November 17, 2016

VIA ELECTRONIC FILING

Marlene H. Dortch, Secretary
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

Re: *Ex Parte*
Response to Qualcomm September 6, 2016 *Ex Parte*
Revision of Part 15 of the Commission's Rules to Permit Unlicensed National Information Infrastructure Devices in the 5 GHz Band, ET Docket No. 13-49

Dear Ms. Dortch:

The Alliance of Automobile Manufacturers ("Alliance") and the Association of Global Automakers ("Global Automakers") hereby submit this letter in response to Qualcomm's September 6, 2016 *ex parte* filing[1] in the above-captioned Federal Communications Commission ("Commission" or "FCC") proceeding. Qualcomm's *ex parte* attempts to address several issues raised in the record regarding its re-channelization proposal. We applaud Qualcomm's engagement in this exchange of views. Such exchanges provide important information and promote our goal of building a consensus solution. With that goal in mind, we submit this filing and attached Appendix with corrections, clarifications, and expansions of the key points on which disagreements remain. We have found that, unfortunately, Qualcomm's responses in many cases misstate or misunderstand the nature of our concern, or simply make incorrect assertions that need to be formally corrected. We hope this letter is understood as attempting to progress our dialogue and move toward a consensus solution.

Over the course of this proceeding, the Alliance and Global Automakers have described the tremendous potential of Dedicated Short Range Communications ("DSRC") to improve safety on our nation's roadways and the need to ensure that operations on all DSRC channels are protected from harmful interference. We previously provided the Commission with a detailed list of questions about re-channelization,[2] which have remained unanswered for more than 3 years. More recently, the Alliance and Global Automakers, along with the Intelligent Transportation Society of America and Denso International America, provided detailed comments about our concerns with the re-channelization proposal.[3] In light of the concerns

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1 Letter from John Kuzin, Qualcomm, to Marlene H. Dortch, FCC, ET Docket No. 13-49 (filed Sept. 6, 2016) ("Qualcomm *Ex Parte*").

2 *See* Letter from Ari Q. Fitzgerald, Counsel, the Alliance of Automobile Manufacturers, *et al.*, to Marlene H. Dortch, Secretary, FCC, ET Docket No. 13-49 (filed Apr. 14, 2016).

3 *See* Comments of the Alliance of Automobile Manufacturers, Association of Global Automakers, Intelligent Transportation Society of America, and Denso International America, Inc., ET Docket No. 13-49 (filed July 7, 2016) ("Alliance *et al*. Comments").

identified in previous filings and in this letter and Appendix, the FCC should reject the re-channelization plan supported by Qualcomm, and instead move forward to test the feasibility of the detect-and-avoid ("DAA") approach.

I. ALL PARTIES AGREE THAT AN INTERFERENCE-FREE OPERATING ENVIRONMENT IS NEEDED FOR DEDICATED SHORT RANGE COMMUNICATIONS.

We are pleased to see that Qualcomm recognizes and emphasizes the importance of a sharing solution that demands an interference-free operating environment for DSRC. As noted by Qualcomm, "it is crucially important to protect latency-sensitive safety-of-life communications from harmful interference" and "it is essential that the introduction of unlicensed operations into the band not cause harmful interference to DSRC."[4] We fully agree with these statements and further clarify that re-channelization potentially introduces several new sources of interference and exacerbates others and that the impact of these sources on performance must be thoroughly tested and recognized. These include:

- Interference from other licensed users in the upper 30 MHz of the band;
- Interference with licensees in the band above 5.925 GHz;
- Co-channel DSRC interference resulting from higher volumes of safety communication traffic in a given channel;
- Co-channel DSRC interference resulting from a loss of priority differentiation within channels;
- Cross-channel DSRC interference due to potentially higher volumes of traffic on adjacent channels;
- Cross-channel DSRC interference due to potentially higher power transmissions on adjacent channels; and
- Cross-channel DSRC interference due to reduced spatial separation from interferers.

We note that all of the above sources of interference are separate from interference from "Unlicensed National Information Infrastructure" ("U-NII") sources themselves, and under re-channelization, are present even when there is no U-NII activity.

While Qualcomm states that "[r]echannelization ensures that Wi-Fi will not interfere with latency-sensitive, safety-of-life DSRC communications,"[5] this is purely conjecture at this point given that there is no objective test data available to validate this statement. We further note that Qualcomm does not claim to protect non-safety DSRC communication from harmful

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4 Qualcomm *Ex Parte* at 1, 2.

5 *Id*. at 2.

interference, though FCC regulations require Part 15 devices to provide such protection.

