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IEEE P802.11 Wireless LANs

Final Report of DSRC Coexistence Tiger Team

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Revision History

R0	Initial draft by Jim Lansford. Portions of this draft were excerpted from a paper presented to the 2013 IEEE Vehicular Networking Conference [1]
R1	Incorporated Appendix C (Cooperative ITS spectrum regulation in the 5GHz band in Europe) by Paul Spaanderman, et al
R2	Comments were collected in document 15/0175, which has a total of 93 comments. This revision incorporated comment resolution from CID 5, 11, 12, 13, 14, 15, 17, 18, 23, 25, 30, 31, 32, 33, 34, 39, 40, 41, 42, 43, 45, 49, 50, 51, 56, 58, 59, and 97
R3	This revision incorporated comment resolution from CID 35, 36, 37, 38, 43, 47, 53, 54, 55, 62, and 96.
R4	All remaining comments listed in document 15/0175r4 included, as applicable. This redline copy, with all changes incorporated, was used to generate a clean pdf, which is document 15/0347r0. This revision also added Appendix D, which was submitted by Walton Fehr of US DoT.

Abstract

With the release of FCC NPRM 13-22 (Docket 13-49), the United States Federal Communications Commission has requested comments regarding allowing unlicensed devices such as those using 802.11-based standards to share the 5.9 GHz band, which is currently allocated for DSRC and other services. If sharing is allowed, the FCC would create a new set of rules for the band that would become U-NII-4. This report is a summary of activities in the IEEE 802.11 Regulatory Standing Committee regarding the issues surrounding U-NII-4 band sharing between WLAN and DSRC; this DSRC Coexistence “Tiger Team” has examined some initial ideas for how band sharing could work. This report describes the work of the Tiger Team since its inception in August 2013, summarizes the issues surrounding the proposed band sharing ideas discussed in the group, assesses the level of support for these concepts among the members of the group, and recommends next steps for validating the sharing methods. The goal of this document is to inform regulators about initial discussions regarding the feasibility and practicality of sharing the 5.9 GHz band and outlining future analysis and field/lab testing that needs to take place to assure that these techniques will protect DSRC transmissions from harmful interference when deployed in the mass market.

1. Background

The FCC allocated 75MHz of spectrum in the 5.9GHz band (5850-5925MHz) for Dedicated Short Range Communications (DSRC) in October 1999. In the FCC NPRM 13-22 (Docket 13-49), the United States Federal Communications Commission has requested comments regarding allowing unlicensed devices such as those using 802.11-based standards to share the 5.9 GHz band, which is currently allocated for DSRC, government radiolocation, and non-government fixed satellite service (FSS) operations, to understand if a feasible sharing solution that protects DSRC users could be developed. DSRC would remain as one of the primary users of the band, but if sharing is allowed, the FCC would create a new set of rules for the band that would be designated as U-NII-4. Existing IEEE standards for Wireless Local Area Networks (WLANs) such as 802.11n and 802.11ac could be modified to operate in this new UNII-4 band if such band sharing rules are approved by the FCC. The FCC did not specify the framework or etiquette by which band sharing would occur; the NPRM requested comments from relevant stakeholders. In August 2013, the IEEE 802.11 Regulatory Standing Committee created a subcommittee called the DSRC Coexistence Tiger Team to convene meetings of stakeholders from WLAN, Intelligent Transportation Systems (ITS), regulatory and other communities to explore possible band sharing techniques that could help inform the regulatory process.

2. Regulatory issues in the 5 GHz bands

As the 2.4 GHz Industrial, Scientific and Medical (ISM) band has become increasingly congested, there has been a great deal of interest in the 802.11/Wi-Fi¹ industry to use the 5 GHz bands, which generally fall under the Unlicensed National Information Infrastructure (UNII) rules of the US Federal Communications Commission (FCC). As originally defined², the UNII bands were designated as shown in TABLE I. :

Band name	Frequency Range (GHz)	Power Level (mW)
U-NII-1	5.15-5.25	250
U-NII-2	5.25-5.35	250 (DFS required) ³
U-NII-2e	5.47-5.725	250 (DFS required)
U-NII-3	5.725-5.825	1000

TABLE I: 5 GHz U-NII BAND ALLOCATIONS IN THE US PRIOR TO 2013 NPRM

While the 5 GHz bands offer significantly more spectral capacity than the 83.5MHz available in the 2.4 GHz ISM band in the US, there is concern that the rapidly accelerating popularity of the new generations of 802.11 WLAN will lead to massive congestion in these bands as well. These issues will be addressed in subsequent sections.

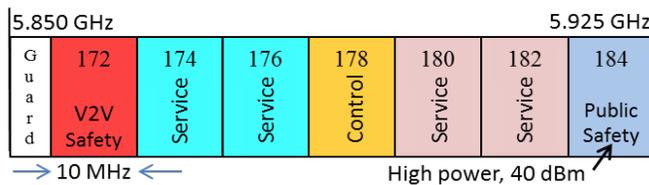
The US Congress established the Intelligent Transportation System (ITS) program in 1991 [3]. In 1999 the FCC, in response to a petition from ITS stakeholders, “allocated the 5.9 GHz band [5.850-5.925 GHz] for DSRC-based ITS applications and adopted technical rules for DSRC operations” [4].

¹ The term “Wi-Fi” refers to “Wi-Fi Certified” products. “Wi-Fi Certified” is a trademark of the Wi-Fi Alliance, an industry group that performs certification testing of WLAN devices which are based on IEEE 802.11 specifications. The terms 802.11, Wi-Fi, and WLAN are often used interchangeably.

² The rules for U-NII-1 and U-NII-3 were modified in March of 2014 [2]. There were numerous changes to the U-NII band rules, and the names of some of the bands were changed as shown in Table II. The allowed transmit power was increased in U-NII-1 and its use is now permitted outdoors; the U-NII-3 band was extended to 5.850GHz.

³ Dynamic Frequency Selection

38 DSRC services are co-primary in the 5.9 GHz band with the government radiolocation service and
 39 with non-government fixed satellite service uplink operations. In 2003 the FCC adopted licensing and
 40 service rules for DSRC [4], including modifications to Parts 90 (for Roadside Units, RSUs) and 95
 41 (for On-Board Units, OBUs) of the Commission’s rules. As shown in Fig. 1, these rules defined a
 42 band plan that reserved 5 MHz at the low end of the band (5.850-5.855 GHz) for future developments
 43 and specified seven 10 MHz channels, i.e. Ch. 172 (5.855-5.865 GHz) through 184 (5.915-5.925
 44 GHz). Channel 178 is designated as the Control Channel, while the remaining six channels are
 45 designated as Service Channels. The rules also permit two 20 MHz service channels, overlapping
 46 respectively with channels 174-176 and 180-182. In 2006 the Commission further refined the DSRC
 47 rules by designating Channel 172 “exclusively for vehicle-to-vehicle safety communications for
 48 accident avoidance and mitigation, and safety of life and property applications.” In addition, it
 49 designated Channel 184 “exclusively for high-power, longer-distance communications to be used for
 50 public safety applications involving safety of life and property, including road intersection collision
 51 mitigation” [5].



