IEEE P802.11  
Wireless LANs

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| Draft TGbd Comments on FCC NPRM Docket 19-138 | | | | |
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Abstract

This document provides a draft of the potential 802.11 TGbd positions and opinions related to the United States (US) Federal Communications Commission (FCC) recently released Notice of Proposed Rule Making (NPRM) on the matter of use of the 5.850-5.925 GHz Band, ET Docket No. 19-138.

r0 – The content of this revision is based on previous available content from some available references. The content has not been yet discussed by 802.11 TGbd and hence is provided only as a place to start the discussion.

r1 – This revision: added proposed text provided by James Lepp and Ioannis Sarris, removed some typos and grammar errors. The content has been presented in IEEE 802.11 TGbd, but no agreement or endorsement of this content has been made by the IEEE 802.11 TGbd nor has there been any endorsement or approval of the content of this document by the IEEE 802.11 WG.

r2 - Additional edits and some additions, provided by Yossi Shaul.

r3 – Feedback from 802.18

r4 – Edits and additions made during the Tuesday PM2 802.11 TGbd MAC ad hoc session. r5 – Edits by Ioannis Sarris & Sebastian Schiessl to address comments made during 802.18 session.

r6 – Additions/edits provided by e-mail from: Ioannis Sarris, Sebastian Schiessl, and Hyun Seo Ohand. Also, some clean up by Joseph Levy (editor of this document).

r7 – Additional edits and inclusion of some additional text. Note: additional edits are required (references need to be fixed, structure and organization need improvement, and references to NPRM should be added.

r8 – Accepted all additions and edits to establish a clean baseline document

r9 - Edits made to address structure, organization, and provide references to the NPRM – these references need to be reviewed. Note additional organization may be necessary as we may want to put our comments in NPRM paragraph order. Also, reference “numbering” needs to be cleaned up.

**Before the Federal Communications Commission**

**Washington, D.C. 20554**

In the Matter of )

)

of Use of the 5.850-5.925 GHz Band ) ET Docket No. 19-138

**Ex Parte OF IEEE 802**

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Chair, IEEE 802 LAN/MAN Standards Committee

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January 2020

# Introduction

IEEE 802 LAN/MAN Standards Committee (LMSC) is pleased to provide comments on the above-captioned proceeding to the NPRM on the use of the 5.850-5.925 GHz Band dated 17 December 2019.

IEEE 802 LMSC is a leading- consensus-based industry standards body, producing standards for wireless networking devices, including wireless local area networks (“WLANs”), wireless specialty networks (“WSNs”), wireless metropolitan area networks (“Wireless MANs”), and wireless regional area networks (“WRANs”). We appreciate the opportunity to provide these comments to the Commission. With the release of FCC NPRM 19-129 (Docket 19-138), the United States Federal Communications Commission has requested comments regarding assess the 5.9 GHz band rules and propose appropriate changes to ensure the spectrum supports its highest and best use. In this NPRM it is proposed to: … continue to dedicate spectrum—the upper 30 megahertz portion of the band—for transportation and vehicle safety purposes, while repurposing the remaining lower 45 megahertz part of the band for unlicensed operations to support high-throughput broadband applications.”

IEEE 802 is a committee of the IEEE Standards Association and Technical Activities, two of the Major Organizational Units of the Institute of Electrical and Electronics Engineers (IEEE). IEEE has about 420,000 members in about 190 countries and supports the needs and interests of engineers and scientists broadly. In submitting this document, IEEE 802 acknowledges and respects that other components of IEEE Organizational Units may have perspectives that differ from, or compete with, those of IEEE 802. Therefore, this submission should not be construed as representing the views of IEEE as a whole.1

The IEEE Std 802.11p-2010 amendment, now incorporated into IEEE Std 802.11-2016, provides core technology for Dedicated Short Range Communication (DSRC). The term "OCB" (outside the context of a BSS) was introduced in IEEE 802.11p, which specified "Wireless Access in Vehicular Environments". The OCB specifications within IEEE Std 802.11 continue to support DSRC-compatible operation.

The IEEE 802.11 Working Group (WG) is now specifying an IEEE Next Generation V2X (NGV) amendment the P802.11bd project. As described below, the IEEE NGV amendment is intended to provide a seamless evolution path from DSRC in the 5.9 GHz DSRC band. Any consideration of the rules governing use of the 5.9 GHz band must recognize the societal value of allowing DSRC and IEEE NGV to operate together throughout the band. It should be noted that one of the advanced features being considered for the P802.11bd project is 20 MHz bandwidth operation. Also, 20 MHz operation may allow for simple sharing of spectrum resources with other IEEE 802.11 based technologies.