II. COMPLETE DEFINITIONS OF SHARING PROPOSALS ARE NEEDED FOR TESTING.

We strongly believe that complete definitions of all sharing proposals must be available in order for testing to proceed in a meaningful way. While Cisco has provided a more complete definition of the DAA approach,[6] significant gaps remain in the definition of re-channelization. For example, while Qualcomm states, "existing Quality of Service enhancement mechanisms in 802.11 standards … can prioritize DSRC over Wi-Fi,"[7] they provide no information about how non-Wi-Fi U-NII devices would prioritize DSRC. Sharing based on an assumption that DSRC devices detect U-NII devices (*i.e.* "mutual" detection, in Qualcomm's words) is counter to the Commission's goals in making unlicensed bands available in a technology-neutral way to promote innovation. Even in the Wi-Fi case there is a lack of recognition that Quality of Service performance varies widely depending on how 802.11e parameters are chosen. Qualcomm cannot expect the Commission or other parties to design their sharing proposal for them, and the time is long past since this design should have been made available.

III. MISINFORMATION AND UNSUPPORTED ASSERTIONS ARE COUNTERPRODUCTIVE TO MOVING TOWARDS A CONSENSUS SOLUTION.

While we welcome the dialogue for reaching a consensus solution for sharing, we are concerned about the misinformed or uninformed statements being made by Qualcomm that will inhibit such progress. As explained below, statements by Qualcomm such as "[t]oday, transmissions in DSRC Ch. 184 will block reception of a [basic safety message ("BSM")] message in Ch. 172 (as well as all other DSRC channels),"[8] are simply inaccurate as demonstrated by test data available in the public domain since 2007.

Other unsupported assertions and mischaracterizations made by Qualcomm include:

- "Under the DAA proposal, widely deployed DSRC roadside infrastructure and DSRC-equipped vehicles will prevent Wi-Fi from accessing in a meaningful manner the entire U-NII-4 band."[9]
    - Cisco, as a key Wi-Fi supplier and the originator of the U-NII-4 concept, clearly disagrees.[10]

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6 *See* Letter from Mary L. Brown, Cisco Systems to Marlene H. Dortch, FCC, ET Docket No. 13-49 at 4 (filed Dec. 23, 2015) ("Cisco Dec. 23, 2015 *Ex Parte*").

7 Qualcomm *Ex Parte* at 3.

8 *Id*.

9 *Id*.

10 *See, e.g.* Cisco Dec. 23, 2015 *Ex Parte*.

- DAA requires detection of DSRC "throughout the band."[11]
    - This statement is not accurate. Cisco's definition of DAA includes this statement: "U-NII-4 devices that operate in the 5850-5925 MHz ITS band shall be capable of detection of ITS transmissions in 10 MHz channels between 5855 MHz to 5905 MHz."[12]
- "20 MHz [DSRC] operations experience a minor performance loss."[13]
    - This statement fails to recognize that 20 MHz channels have only half the *reception* area as 10 MHz channels, due to a higher noise floor. 20 MHz channels similarly have half the *detection* area, which not only exacerbates the hidden terminal problem for DSRC, but also is contrary to Qualcomm's persistent claim that "802.11ac Wi-Fi devices … will more reliably detect … DSRC operations that use the same 20 MHz-wide channels."[14] The fact that this task may be easier for existing Wi-Fi chips is not the same as "reliable."
- [T]he [Medium Access Control ("MAC")] part of a DSRC packet" allows a receiver to "verify that the detected packet is indeed DSRC."[15]
    - There is no "DSRC bit" in the MAC header.

In order to have meaningful solution-based discussions, formal technical statements need to be based on objective and verifiable materials.

IV. SAFETY-OF-LIFE TESTING REQUIREMENTS NEED TO BE DEFINED BY QUALIFIED SOURCES.

Given that Qualcomm appears to be technically unsure of the current operational DSRC characteristics, it is difficult to understand how they can make claims that re-channelization won't require much testing. Qualcomm disputes our assertion that re-channelization will create a need for significant additional testing by the DSRC community. As Qualcomm states, "[a]s a DSRC chipset provider, Qualcomm has explained that re-channelization can be implemented via software changes."[16]

Simply making a software change is one thing but ensuring that the DSRC system works properly, especially in safety-of-life situations, is another. With due respect to the many areas in

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11 Qualcomm *Ex Parte* at 3.

12 Cisco Dec. 23, 2015 *Ex Parte* at 4.

13 Qualcomm *Ex Parte* at 4.

14 *Id*.

15 *Id*. at 5.

16 *Id*. at 2.

which Qualcomm possesses expertise, we do not consider testing of vehicle safety systems to be one of them. Qualcomm did not participate in any of the tests that formed the basis of the National Highway Traffic Safety Administration's 2014 decision to pursue a mandate for DSRC Vehicle-to-Vehicle safety. Qualcomm's statements oversimplify the need for testing and clearly demonstrate their lack of understanding of the capabilities required in a safety-of-life environment.

V. DETECTION OF DSRC TRANSMISSIONS APPLIES TO BOTH RE-CHANNELIZATION AND DAA.

We note that Qualcomm seems concerned with DAA's ability to detect DSRC, stating "DAA … would require extensive testing to ensure successful detection of any DSRC operations."[17] But, as Qualcomm's other statements make clear, re-channelization also requires DSRC detection. For example, as noted above, Qualcomm states that under re-channelization "802.11ac Wi-Fi devices … will more reliably detect … DSRC operations."[18] Therefore, this concern applies equally to both the re-channelization and DAA proposals.