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Figure 1: FCC DSRC Band Plan

54 3. Dedicated Short Range Communications

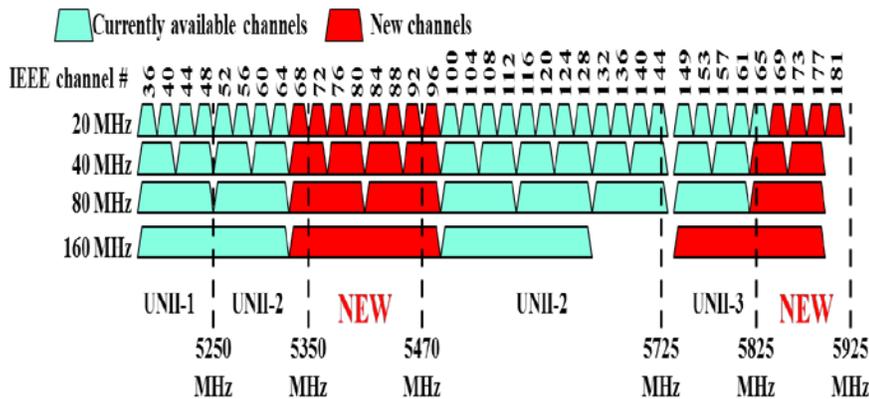
55 DSRC is an ITS technology that enables direct vehicle-to-vehicle (V2V) and vehicle-to/from-
 56 infrastructure (V2I) communication [6]. In recent years a consortium of automakers, in cooperation
 57 with the US Department of Transportation (DOT), has engaged in research directed at deployment of
 58 DSRC systems [7, 8]. The focus of the research is V2V communication of vehicle state information
 59 (location, speed, acceleration, heading, etc.) through so-called Basic Safety Messages (BSMs) [9],
 60 and the development of collision-avoidance applications that use the BSM data to identify potential
 61 collision threats and take appropriate action, e.g. warn the driver or other actions. These applications
 62 place robustness and latency requirements on the underlying wireless communication system. While
 63 the focus in discussions of DSRC is often on V2V safety communication, the system is capable of
 64 supporting a wide variety of other ITS applications, including V2I-based safety, automated driving,
 65 efficient mobility, reduced environmental impact, and electronic commerce (e.g. tolling). Some of
 66 these services also impose robustness and latency requirements on the wireless communication
 67 system.

68 DSRC systems communicate using a variation on the common IEEE 802.11 Physical (PHY) and
 69 Medium Access Control (MAC) protocols. This variation, referred to as Wireless Access in Vehicular
 70 Environments (WAVE) is specified in the IEEE 802.11p amendment [10]. The WAVE capability
 71 enables ad hoc communication with low latency, as required for scenarios in which high speed
 72 vehicles are only in range of one another for a few seconds before a potential collision. The
 73 relationship between WAVE DSRC and more conventional uses of the IEEE 802.11 protocols is
 74 discussed below. The higher layers of the DSRC protocol stack are based on standards defined by the
 75 IEEE 1609 Working Group and by SAE International [11].

76 4. The FCC 13-22 NPRM

77 In response to the rapidly accelerating adoption of 802.11, particularly the emerging 802.11ac
 78 standard, the FCC issued a Notice of Proposed Rulemaking (NPRM) in early 2013 that proposed

79 adding 195MHz of additional 5GHz spectrum for use by unlicensed devices such as 802.11.⁴ In
 80 addition, the NPRM proposed changes in the existing U-NII-1, U-NII-2, and U-NII-2e bands to make
 81 them more useful for unlicensed devices, including making U-NII-1 available outdoors and
 82 streamlining the DFS process for U-NII-2 and U-NII-2e (a portion of these new rules have been
 83 approved; see [2]). A mapping between the recently approved or proposed new unlicensed spectrum
 84 and 802.11 channels is shown in red in Fig. 2. As a reminder, the band from 5.850-5.925 GHz is
 85 allocated to ITS, radiolocation, and FSS, and the inclusion of this band in the NPRM would permit
 86 one additional 80 MHz and one additional 160 MHz contiguous channel, as well as several additional
 87 non-contiguous 80+80MHz channel combinations for 802.11 operation. Unlicensed devices
 88 following standards other than 802.11 would also be permitted to operate anywhere in the bands
 89 labelled “New” in the figure.
 90



91 Figure 2: Current and proposed 5 GHz channels for 802.11ac

92 The previous designations and the new designations for these unlicensed bands are shown in TABLE
 93 II.
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Frequency (GHz)	Old Name	New Name
5.15-5.25	U-NII-1	U-NII-1
5.25-5.35	U-NII-2	U-NII-2A
5.35-5.47		U-NII-2B
5.47-5.725	U-NII-2e	U-NII-2C
5.725-5.850 (Upper band edge extended to 5.850 in 2014)	U-NII-3	U-NII-3
5.85-5.925	ITS	U-NII-4

95 TABLE II: 5 GHz U-NII BAND DESIGNATIONS PRIOR TO 2013 AND AS DESCRIBED IN FCC NPRM 13-22

96 The most significant proposed change is allowing the band allocated to DSRC to be shared with
 97 unlicensed devices such as 802.11, which would become the proposed U-NII-4 band. The automotive
 98 and WLAN industries have thus engaged in dialog to discuss possible mechanisms that could
 99 facilitate DSRC-WLAN sharing in U-NII-4 while not causing harmful interference to DSRC, which
 100 is a requirement for Part 15 devices.
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⁴In this paper, references to the “NPRM” mean FCC NPRM 13-22, which is Docket 13-49.

5. Mission and Scope of IEEE 802.11 REG SC DSRC Coexistence Tiger Team

The FCC's NPRM asked for comments on the feasibility of band sharing between DSRC and unlicensed devices; the Regulatory Standing Committee of the 802.11 Working Group created this DSRC Coexistence Tiger Team in August 2013 to explore band sharing between DSRC and a possible future 802.11 amendment. [12]. The mission of this Tiger Team was to “work toward a document that would describe and quantify possible coexistence mechanisms between DSRC and extensions of the 802.11 base standard into the proposed UNII-4 band, if the FCC allows such band sharing in a future R&O.” [13] Because this is a group within the Regulatory Standing committee, it can take into account the regulatory issues described previously. Only IEEE 802.11 Working Group participants may vote on certain matters before the Regulatory Standing Committee, but anyone has been able to participate in this Tiger Team activity. To date the group has attracted a global spectrum of participants from the automotive industry, 802.11 WLAN chip and system vendors, and other stakeholders from government and industry.

6. Goals

The goals of the DSRC Coexistence Tiger Team have been [13]:

- Review of ITS/DSRC field trials
- Review of work to date on coexistence
- Modelling/simulation of possible coexistence approaches
- Testing and presentation of results from proposed prototype approaches

7. Timeline

The DSRC Coexistence Tiger Team established several milestones [12]:

- Completion of review of field trials and coexistence work
- Call for proposals for coexistence mechanisms [November 2013]
- Snapshot of progress to date [February 2014]
- Complete modelling/simulation of possible coexistence approaches
- Testing and presentation of results from prototype testing
- Final report with evaluation of results and recommendations

There have not been any presentations on modelling, simulation, or testing during the duration of this Tiger Team, so those items are not within the scope of this Report.

8. Overview of DSRC Coexistence Activities since its inception

As noted previously, the Tiger Team was created in August of 2013. Between the group's creation and the end of 2014, the group held 25 conference calls, reviewed 12 presentations, and had extended discussions about the issues surrounding band sharing. The following are the types of presentations that the group reviewed:

- Presentations on use cases
- Presentations on interference
- Presentations on CCA
- Presentations on European activities
- Presentations on USDoT activities
- Presentations on proposed coexistence techniques
- Presentations on DSRC response to proposals

An exact list of presentations with a link to each on the IEEE 802.11 document server called Mentor is listed in Appendix B.

While the presentations on use cases, CCA, and regulatory activities were useful to help frame the discussion, there were presentations on two specific proposals for band sharing which directly addressed the group's charter:

- 1) “Proposal for U-NII-4 Devices,” Peter Ecclesine, [15] and
- 2) “Proposal for DSRC band Coexistence,” Tevfik Yucek [18]

153 The remainder of this report will summarize these two proposals and the group's support for carrying this
154 work forward.

