find such a suitable grant, it will decide to wait until the original grant is no longer suspended before resuming operation.

Regardless of the chosen approach, the CBSDs are encouraged to continue to heartbeat the suspended grants in order to know when the original channels become available again and they can resume operation in their original channel.

As previously mentioned, the approaches described above can be equally applied to PAL or GAA grants, including the GAA grants that would be impacted due to PAL channel relocation. The upper 50 MHz of the band can only be used for GAA operation and those grants will also soon benefit from extended transmission expiry times, as such they will become a prime target for relocation of the GAA grants.

Once the incumbent event is concluded, the GAA CBSD Users will have the option to resume activity on their original channel or to stay on the channel obtained after the incumbent activity started; each CBSD User will have to evaluate which option works best for them.

Although the upper 50 MHz channels are not impacted by the DPA activations and it is tempting for GAA CBSD Users to stay in those channels, the upper channels could become crowded, and they will potentially experience higher interference from deployments of other CBSD users operating in the same area.

12 WInnForum Documents Impacted

The documents impacted to support the PAL Channel Reassignment are listed below:

Table 12-1: Impacted WInnForum Documents

Document	Impacts	Responsible WinnF Working Group
WINNF-TS-0112 - CBRS Operational and Functional Requirements [1] WINNF-TS-1020 Post Initial Certification Revisions to WINNF-TS-0112-V1.9.1 [9]	Update requirements to enable co-operation between SAS Administrators in the new Poat Initial Certification document [9] Update requirements to enable co-operation between SAS Administrators to avoid conflicts and protect the reassigned PAL channels	WG1
WINNF-SSC-008 - WInnForum Coordinated Periodic Activities Among SASs [2]	Updates to policy document for PAL channel coordination for reassignment and protection	WG1 CBRS SSC-Steering Committee
● WINNF-SSC-3 - SSC Traceability Matrix, [3] ● WINNF-TS-3002 - Extensions to SAS-CBSD Interface Technical Specification (Release 2), [4] ● WINNF-TS-3003 - Extensions to SAS-SAS Interface Technical Specification (Release 2) [5]	New Optional certification	WG3 CBRS SSC-Steering Committee
● WINNF-TS-1001 - CBRS Release 2 Operational and Functional Requirements, [6] ● WINNF-SSC-10 - WInnForum Recognized Grouping Information [7]	Potential Grouping information changes for Partial PPA/Clusters	WG1 CBRS SSC-Steering Committee

WINNF-TS-0016 - SAS to CBSD Technical Specification [8]	Apply the tests int the Post Initial Certification Test Document [10] Add *channelType* parameter to *OperationParam* object indicating PAL channel reassignment	WG3
WINNF-TS-4010 Post Initial Certification Revisions to WINNF-TS-0061-V1.5.1 [10]	Design required Test Program, if Needed	WG4

13 Open Areas

This section includes some open areas that require close attention. Examples of those areas are

- Resolution of channel reassignment order among SAS administrators at the time of DPA activation

14 Document Change History

Table 14-1: Change History

Document history		
V1.0.0	26 February 2024	Initial Release