VI. WE URGE THE FCC TO EXPEDITIOUSLY EVALUATE SHARING PROPOSALS FOR THE 5.9 GHZ SAFETY SPECTRUM BAND.

In summary, DSRC is ready today and each day of delay means more unnecessary loss of life. The Alliance and Global Automakers respectfully request that the Commission take this letter, and its critiques of Qualcomm's September 6, 2016 *ex parte* filing, into consideration when evaluating the DAA approach against the re-channelization approach and its ability to share the spectrum with DSRC without harmful interference. While spectrum-sharing options should be investigated and better understood, consideration should also be given to the more pragmatic elements of a sharing solution. A re-channelization solution will both significantly delay deployment and severely constrain the safety-of-life capability of DSRC technology. A DAA solution, which still needs to be tested, supports both immediate deployments of safety technology solutions and the full breadth of lifesaving capability the 5.9 GHz band was always intended to offer. We further assert, and the FCC should support, that if re-channelization and/or DAA devices are unable to produce an interference-free sharing solution, the devices should be withdrawn from further consideration.

Respectfully submitted,

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[17] *Id*. at 3.

[18] *Id*. at 4.

APPENDIX

DETAILED TECHNICAL COMMENTS ON QUALCOMM'S SEPTEMBER 6, 2016 *EX PARTE*

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I. INTRODUCTION

This appendix provides additional detailed technical comments related to (1) additional testing needs, (2) cross-channel interference issues, and (3) detection and prioritization in the lower portion of the DSRC band (below 5.895 GHz).

II. ADDITIONAL TESTING NEEDS

A. Re-channelization Will Require Additional Testing.

Qualcomm disputes our assertion that re-channelization will create a need for significant additional testing by the DSRC community. They claim that "radio characteristics of DSRC band transmissions are relatively uniform across the 75 MHz-wide DSRC band,"[19] and thus validation testing "would be minimal."[20]

Qualcomm's argument fails to recognize that DSRC performance depends on many factors, not just radio characteristics. Re-channelization requires fundamental changes in the way DSRC will use the band, including compressing safety communication from 7 channels down to 3 channels, moving safety communication closer to sources of interference, and requiring DSRC to use sub-optimal 20 MHz channels. These disruptions all have the potential to degrade DSRC performance, with or without the presence of unlicensed activity.

Different sharing proposals would involve different testing approaches, some of which are more burdensome than others.

- In other cases of spectrum sharing that have been approved by the Commission, *e.g.* sharing with Terminal Doppler Weather Radars ("TDWRs"), no changes to the incumbent licensee's technology or operation were required.[21] It follows that testing to validate a sharing proposal, *e.g.* Dynamic Frequency Selection, could consist of comparing performance with unlicensed activity turned off and turned on, as appropriate for various scenarios.

- In the DSRC spectrum sharing case, DAA requires no changes to DSRC technology or operation, so similar unlicensed on/off testing is sufficient—and simple.

- But, the DSRC technology and operational changes required by re-channelization impose a more complex testing burden to validate the proposal. For example, to assess the viability of safety communication under re-channelization, it is not only required to measure performance with unlicensed activity turned off and on, but also to compare

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19 *Id*. at 2.

20 *Id*.

21 *See Revision of Part 15 of the Commission's Rules to Permit Unlicensed National Information Infrastructure (U-NII) Devices in the 5 GHz Band*, First Report and Order, 29 FCC Rcd 4127 (2014).

performance under the re-channelization regime (even without unlicensed activity) and under current FCC DSRC regulations.

- Similarly, to assess the viability of DSRC communication below 5.895 GHz, it is not only required to measure performance with unlicensed activity turned off and on (which will depend on re-channelization priority features not yet supplied), but also to compare performance under the 20 MHz channel bandwidth required by re-channelization with performance under the DSRC community's preferred 10 MHz channel bandwidth. Accordingly, testing the viability of DSRC safety communication under re-channelization is much more complex than simply turning unlicensed activity on and off and measuring the difference.

The automakers and the United States Department of Transportation ("DOT") have the expertise and the responsibility to determine what testing is required to validate a vehicle safety feature. Safety-of-life systems cannot be deployed without adequate testing. We realize that the rigor associated with testing automotive safety systems is higher than that associated with many of Qualcomm's more traditional market segments.

B. Qualcomm Only Addresses Two Aspects of Additional Testing Requirements.

First, Qualcomm concedes that "testing to assess sharing with Wi-Fi operations will be needed,"[22] though later Qualcomm implies that the only Wi-Fi concern meriting testing is cross-channel interference into DSRC channels above 5.895 GHz.[23] While this is indeed critical, we assert that testing of Wi-Fi (more generally U-NII) interference with DSRC operations below 5.895 GHz (co-channel) is also critical. The "no harmful interference" proscription for Part 15 devices is not solely limited to cases where the licensed device is engaged in safety-of-life operations. This also has implications for detection and prioritization of DSRC that are addressed separately below.