155 9. Proposal 1: Sharing using existing DSRC channelization and CCA in 10MHz 156 channels

157 Prior to the formation of the DSRC Coexistence TT, there was a presentation in the 802.11 Wireless
158 Next Generation Standing Committee (WNG SC) that outlined some initial ideas for band sharing
159 [14] and addressed the issue of CCA in 10 MHz channels. After the initial DSRC Coexistence TT
160 meeting, a preliminary proposal was brought to the Tiger Team in September of 2013. In particular, a
161 document entitled "Proposal for U-NII-4 Devices" [15], also known as the 13/0994 proposal, has
162 been reviewed by the group. Highlights of the proposal are:

- 163 ➤ Detection of DSRC by WLAN in 5850-5925 MHz
- 164 ➤ -85dBm detection of 802.11p preambles in 10MHz bandwidth
- 165 ➤ Must detect on any of the seven 10MHz channels in the U-NII-4 band – if any channel is
166 busy, then unlicensed devices should defer so they don't impart co-channel or out-of-
167 channel interference
- 168 ➤ >90% detection probability within 8μsec
- 169 ➤ Once a 10 MHz preamble (802.11p) has been detected, the frequency band from 5825-
170 5925MHz will be declared busy for at least 10 seconds. During a busy period, the DSRC
171 channels will continue to be monitored, and any new DSRC packet detection will extend
172 the CCA busy state for ten seconds from the time of detection.
- 173 ➤ The maximum time of transmission for any U-NII-4 packet will be 3 msec

174 Note that several of the numeric values listed above are intended to be subject to further discussion.
175 There are also some differences between the timing parameters between 802.11p and 802.11ac; these
176 would need to be resolved as noted in [14] and [16].

177 Note that this proposal is a hybrid of traditional CCA and DFS. It uses standard 802.11 CCA (in a 10
178 MHz bandwidth) for detection of the DSRC user, taking advantage of very specific knowledge of the
179 primary signal characteristics. It also employs CCA not only on the channel of intended operation, but
180 also on other DSRC channels. Most importantly, once detection has occurred, the CCA function will
181 define the channel state as busy, i.e. unavailable for unlicensed transmissions, for a relatively long
182 period compared to normal CCA deference. In this way, CCA-based detection resembles DFS in
183 structure. On the other hand, the non-occupancy is likely to be significantly shorter than the 30
184 minute silence period requirement for DFS. There is also no separate channel availability check as in
185 DFS; this is combined with the 10 second busy holdover time after the most recent detection. Another
186 difference from DFS is that under the 13/0994 proposal, every STA that wants to use the U-NII-4
187 band performs DSRC detection; there is no master or client role as there is in DFS. Finally, there is no
188 distinct channel move time; once a DSRC transmission is detected, unlicensed use of the band ceases
189 immediately.

190 While this approach specifically leverages commonality between unlicensed 802.11 and licensed
191 DSRC signals, it could in theory also be employed by non-802.11 devices wishing to share the band
192 on an unlicensed basis. From a technical perspective, any device can implement this detection
193 function. From a practical perspective, non-802.11 devices may not find adding this CCA mechanism
194 cost effective.

195 While no definitive action has been taken on this proposal during the duration of the Tiger Team, the
196 concepts outlined should be carried forward into analysis and simulation studies to determine their
197 merit. Note that the proposed CCA threshold (-85 dBm) is well above the sensitivity level of typical
198 802.11p/DSRC implementations, so this level may have to be revised downward. Some
199 implementations of DSRC have a sensitivity level approaching -95dBm, so the CCA threshold of a
200 U-NII-4 device would need to be comparable to this level.

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Some Tiger Team members suggested there are two issues with this approach:

- 203 > Changes will be required to modify the behavior of existing 802.11ac systems. The
- 204 current CCA mechanism is not defined for 10MHz channels (although it is for other
- 205 parts of the 802.11 family such as 802.11a) and, more importantly, the secondary CCA
- 206 mechanisms defined in 802.11ac do not comprehend secondary devices using Carrier
- 207 Sense in multiple channels, certainly not the seven channels in DSRC; in the case of
- 208 DSRC coexistence, secondary CCA at Carrier Sense levels (<-85dBm) would have to be
- 209 performed in multiple channels simultaneously [17]. This would require changes in the
- 210 base 802.11 specification and would add complexity to existing 802.11ac chipsets.
- 211 > Even if Carrier Sense could be demonstrated to operate at levels below -90dBm in
- 212 10MHz channels, there is no guarantee that modified 802.11ac systems would not
- 213 impact DSRC operation. Adequate testing would be required to make sure that
- 214 deployment of these 802.11 systems would not impact the critical functions of DSRC
- 215 systems, particularly collision avoidance.
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217 **10. Proposal 2: Sharing using modified DSRC channelization and CCA in 20MHz**

218 **channels**

219 Another submission that has been made in the group proposes changes to DSRC [18,19,20]; also

220 known as document 13/1449r2, it would revamp the existing band plan as defined in the FCC Report

221 and Order 03-324 and allow unlicensed devices such as 802.11 to share only the lower 45MHz

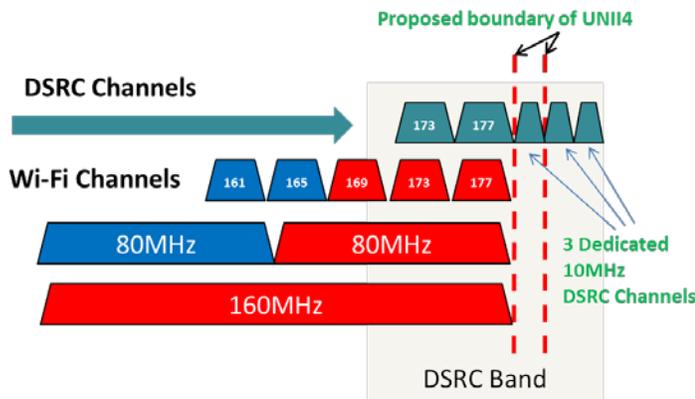
222 portion of the band, while reserving several channels at the top of the band exclusively for the use of

223 DSRC systems. It also proposes that non-safety-of-life DSRC applications use only 20MHz channels

224 in the lower 40MHz of the band (5855-5895MHz), not the existing 10MHz channels. Figure 3 shows

225 how the proposed new band plan would look.

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227 Figure 3: Proposed rebanding of DSRC channels in 13/1449r2

230 Like Proposal 1 (13/0994), Proposal 2 would require further study and testing to verify that it would

231 adequately protect DSRC applications from harmful interference. This proposal would possibly

232 require a new FCC rulemaking to change the FCC 03-324 band plan, as well as some new testing of

233 DSRC systems to verify that these changes would have little or no impact. Certainly some aspects of

234 the existing tests, such as upper layer messaging (parts of P1609 and J2735), would still be relevant,

235 but the potential for new forms of co-channel interference, adjacent channel interference, and

236 congestion would mean that at least some portions of the testing would have to be re-done. In

237 addition, changing the lower 40MHz portion of the DSRC band to two 20MHz channels instead of

238 four 10MHz channels is not comprehended in the P1609 specification, so that would need to be re-

239 written and tested⁵.

⁵ The existing spectrum allocation allows two 20MHz channels spanning channels 174-176 and 180-182.

240 On the other hand, the objectives of this proposal were to provide protection for BSM traffic because
241 they would not have to share with unlicensed devices at all, and to allow modified 802.11ac chipsets
242 to be used with 160MHz bandwidth channels to span from U-NII-3 into the new (shared) U-NII-4
243 band. While the secondary CCA mechanism in 802.11ac currently uses Energy Detect, which is
244 20dB higher than the threshold defined for Carrier Sense, modification of the existing 802.11ac
245 standard to incorporate 20MHz Carrier Sense secondary CCA in the U-NII-4 band would likely not
246 result in a major change (if any) to existing standards or chipsets, since 20MHz CCA is already
247 defined and in use.

248 **11. Support for the Proposals among Participants**

249 During the course of the DSRC Coexistence Tiger Team's existence, there were numerous
250 presentations and discussion about the merits of each proposal. Members of the DSRC community
251 gave a presentation that listed their concerns about the proposals, primarily Proposal #2 (13/1449r2)
252 by Yucek, and stressed that they felt Proposal #1 (13/0994) was the most promising of the two from
253 their perspective [21]. Other members of the Tiger Team raised issues about DSRC in an attempt to
254 assess the robustness of existing DSRC systems against known interference [22], but there was no
255 formal response to these questions. In addition, the US Department of Transportation gave a
256 presentation [23] and contributed Appendix D to this report that contains their assessment of band
257 sharing and their views of the two proposals.
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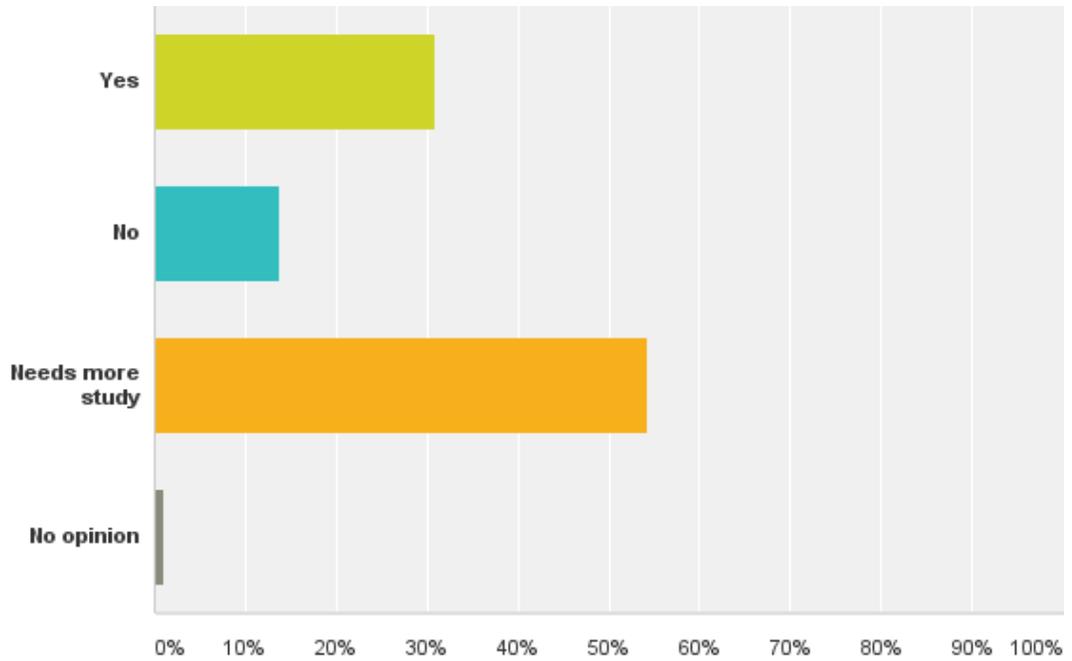
259 Despite 18 months of meetings and presentations, there was no clear consensus or compromise for a
260 single proposal. Lacking a clear consensus, the group undertook an effort to assess the level of
261 support among the participants for aspects of the two proposals. The Chair, in conjunction with the
262 Tiger Team members, developed a set of straw poll questions that explored elements of the proposals.
263 At the time the straw poll was conducted, the Tiger Team consisted of 124 members who wished to
264 have their names recorded for purposes of the straw poll; their names are listed in Appendix A. On
265 February 9th, 2015, the straw poll was launched using a web-based tool called Survey Monkey, and
266 members were given two weeks to respond to the poll; 94 of the members responded to the straw poll.
267 Respondents could also supply comments to each of the questions, and indicate whether those
268 comments should be anonymous or if he/she wanted his/her name attached to those comments in this
269 report. In the following sections, each of the questions is listed, along with a summary of the
270 responses. Dozens of comments were submitted in response to the straw poll questions. Due to the
271 number and length of the comments, they are stored in a separate file, which is located on the IEEE
272 document server "Mentor" at the following link:
273 [https://mentor.ieee.org/802.11/dcn/15/11-15-0352-01-0reg-dsrc-tiger-team-straw-poll-comments-](https://mentor.ieee.org/802.11/dcn/15/11-15-0352-01-0reg-dsrc-tiger-team-straw-poll-comments-sorted.xlsx)
274 [sorted.xlsx](https://mentor.ieee.org/802.11/dcn/15/11-15-0352-01-0reg-dsrc-tiger-team-straw-poll-comments-sorted.xlsx)
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276 Note that the comments were extracted from the straw poll survey verbatim, and there was no attempt
277 to correct grammatical, spelling, or other formatting errors.
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11.1 Question 1

Do you believe it is technically feasible to protect DSRC systems from harmful interference if unlicensed (Part 15) devices share the 5.9 GHz band?



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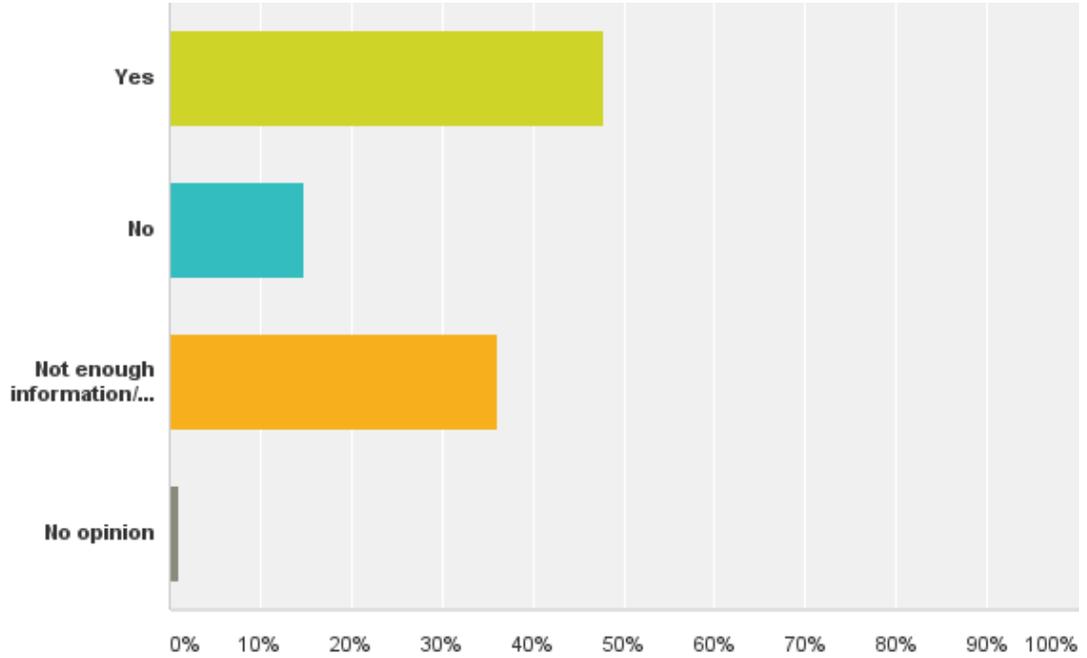
Answer Choices	Responses
Yes	30.85% 29
No	13.83% 13
Needs more study	54.26% 51
No opinion	1.06% 1
Total	94

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11.2 Question 2

Regarding the proposal in document 13/994r0 by Peter Ecclesine of Cisco Systems
<https://mentor.ieee.org/802.11/dcn/13/11-13-0994-00-0reg-proposal-for-u-nii-4-devices.docx>
Do you believe this proposed band sharing technique has merit and, after developing a more complete definition and field testing, should be considered a basis for a band sharing solution?