Second, Qualcomm states, "testing to confirm the viability of operating the [sic] safety channel in the upper portion of the band per the re-channelization plan would be minimal."[24] They rely on an assumption that the "radio characteristics" of channel 172 are similar to those of the upper band. But, just as the auto industry did not presume the viability of channel 172 without lab and field testing, only testing can confirm if Qualcomm's assumption about the upper channels is accurate. Even if true, that assertion ignores a host of testing issues that arise under re-channelization for safety communication above 5.895 GHz, as detailed in our July 7, 2016 comments.[25]

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22 Qualcomm *Ex Parte* at 1.

23 See *id*. at 2 ("[S]ome testing may be needed to measure the impact of DSRC traffic in adjacent channels.").

24 Qualcomm *Ex Parte* at 2.

25 Alliance *et al*. Comments at 29-38.

In particular, re-channelization both introduces new sources of interference and exacerbates other sources of interference and the impact of these sources on communication and application performance must be thoroughly tested. These include:

- *Interference from other licensed users of the band*, which are not uniformly spread over the band.

- *Interference with licensees in the band above 5.925 GHz*. We note that the Commission's Public Notice characterizes this band as "heavily-used" by Fixed Satellite Service.[26]

- *Co-channel DSRC interference resulting from higher volumes of safety communication in a given channel*, which stems directly from the compression of safety communication from seven channels into three channels. This source of interference will require not only additional testing but a reassessment and potential redesign of a channel congestion control algorithm that took several years to design and validate.

- *Co-channel DSRC interference resulting from a loss of channel access priority differentiation within each channel that would, under re-channelization, exclusively carry safety-of-life communication*, compared to differentiation available within existing DSRC channels between safety-of-life and non-safety-of-life communication. Under existing band usage rules, if one DSRC device is waiting to send a safety-of-life packet while another DSRC device is waiting to send a non-safety-of-life packet on the same channel, Enhanced Distributed Channel Access ("EDCA") mechanisms could be used to give the safety-of-life packet prioritized channel access, both reducing the probability of a packet collision and reducing latency. Under re-channelization, each channel would carry a more homogeneous mix of packets, reducing the ability to apply prioritization mechanisms.

- *Cross-channel DSRC interference due to potentially higher volumes of traffic on adjacent channels*. Under re-channelization, presumably all traffic that currently would be sent on the three channels 172, 178, and 184 (limited by FCC regulation to safety and control traffic) would move to the three channels 180, 182, and 184. In addition, all safety communication that currently would be sent on channels 174, 176, 180, and 182 would also be sent on channels 180, 182, and 184. It follows that by combining all of three channels and part of four channels into just three channels (180, 182, and 184), the amount of channel access competition faced by a typical DSRC safety packet would be higher under re-channelization. Higher channel access competition is associated with higher packet failure (collision) and higher latency. We also note that some of the safety applications that will use channels 174, 176, 180 and 184 under existing DSRC rules can be quite bandwidth intensive, including vulnerable road user (*e.g*. pedestrian) safety and

[26] Public Notice, *The Commission Seeks to Update and Refresh the Record in the "Unlicensed National Information Infrastructure (U-NII) Devices in the 5 GHz Proceeding*, FCC 16-68, n. 19 (2016) ("Public Notice").

cooperative automated driving communication (*e.g*. C-ACC, platooning, and sensor sharing).

- *Cross-channel DSRC interference due to potentially higher power transmissions on adjacent channels*. We note that channel 172 was chosen for the BSM in large measure to create spectral distance from high power interference from channels 178 and 184.

- *Cross-channel DSRC interference due to reduced spatial separation from interferers compared to the existing band usage plan*. For example, to minimize interference with BSM reception on channel 172, we currently map applications to channels to restrict the probability of a transmission on channel 174 by the same vehicle or a near vehicle. Indeed, SAE's J2945 draft standard restricts channel 174 to I2V applications.[27] Under re-channelization, when all safety communication is restricted to three channels above 5.895 GHz, we would lose that application mapping flexibility. We may have BSM, C-ACC, sensor sharing, signal preemption, emergency vehicle alert, and other vehicle-transmission applications on the same or adjacent channels, with resulting higher interference.

Qualcomm says "while some testing may be needed to measure the impact of DSRC traffic in adjacent channels, such measurements likely were already carried out since DSRC always has planned to use the full 70 MHz of the DSRC band."[28] However, as the list above attests, the interference conditions under re-channelization are quite different from those that have previously been tested, even with unlicensed activity turned off. Thus, Qualcomm's casual dismissal of the additional testing requirements is invalid.

Qualcomm further states, "[r]echannelization ensures that Wi-Fi will not interfere with latency-sensitive, safety-of-life DSRC communications because it relocates them to spectrum that Wi-Fi devices are not permitted to use."[29] This, of course, ignores the high potential for cross-channel interference from unlicensed activity below 5.895 GHz into these upper channels that they "are not permitted to use."[30] Unlicensed energy will be in those channels at levels for which no out-of-band-emissions ("OOBE") limit has yet been proposed. Qualcomm admits as much elsewhere when conceding, "there is no question that testing to assess sharing with Wi-Fi operations will be needed."[31] The testing that Qualcomm does not question is inconsistent with the idea that re-channelization "ensures that Wi-Fi will not interfere."[32]

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27 SAE International, *On-Board System Requirements for V2V Safety Communications*, Standard J2945/1_201603 (Mar. 30, 3016) *available at* http://standards.sae.org/j2945/1_201603/ ("SAE J2945 Draft Standard").

28 Qualcomm *Ex Parte* at 2.

29 *Id*.

30 *Id*.

31 *Id*. at 1.

32 *Id*. at 2.

Qualcomm also states that it "strongly believes that the testing to demonstrate the viability of the re-channelization plan would be much less intensive and time consuming than the testing required to verify the viability of DAA."[33] Qualcomm then elaborates on this point, noting "DAA … would require extensive testing to ensure successful detection of any DSRC operations throughout the band."[34] The implication is that re-channelization does not depend on detection. But this implication is inconsistent with Qualcomm's statements elsewhere about their preference for detecting DSRC in 20 MHz channels. In fact, as explained in more detail below, detection of DSRC under re-channelization is more difficult than under DAA due to the re-channelization requirement that DSRC use the same packet structure in 20 MHz as Wi-Fi does. So, re-channelization *does* require testing of DSRC detection, and indeed, a more difficult form of detection than that used by DAA. Therefore, it is disingenuous for Qualcomm to claim DAA's detection feature renders the testing of re-channelization "much less intensive and time consuming."[35]

III. CROSS-CHANNEL DSRC INTERFERENCE

A. DSRC to DSRC Interference

As noted above, re-channelization concentrates safety communication in three channels, a likely effect of which will be to increase the probability of safety packet collisions and channel access latency. In response to this analysis, Qualcomm makes a very strange claim. Qualcomm states that "[t]oday, transmissions in DSRC Ch. 184 will block reception of a BSM message in Ch. 172 (as well as all other DSRC channels)."[36] If this was true, none of the other 6 channels and their applications would operate well. But Qualcomm supplies no equations, no simulations, and no test results to back up this claim. Fortunately, we have test results showing that it is simply untrue. These results were developed by automakers and the U.S. DOT working in the Crash Avoidance Metrics Partnership ("CAMP") Vehicle Safety Communications – Applications ("VSC-A") project. These data are already in the public domain, having been presented to the IEEE 802.11 WG in 2007.[37] Here we highlight two key results from those tests.

Test 1 Three DSRC devices: DSRC transmitter (Tx), receiver (Rx), and interferer. The DSRC Tx and Rx are communicating on channel 172. The DSRC interferer is on another channel. Interferer distance to DSRC Rx = 0.5 meters, modeling the case that both are on the same car. DSRC Tx and Interferer both use 20 dBm Tx power.

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33 *Id*.

34 *Id*. at 3.

35 *Id*. at 2.

36 *Id*. at 3.

37 Cross-Channel Interference Test Results: A Report from the VSC-A Project, Document IEEE 802.11 11-07-2133-00-00p (July 17, 2007) *available at* https://mentor.ieee.org/802.11/dcn/07/11-07-2133-00-000p-cross-channel-interference-test-results-a-report-from-the-vsc-a-project.ppt.

- Tests show that when the interferer is in channel 178, three channels away, there is negligible (< 1%) DSRC packet loss for DSRC Tx-Rx distances up to 100 meters.[38]

- Furthermore, when the interferer is in channel 176, 2 channels away, there is negligible DSRC packet loss for DSRC TX-RX distances up to 50 meters.[39]

Qualcomm's speculative claim that a DSRC transmission will prevent DSRC reception up to six channels away was thus *proven incorrect* in 2007, even for the extremely challenging case in which the interference signal is only 50 centimeters from the DSRC receiver.

Test 2 As in Test 1, three DSRC devices. DSRC interferer distance to DSRC Rx = 2.5 meters (*e.g*. modeling a car in the adjacent lane). DSRC Tx and Interferer both use 20 dBm Tx power.

- When the interferer is in channel 178, three channels away, there is negligible DSRC packet loss for DSRC TX-RX distances up to 200 meters.[40]

- When the interferer is in channel 176, two channels away, there is negligible DSRC packet loss for DSRC TX-RX distances up to 200 meters.[41]

Again, Qualcomm's claim that a DSRC transmission will prevent DSRC reception up to six channels away is *proven incorrect*.

We note that we expect that current DSRC devices will perform even better than these 2007 prototypes. We further note that these DSRC devices, conforming to DSRC standards, used significantly tighter transmit spectral filters than normal Wi-Fi devices, so we cannot extend these results to predict Wi-Fi-to-DSRC interference.