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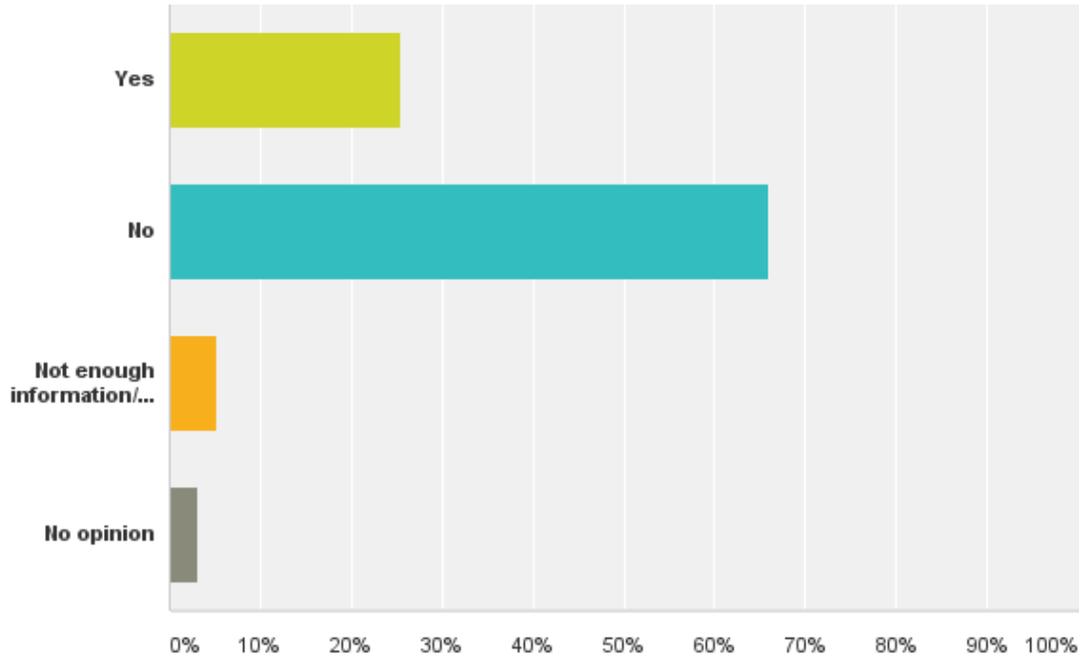
Answer Choices	Responses
Yes	47.87% 45
No	14.89% 14
Not enough information/needs more study	36.17% 34
No opinion	1.06% 1
Total	94

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11.3 Question 3

Regarding the proposal in document 13/1449r2 by Tevfik Yucek of Qualcomm (and others)
<https://mentor.ieee.org/802.11/dcn/13/11-13-1449-02-0reg-proposal-for-dsrc-band-coexistence.pptx>
<http://apps.fcc.gov/ecfs/document/view?id=7022418821>
 Do you believe this proposed band sharing technique has merit and, after developing a more complete definition and field testing, should be considered a basis for a band sharing solution?



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Answer Choices	Responses
Yes	25.53% 24
No	65.96% 62
Not enough information/needs more study	5.32% 5
No opinion	3.19% 3
Total	94

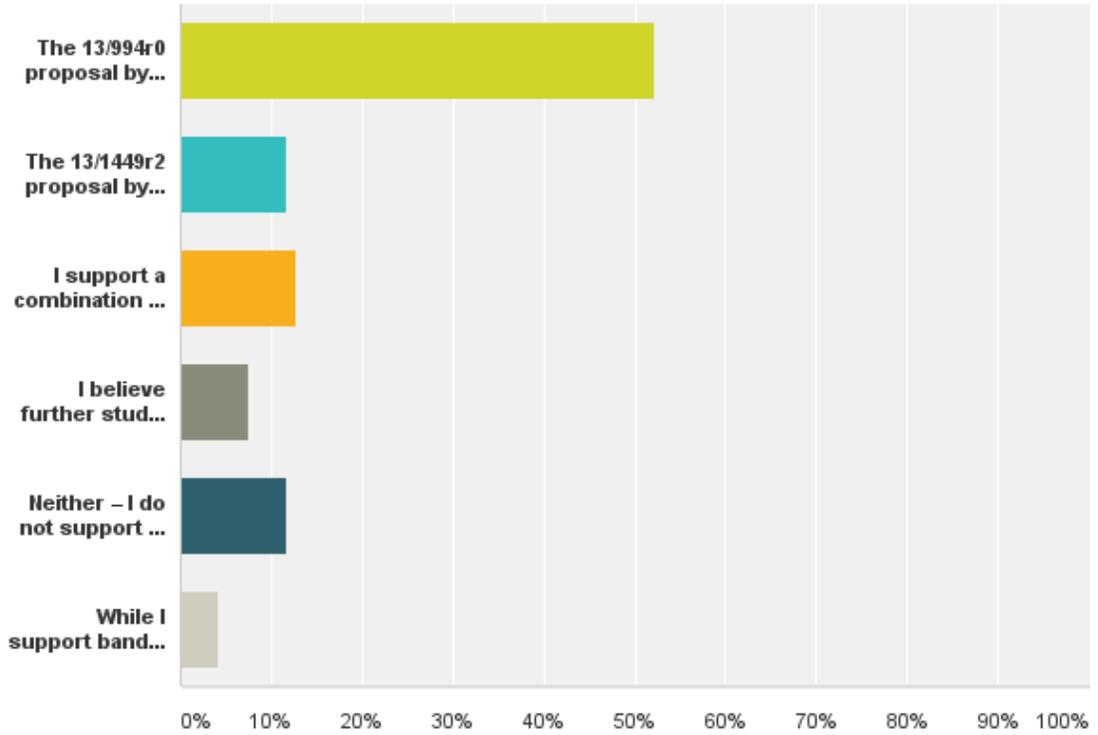
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11.4 Question 4

Which proposal do you support for further specification development and field testing?

- The 13/994r0 proposal by Ecclesine
- The 13/1449r2 proposal by Yucek
- I support a combination of both proposals with additional details added
- I believe further study of both proposals independently is needed
- Neither – I do not support any band sharing
- While I support band sharing, I do not believe either approach can form the basis for an acceptable band sharing solution – we need something different



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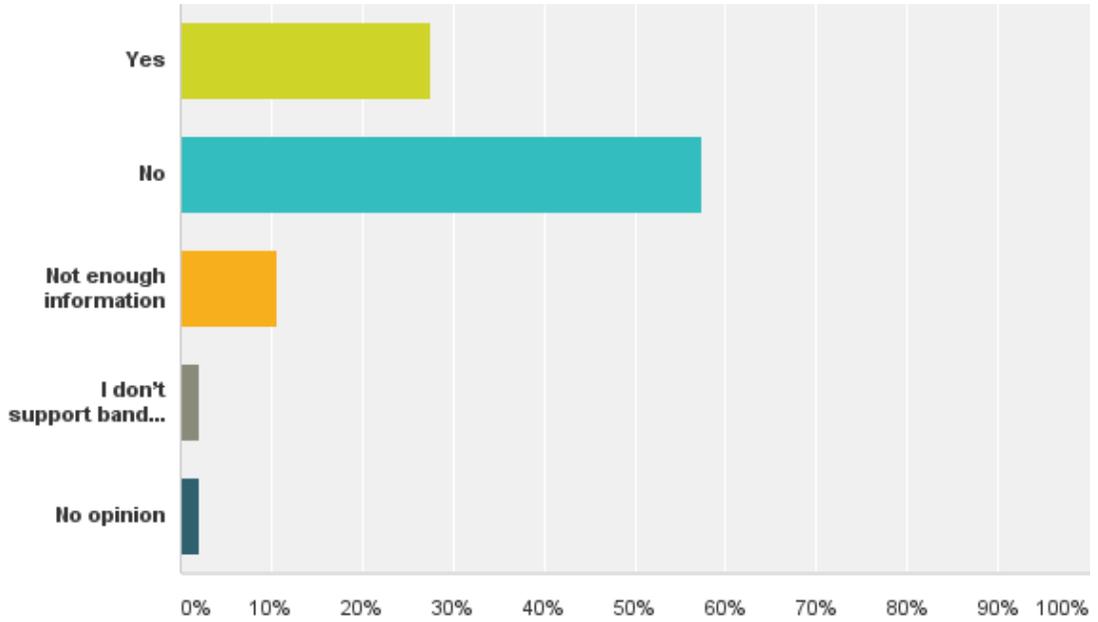
Answer Choices	Responses
The 13/994r0 proposal by Ecclesine	52.13% 49
The 13/1449r2 proposal by Yucek	11.70% 11
I support a combination of both proposals with additional details added	12.77% 12
I believe further study of both proposals independently is needed	7.45% 7
Neither – I do not support any band sharing	11.70% 11
While I support band sharing, I do not believe either approach can form the basis for an acceptable band sharing solution – we need something different	4.26% 4
Total	94

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11.5 Question 5

Would you support a Part 90/95 rule change to move the V2V Safety Channel (currently in Channel 172) to one of the upper channels (180, 182, or 184)?