B. Wi-Fi to DSRC Cross-Channel Interference

Under existing DSRC rules, there is a concern about cross-channel interference to DSRC reception in channel 172 from Wi-Fi devices transmitting in the U-NII-3 band. DAA does not add any U-NII-4 cross-channel or co-channel interference because devices vacate the channel upon detection of DSRC activity. Further, DAA will reduce cross-channel interference from 20 MHz Wi-Fi U-NII-3 operation by extending the vacating band down to 5.825 GHz (*i.e*. vacating Wi-Fi channel 165). Qualcomm states, "[u]nlike the rechannelization plan, DAA does not counter the OOBE interference from existing U-NII-3 devices into the DSRC band."[42] This statement ignores the reduced U-NII-3 OOBE that will result from the extended vacation band.

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38 *Id*. at 12.

39 *Id*.

40 *Id*. at 14.

41 *Id*. at 14.

42 Qualcomm *Ex Parte* at 2.

By contrast, re-channelization does nothing to change U-NII-3 interference into the DSRC band. It attempts to mitigate the impact of that interference by moving the most sensitive DSRC traffic away from the U-NII-3 band, but this fails to achieve the desired effect in two ways. First, it would actually increase cross-channel Wi-Fi interference to the most sensitive DSRC communication by locating new U-NII-4 channels even closer (as described below). As noted above, Qualcomm asserts that this interference is not interference when it states "[r]echannelization ensures that Wi-Fi will not interfere with latency-sensitive, safety-of-life DSRC communications."[43] Second, re-channelization ignores the fact that important, licensed DSRC communication would remain in the channels adjacent to the U-NII-3 band, and would be susceptible to interference from that band.

Under existing DSRC rules and under DAA, DSRC safety communication will occur throughout the band, and DSRC safety communication in channel 172 is most susceptible to cross-channel U-NII interference. By contrast, under re-channelization, DSRC safety communication is compressed to channels 180, 182, and 184, and is susceptible to cross-channel U-NII-4 interference. As a result of reduced spectral distance under re-channelization, interference in channels 180, 182, and 184 from U-NII-4 Wi-Fi devices is likely to be significantly worse than interference in channel 172 from U-NII-3 Wi-Fi devices under DAA or existing rules. The bottom portion of Figure 1, below, shows that, under re-channelization, a Wi-Fi channel of bandwidth 20, 40, 80, or 160 MHz may be immediately adjacent to channel 180, *i.e*. 0 MHz separation. Furthermore, it will have only 10 MHz separation from channel 182 and 20 MHz from channel 184.

By contrast, under DAA (as illustrated in the top portion of Figure 1) the nearest Wi-Fi channel has 40 MHz separation from channel 172 for 20, 40, and 80 MHz Wi-Fi channels, and 205 MHz separation for 160 MHz channels. Even without the extended vacation of DAA, under existing U-NII-3 and under re-channelization the only difference to the top portion of Figure 1 is that 20 MHz channel 165 is permitted; it has separation of 20 MHz from channel 172, closer than the 40 MHz separation under DAA. The closest U-NII-3 40 and 80 MHz channels remain 40 MHz from channel 172 under all proposals. Based on the record before the Commission with respect to U-NII-3 OOBE, typical devices have significantly reduced OOBE 40 MHz from the channel edge compared to at the channel edge. Qualcomm has explained that they intend to use the same devices in the U-NII-4 band as they currently use in U-NII-3, if permitted. Therefore, we can expect more interference from such devices when acting as U-NII-4 into channels 180, 182, and 184 than we will see from the same devices when acting as U-NII-3 into channel 172. Qualcomm's assertion that U-NII-3 interference under DAA is a concern, but that re-channelization "ensures that Wi-Fi will not interfere" is inconsistent.[44] This is one reason why we objectively prefer DAA, and why re-channelization requires extensive testing.

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43 *Id*.