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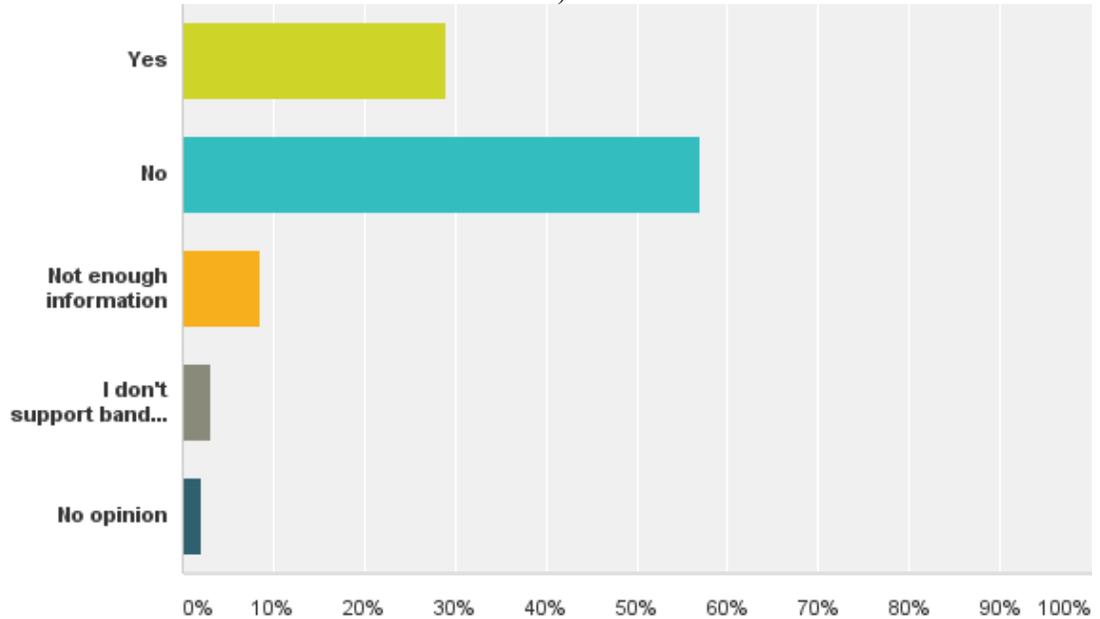
Answer Choices	Responses
Yes	27.66% 26
No	57.45% 54
Not enough information	10.64% 10
I don't support band sharing	2.13% 2
No opinion	2.13% 2
Total	94

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11.6 Question 6

Would you support a proposal to use one of the upper channels (180/182/184) for V2V Safety Channel traffic instead of Channel 172? (No rule change. Part 95 still applies to Channel 172. Channel 172 would be shared with Part 15 devices)



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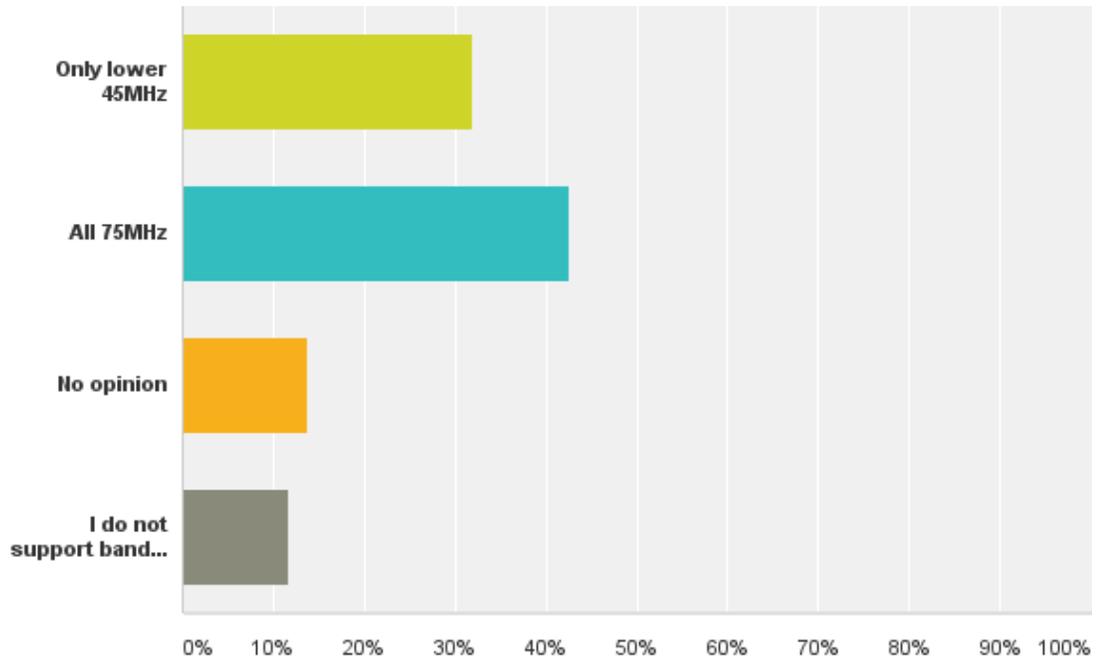
Answer Choices	Responses
Yes	29.03% 27
No	56.99% 53
Not enough information	8.60% 8
I don't support band sharing	3.23% 3
No opinion	2.15% 2
Total	93

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11.7 Question 7

If band sharing is allowed, would you prefer that the upper edge of the U-NII4 band be at 5.925 GHz (all 75MHz) or 5.895 GHz (only the lower 45MHz)?



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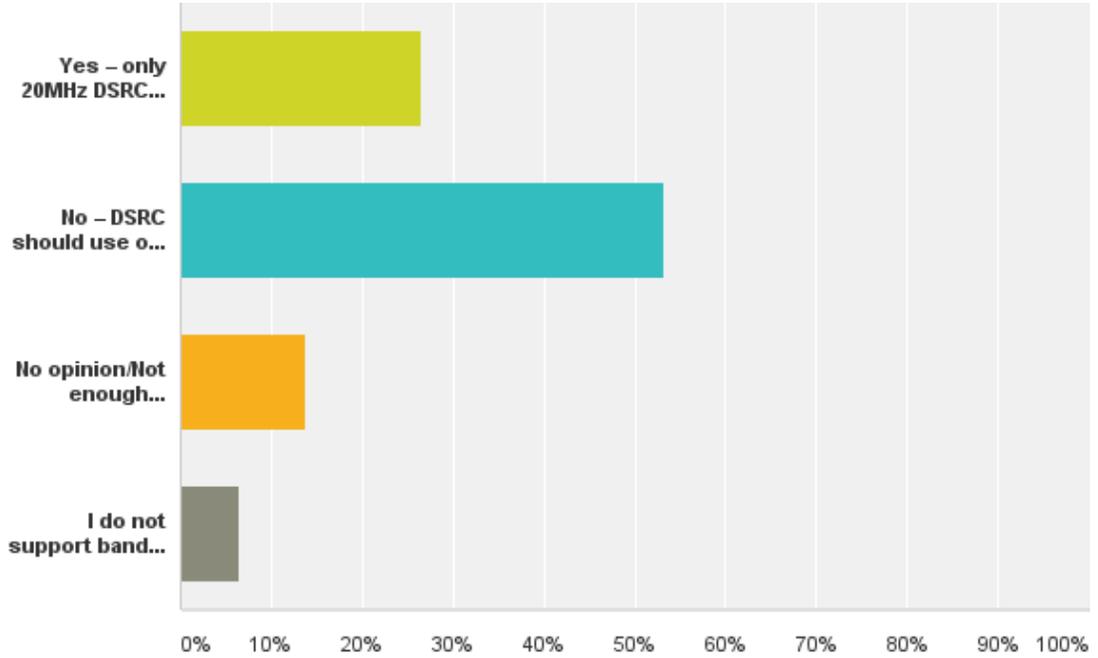
Answer Choices	Responses
Only lower 45MHz	31.91% 30
All 75MHz	42.55% 40
No opinion	13.83% 13
I do not support band sharing	11.70% 11
Total	94

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11.8 Question 8

If sharing is only allowed in the lower 45MHz portion of the band (5850-5895MHz), should DSRC only use 20MHz channels 173 and 177 in that shared portion of the band? (Note: Channels 172 & 178 in Part 95 are defined as 10MHz in bandwidth, so a rule change may be required. Channels 173 and 177 align with 11ac.)



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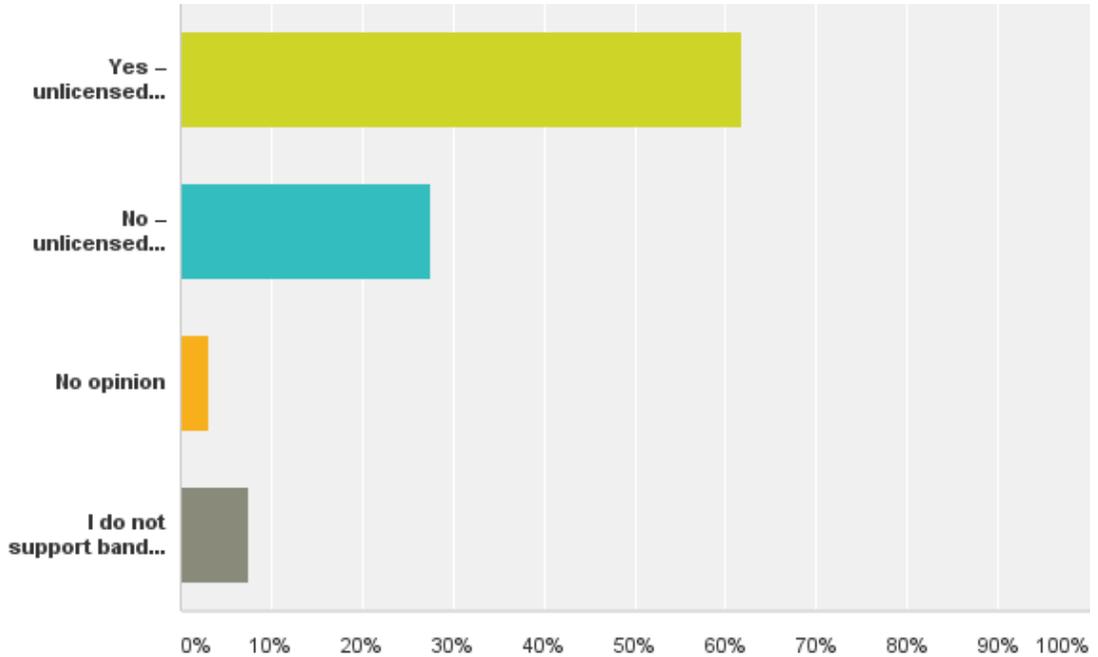
Answer Choices	Responses
Yes – only 20MHz DSRC channels in the shared band	26.60% 25
No – DSRC should use only 10MHz channels	53.19% 50
No opinion/Not enough information	13.83% 13
I do not support band sharing	6.38% 6
Total	94

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11.9 Question 9

If a Clear Channel Assessment approach is adopted as outlined in document 13/994r0 by Ecclesine, would unlicensed devices need to vacate the entire 5850-5925 MHz band after detecting a DSRC signal on any one channel within the band in order to avoid harmful interference?



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Answer Choices	Responses
Yes – unlicensed devices would need to vacate the entire shared band (5850-5925 MHz) after detecting a DSRC signal on any channel	61.70% 58
No – unlicensed devices could still operate in other unoccupied parts of the shared band (5850-5925 MHz) after detecting DSRC signals on one or more channels	27.66% 26
No opinion	3.19% 3
I do not support band sharing	7.45% 7
Total	94

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11.10 Summary

As these straw poll results indicate, most members believe there is not enough information to make a clear decision (see Question 1), although members showed a preference for the 13/0994r0 proposal by Ecclesine over the 13/1449r2 proposal by Yucek (see Question 4). Clearly, more work needs to be done beyond the time frame of this tiger team before any definitive technical recommendations could be made.

379 12. Next Steps

380 As mentioned previously, this report only outlines some proposed band sharing ideas; more detailed
381 analysis, simulation, and – most importantly – field testing will be necessary to adequately verify that
382 unlicensed devices are not causing harmful interference to DSRC systems under a proposed band
383 sharing method⁶. Field trials will be an important part of evaluating DSRC coexistence in the U-NII-
384 4 band; as analysis continues on these proposals beyond the time frame of this Tiger Team, prototype
385 development of sharing technologies can occur in parallel. The materials considered in this Tiger
386 Team, particularly the use cases, should be of significant value in designing these field trials. While
387 it is not known if a test bed, such as the one deployed in Ann Arbor (MI) for the US Department of
388 Transportation’s DSRC Model Deployment, will be available for testing of the DSRC coexistence
389 techniques described in this report, it is expected that there will be facilities available to perform “real
390 world” testing to insure that the proposed coexistence approaches achieve satisfactory band sharing
391 performance. It is assumed that stakeholders from the ITS/DSRC and 802.11 communities, as well as
392 potentially from government agencies, will participate in field/lab testing of any of these candidate
393 spectrum sharing technical solutions.

394 13. Conclusion

395 The 5 GHz band is of great importance to both the 802.11 WLAN and V2V/V2I industries. With the
396 release of the 13-22 NPRM, the FCC has created the possibility for a substantial increase in available
397 unlicensed spectrum for 802.11 WLAN, particularly the ability to use 160MHz channels as described
398 in 802.11ac. The proposed sharing of the ITS/DSRC band from 5.85-5.925 GHz poses numerous
399 technical challenges that the WLAN and ITS industries must address to make sure that the
400 applications – including crash avoidance - enabled by DSRC are not harmfully interfered with by
401 unlicensed users of this band. With the conclusion of this activity, this 802.11 DSRC Coexistence
402 Tiger Team has brought the various stakeholders together and laid the groundwork for field/lab
403 testing once one or more sharing proposals are fully developed and prototype U-NII-4 devices
404 become available. While the Tiger Team did not agree on a single consensus position for band
405 sharing, information given in this report along with subsequent follow-on testing can form the basis
406 of future regulatory policy, standards efforts, and technology deployments.
407

408 14. References

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458 **Appendix A: Participants in the DSRC Coexistence Tiger Team**

459

460 Leadership:

461 Jim Lansford, Chair, DSRC Coexistence Tiger Team (CSR)

462 Rich Kennedy, Chair, IEEE 802.11 Regulatory Standing Committee (Mediatek)

463

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VK Jones	Qualcomm
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Charles Perkins	Futurewei
James Wang	Mediatek
Mingguang Xu	Marvell

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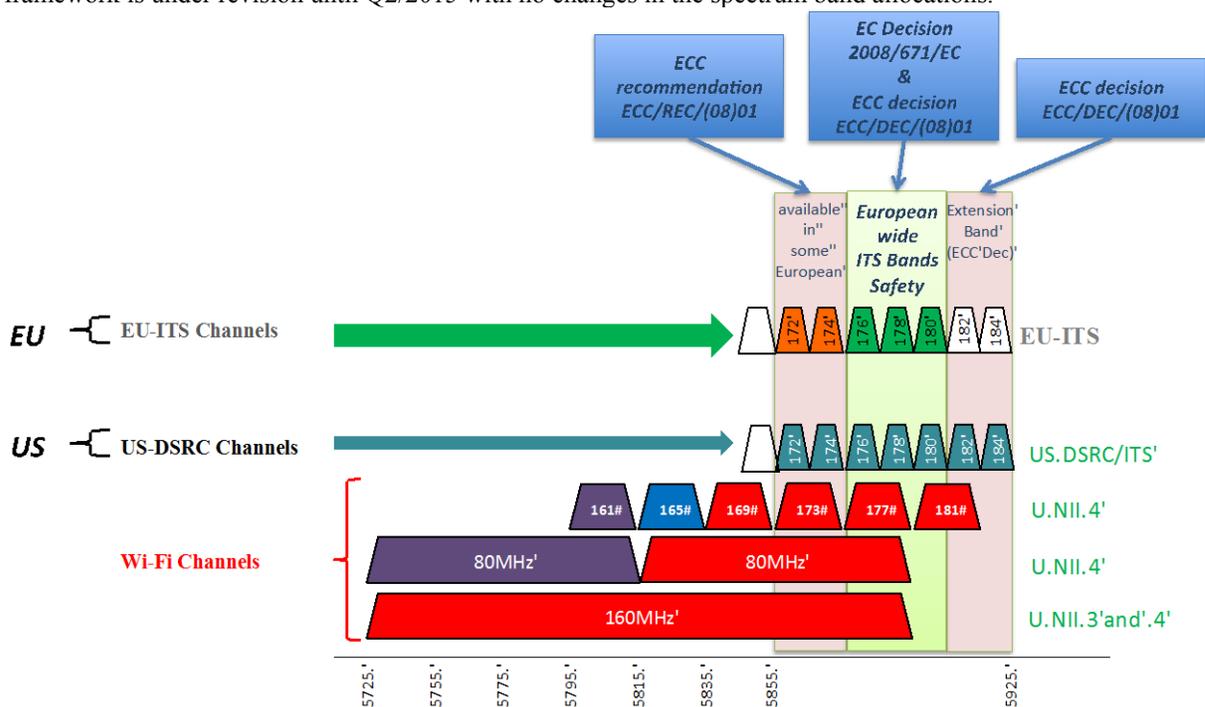
Appendix B: Documents submitted to the DSRC Coexistence Tiger Team (Links on IEEE Mentor server)