44 Qualcomm *Ex Parte* at 2.

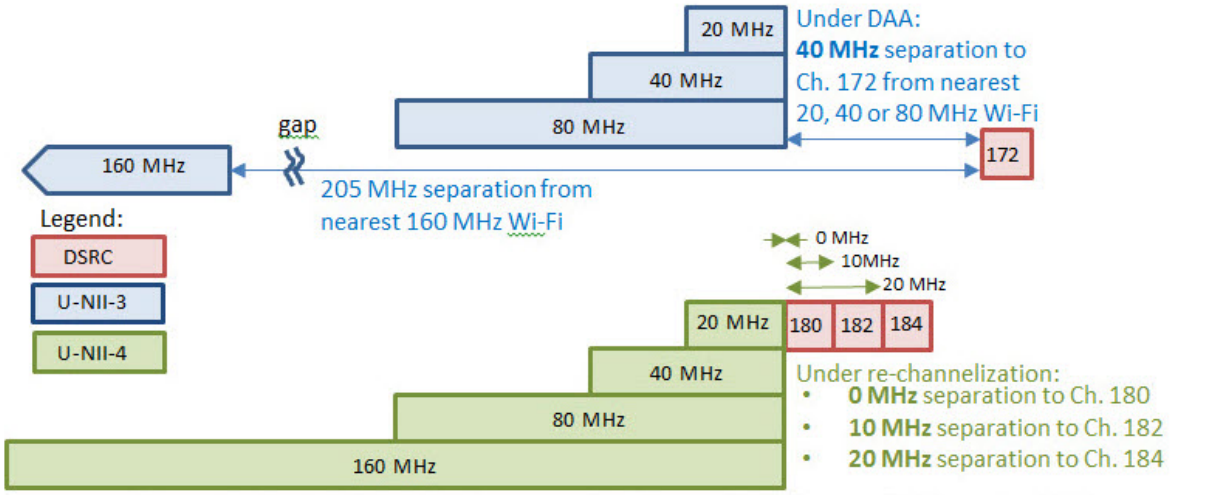

Figure 1: (top) U-NII-3 Wi-Fi separation from DSRC channel 172 under DAA, (bottom) U-NII-4 Wi-Fi separation from channels 180, 182, and 184 under re-channelization

IV. DETECTION AND PRIORITIZATION

There are several issues with detection and prioritization. As noted above, detection of the presence of DSRC actors is a necessary feature of re-channelization if some priority is to be given to DSRC traffic. Qualcomm has been equivocal about whether any prioritization is desirable for DSRC. Further, the FCC Phase 1 Test Plan states that the prototype devices Qualcomm provided to the Commission "do not actually implement the prioritization scheme advocated by the re-channelization proponents."[45] We believe prioritization, and thus detection, are clearly required under the Commission's rule prohibiting U-NII devices from harmfully interfering with licensed incumbent operations. We identify the following four issues with detection.

First, assuming DSRC is required to operate in 20 MHz channels, how many of those channels will a U-NII device detect simultaneously? It seems clear the device must detect on both DSRC channels (173, 177) at the same time. To give meaningful interference protection, the detection on each channel must be with full sensitivity, for example as defined in IEEE 802.11 for a primary channel, or as defined in SAE J2945/1 for Basic Safety Message reception.[46] Qualcomm's approach is flawed in that that they seem to want to apply existing 802.11ac silicon directly to sharing in the 5.9 GHz band. Qualcomm objects to detecting 10 MHz DSRC as proposed in DAA because it likely "would require new hardware."[47] But neither the existing 802.11 standard nor existing 802.11 hardware detect two primary 20 MHz channels

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45 *See* FCC, Office of Engineering and Technology Laboratory Division, *U-NII-4-to-DSRC EMC Test and Measurement Plan, Phase I: FCC Laboratory Tests*, ET Docket No. 13-49 at 11 *available at* https://transition.fcc.gov/oet/fcclab/DSRC-Test-Plan-10-05-2016.pdf.

46 *See* SAE J2945 Draft Standard.

47 Qualcomm *Ex Parte* at 3.

simultaneously. Only one primary channel is defined at a time and any detection on remaining channels is "secondary," with inferior sensitivity. That may be acceptable on the multiple 20 MHz portions of an 80 MHz or 160 MHz 802.11ac channel, but treating one or both DSRC channels as secondary with coarse detection sensitivity will not provide the robust detection needed to protect DSRC from harmful interference. We suggest that the Commission not define sharing rules to specifically accommodate existing Wi-Fi hardware at the expense of protection for DSRC. New hardware was required to protect licensed TDWR devices from unlicensed Wi-Fi emissions; it is understandable that modest Wi-Fi hardware or digital signal processing software changes are likely required to protect licensed DSRC links as well.

Qualcomm has not yet explained if they plan to utilize existing 802.11ac hardware, with inferior secondary channel detection, or to modify the hardware so it is capable of detecting at least two channels simultaneously with full sensitivity. Their responses to date have been inconsistent. If hardware will not be modified, they must explain how DSRC communications in the reduced sensitivity secondary channel will be protected from co-channel interference. If hardware will be modified to provide full sensitivity detection on two 20 MHz channels, they should explain why they are willing to do that and not support four 10 MHz full sensitivity detectors (as required by DAA). The differences in cost of design, chip area, power consumption, and time-to-market between two full sensitivity 20 MHz detectors and four full sensitivity 10 MHz detectors are likely to be negligible. If Qualcomm disagrees with this assertion, we invite them to explain why. We note that 10 MHz detection is a solved problem that is already in the 802.11 standard and is part of every DSRC chipset today—including those from Qualcomm.

Second, detection is actually more difficult in re-channelization than in DAA. We have previously noted that if DSRC is required to use 20 MHz channels, there will be no distinction between the preambles of DSRC packets and non-DSRC Wi-Fi packets in those channels. Qualcomm attempts to address this, stating "Wi-Fi equipment can decode the 'MAC' part of a DSRC packet and verify that the detected packet is indeed DSRC."[48]

We are unsure what Qualcomm envisions and invite them to be more transparent on this important point. There is no "DSRC bit" in the 802.11 MAC header. This raises several questions for Qualcomm:

- Precisely how will they distinguish a 20 MHz DSRC packet from a non-DSRC Wi-Fi packet?
- Have they devised a test that will work on every packet? On most packets?
- How deep into the packet is decoding required?
- Have they implemented and tested a 20 MHz DSRC detector?