- 466
- 467
- 468 – <https://mentor.ieee.org/802.11/dcn/13/11-13-0552-00-0wng-802-11p-dsrc-and-802-11ac-coexistence.ppt>
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490 **Appendix C: Cooperative ITS spectrum regulation in the 5GHz band in Europe**

491 **Overview**

492
 493 The European ITS spectrum regulation is based on an decision of the Electronic Communications Committee of the
 494 European Conference of Postal and Telecommunications Administrations (CEPT/ECC) (ECC/DEC/(08)01) for the
 495 band 5895 MHz to 5905MHz including an extension band from 5905MHz to 5925MHz and a CEPT/ECC
 496 recommendation (ECC/REC/(08)01) for the band 5855MHz to 5875MHz. The Recommendations is implemented in
 497 a limited number of European countries.
 498 In addition, the European Commission allocates the frequency band 5875 – 5905 MHz in a legally binding way in
 499 the European Union for safety-related ITS application (Commission Decision 2008/671/EC), a.k.a. cooperative ITS
 500 (C-ITS) and vehicle-to-x communications (V2X).. This band is available for a European wide deployment of
 501 cooperative ITS services. The cooperative ITS spectrum allocation in Europe is depicted in Figure C-1. This legal
 502 framework is under revision until Q2/2015 with no changes in the spectrum band allocations.



503 **Figure C-1: European cooperative ITS spectrum allocation**

504
 505 **Mitigation requirements**

506 In Europe an activity on potential mitigation techniques and procedures to protect existing services have been
 507 initiated by the EU commission with a mandate to the CEPT.
 508 As an initial result of this mandate (see CEPT Report A to the EU commission), work on mitigation techniques has
 509 been initiated to enable the compatibility between individual RLAN⁷ devices and ITS. These studies have focussed
 510 on “listen-before-talk” process, where the potential interferer tries to detect whether a channel is busy before
 511 transmitting a data packet.

512 Two possible approaches are under study:

- 513 • Generic Energy Detection without any consideration of the interferer and victim signal frames: preliminary
 514 analysis indicated that a detection threshold of the order of -90 dBm/10 MHz would be required for a
 515 reliable detection of ITS. Further consideration is required, including on the feasibility of such a detection
 516 threshold and its impact on the RLAN operation.

⁷ European regulators generally refer to WLAN as RLAN

- 517 • Combination of energy detection and carrier sensing, such as one of the Clear Channel Assessment (CCA)
518 modes defined in 802.11 standards. Further studies are required to assess the applicability to ITS of the
519 interference avoidance techniques currently employed in 5 GHz RLAN systems under dynamic multipath
520 fading conditions.

521 In the further development of the detection mechanisms the mobile characteristics of the ITS environment has to be
522 taken into account. This can be achieved by deploying dynamic multipath fading channel models in the evaluation
523 process of the investigated mitigation techniques. These channel models are under development in ETSI TC ITS.
524 In face of the market deployment of ITS-G5 systems in 2015 the European channel allocation and the deployed
525 bandwidth (10 MHz) in the ITS systems can no longer be changed at this point in time. All suggestions and
526 mitigation techniques relying on reallocating spectrum or demanding the change of the channel bandwidth cannot be
527 considered as a feasible solution.

528 **Conclusion**

529
530 In its report to the EU commission the European regulators have stated some important requirements for a potential
531 coexistence between future RLAN deployment and ITS in the 5GHz band:

- 532 • The European channel allocation and the channel bandwidth of 10 MHz cannot be changed.
- 533 • Channel reallocation to avoid interference between C-ITS and 802.11 RLAN is not feasible. In Europe not all
534 channels are allocated yet, therefore channel relocation is not supported by the European regulators.
- 535 • The detection of C-ITS signals should consider the sensitivity and dynamic conditions of C-ITS, i.e. a highly
536 dynamic environment, including (Doppler/multipath) effects from moving signal sources on the transmitted and
537 received signals.

538 A potential future RLAN spectrum regulation in Europe will be based on these basic assumptions. The further
539 development of mitigation techniques for the European regulation is now under development and evaluation in
540 ETSI TC BRAN in close cooperation.

541

Appendix D: USDOT Participation in IEEE Tiger Team re. 5 GHz Spectrum Sharing

US Department of Transportation (USDOT) staff participated in IEEE Tiger Team Meetings. USDOT's primary role was to monitor the progress of the team's work. When appropriate, USDOT provided clarifying information to the team and/or technical input based on their technical expertise. USDOT did not seek to advocate any specific outcome; rather USDOT sought to respect the value of the consensus processes of IEEE.

USDOT reviewed the two potential approaches to spectrum sharing made available to the Tiger Team; and offers the following initial evaluation, recognizing that insufficient detail was provided to reach any conclusions on either approach's risk to transportation safety use of the spectrum:

13/1449r2 proposal by Yucek:

1. The current proposal appears inconsistent with the premise of the spectrum sharing concept proposed in the FCC NPRM (FCC 13-22, February 20, 2013); namely, that unlicensed users would operate in the 5 GHz band on a non-interference basis with respect to the incumbent licensed systems. This proposal actually appears to be a reallocation of spectrum away from the current incumbent and thus appears to be outside the bounds of the NPRM.
2. Limiting the DSRC incumbent to primary use of only 30 MHz of spectrum is insufficient to support even a portion of all planned safety applications which include vehicle-to-infrastructure (V2I) as well as vehicle-to-vehicle (V2V) applications.
3. Moving the safety channel, the control channel, and the high powered public safety communications into adjacent channels would be expected to substantially increase adjacent channel interference levels, which places at risk the effectiveness of the safety critical applications that provide imminent crash notification alerts to drivers.
4. The proposed approach would effectively invalidate a substantial portion of the many years of safety application testing and international standards development and harmonization work undertaken by the USDOT and industry partners. This work has had European and Asian partners using both governmental and industry funding and support. It would require much of this research and testing work to be repeated; such additional work would delay availability of life-saving technologies and impose large costs.
5. The proposal does not provide sufficient detail to support analysis of potential impact on safety applications beyond the points made above.
6. As a result, this proposal as submitted appears problematic on many levels and is technically unsuitable to meet the non-interference criteria set forth in the NPRM.

13/0994r0 proposal by Ecclesine:

1. This proposal did not provide sufficient detail to support analysis to understand the impact on safety applications. Additional detail which would have been beneficial includes but is not limited to:
 - What is the 802.11ac back-off time if DSRC is detected?
 - What is the ability or sensitivity of 802.11ac to detect the DSRC 10 MHz channel?

USDOT looks forward to continuing cooperation in supporting research for successful sharing methodologies and is ready to actively participate in testing and evaluation when equipment becomes available.