Further, we note that detection under re-channelization requires a significantly stronger DSRC signal than detection under DAA. There are two reasons for this: first, the 20 MHz channel used

[48] *Id*. at 5.

in re-channelization has 3 dB more noise than the 10 MHz channel used by DSRC in DAA; and second, decoding the MAC header or higher layers requires higher Signal-to-Noise Ratio ("SNR") due to more complex modulation compared to identifying the short training symbols of the 802.11 preamble. Therefore the DSRC signal strength must be 3 dB higher under re-channelization just to compensate for the higher noise in the 20 MHz channel, and then must further increase by several dB to allow decoding of the more complex modulation used by the higher layers. Additional questions include:

- How much higher DSRC signal strength is required to detect a 20 MHz DSRC packet using Qualcomm's deep-packet inspection vs. detection of a 10 MHz DSRC preamble according to DAA?

- What is the impact on the detection range and robustness?

Third, the lack of a specific prioritization proposal is problematic. Under re-channelization, even if DSRC devices use 20 MHz channels below 5.895 GHz, and even if a U-NII-4 device can detect the presence of DSRC communication, there remains the question of how that device can continue to use the band without co-channel interference to DSRC. In response to our request for a specific proposal, Qualcomm instead provides a vague answer: "existing Quality of Service enhancement mechanisms in 802.11 standards, such as 802.11e, can prioritize DSRC over Wi-Fi."[49] The IEEE 802.11e Quality of Service mechanism, also called EDCA, is specified in the IEEE 802.11-2012 standard using eight User Priorities, which map to four Access Categories ("ACs"). The channel access protocol for each AC is parameterized by:

- Contention Window Minimum (CWmin)

- Contention Window Maximum (CWmax)

- Arbitration InterFrame Space Number (AIFSN)

- Transmission Opportunity (TXOP) limit

Therefore, the EDCA parameter set for a given 802.11 mode is governed by a set of four ACs with four parameters each, for a total of sixteen interdependent parameters. Furthermore, the DSRC mode within 802.11 uses a different default set of EDCA parameters than the non-DSRC (Wi-Fi) mode. The DSRC set is chosen with more emphasis on reducing packet collisions and does not allow packet bursts. The non-DSRC set is chosen with more emphasis on reducing channel access latency (*e.g.* for voice and video) and allows packet bursts. Accordingly, when DSRC devices share a channel with non-DSRC 802.11 devices, the channel access latency and probability of collision suffered by a DSRC packet will vary widely based on a complex function of 32 EDCA parameters and the per-AC queue state of each device.

Qualcomm's proposal does not specify a single EDCA parameter value. In its Public Notice, the Commission stated, "[w]e ask parties to propose mitigation techniques with adequate specificity

[49] *Id*. at 3.

and detail so that we can compare and contrast them."[50] Merely stating that EDCA "can prioritize DSRC over Wi-Fi" clearly fails to provide the required specificity and detail.[51]

Fourth, the suggested prioritization technique assumes that all U-NII devices are Wi-Fi. Qualcomm claims that the EDCA (IEEE 802.11e) mechanism can provide priority to DSRC, and thus avoid co-channel interference. This argument is fundamentally flawed because DSRC devices will not generally detect U-NII transmissions. When a DSRC device has a packet to send, it will defer if another DSRC device is already transmitting, because its "Clear Channel Assessment – Carrier Sense" ("CCA-CS") function will detect the other DSRC preamble and declare the channel busy. But, when the channel is occupied by a non-Wi-Fi U-NII packet, the DSRC device's CCA-CS function will not detect that the channel is busy, and will not defer its transmission. When a DSRC transmission overlaps a U-NII transmission, the DSRC packet will usually be lost. The EDCA mechanism does nothing to prevent this harmful interference.

The flaw in Qualcomm's argument is an assumption that all U-NII transmissions use Wi-Fi. If the Commission decides to define a U-NII-4 band, it is unlikely to constrain U-NII devices to use any particular preamble, waveform, or protocol. If the U-NII device does not use the same preamble as DSRC, EDCA simply will not work. The prioritization that EDCA attempts to provide is premised on all contending devices having the same ability to detect transitions in the channel state from busy to idle. That premise is invalid in a U-NII environment.

The Commission's strategic effort to open spectrum for unlicensed use is intended to foster innovation, including in new communication technologies. Qualcomm is among the most ardent promoters of non-Wi-Fi U-NII technologies, such as LTE-Unlicensed and LTE-AA. During the life cycle of a typical DSRC vehicle, no doubt many new non-Wi-Fi technologies will be introduced in the U-NII bands. Re-channelization will not be able to prevent harmful interference with such technologies. It is troubling to see Qualcomm rely on "mutual DSRC and Wi-Fi" detection, knowing that this is inconsistent with non-Wi-Fi usage of the U-NII band.

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50 Public Notice at 9.

51 Qualcomm *Ex Parte* at 3.