Additional background information: the IEEE 802.11 Regulatory Standing Committee provided an open, public forum to study the issues surrounding U-NII-4 band sharing between Wireless Local Area Networks and Dedicated Short Range Communications; this DSRC Coexistence “Tiger Team” has examined some initial ideas for how band sharing could work. The complete record of the work of the Tiger Team since its inception in August 2013, identifies the issues surrounding the proposed band sharing ideas discussed in the group, assesses the level of support for these concepts among the participants in the group, and recommends next steps for validating the sharing methods. The record is contained in a subset of the documents stored at <https://mentor.ieee.org/802.11/documents?is_group=0reg>. The relevant documents are dated between 21 August 2013 and 11 March 2015; most, but not necessarily all, include the word "DSRC" and/or "Tiger" in the title.

The record will 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.

II. Current deployments are using the entire band

As the US Department of Transportation noted, in October 2018 there were already more than 70 active DSRC deployments, using all seven channels and with thousands of vehicles on the road2. IEEE 802 believes that allowing automakers and infrastructure owner-operators to evolve their deployments to NGV over time will protect past and future investments in DSRC, providing a critical incentive for additional deployment of these life-saving technologies. As outlined below, we are concerned that alternative deployment models, will undermine existing investments and discourage widespread deployment of V2X technology.

IIa. On Interoperability and Coexistence.

We recommend that the commission base decision on how to allocate spectrum to technologies should be based on objective analysis, data, and studies.

} is this too controversial to bring up?

who wants the $s. could look back at original FCC R&O on interoperability, 2003.

# Definitions:

To facilitate this discussion, we offer specific definitions of key terms. These definitions describe various relationships between IEEE Std 802.11-2016 OCB (802.11p) devices and IEEE P802.11bd devices (also known as DSRC and IEEE NGV devices, respectively). While these definitions are for devices implementing the DSRC and NGV technologies, they may also be applied more generally to analyze the relationship between other V2X technologies. These definitions are agreed3 within IEEE 802.11 TGbd (the task group developing the IEEE P802.11bd NGV amendment):

• **Interoperability –** IEEE 802.11p devices to be able to decode at least one mode of transmission of IEEE 802.11bd devices, and IEEE 802.11bd devices to be able to decode IEEE 802.11p transmissions

• **Co-existence** – IEEE 802.11p devices to be able to detect IEEE 802.11bd transmissions (and hence defer from transmissions during IEEE 802.11bd transmissions causing collisions) and vice versa

• **Backward compatibility** – Ability of IEEE 802.11bd devices to operate in a mode in which they can interoperate with IEEE 802.11p devices

• **Fairness** – Ability of IEEE 802.11p devices to have the same opportunities as IEEE 802.11bd devices to access the channel

# Comments on the proposal to “create sub-bands within the 5.9 GHz band to allow unlicensed operations to operate in the lower 45 megahertz of the band (5.850-5.895 GHz) and reserve the upper 30 megahertz of the band (5.895-5.925 GHz) for ITS.” [A], paragraph 11

## IEEE 802.11 support of the full band

IEEE Std 802.11-2016 and its amendment 802.11ax provide specifications that are applicable for supporting WLAN (Wi-Fi) and ITS applications (use cases) for the full 75MHz of spectrum between 5850 and 5925 MHz . IEEE 802 applauds the rules designed to extend wider channels across 5850-5925, as this enables IEEE Std 802.11-2016 and 802.11ax based devices to use 80MHz and 160MHz.

## IEEE 802.11 support of the ITS frequency band

The IEEE Std 802.11-2016 OCB functionality (802.11p) and ongoing work in the IEEE 802.11 TGbd provide technical capabilities for ITS in the defined ITS band around the world, not just in the USA. The ITS band has been thoroughly studied at previous World Radio Conferences. The available ITS bands should be available for the deployment of IEEE Std 802.11-2016 OCB functionality (802.11p) and future evolving technologies such as those currently being developed in 802.11 TGbd task group from 5895-5925MHz. It is specified this way to support ITS applications in other regulatory domains.

In summary, IEEE 802.11 is continuing to evolve the radio technology for various applications including WLAN connectivity and ITS in all regions around the world. {whether the NPRM results in 10MHz for the DSRC Service, 30MHz for the DSRC Service or maintains the 75MHz for the DSRC Service,.}

} need to review from point of view of 802.11 in general to support general partitioning from the FCC? considering for all of 802.11.

can we just be silent on the 75MHz partitioning overall?

text was meant to by the whole 75MHz for 802.11 in general. can edit some.

# Comments on “… the transportation and vehicular-safety related applications that are particularly suited for the 5.9 GHz band as compared to other spectrum bands, and how various bands can be used efficiently and effectively to provide these applications.” [A], paragraph 19

## On the spectrum needs for achieving the full benefit of traffic safety technologies:

Over the past decade, a lot of effort has been dedicated to validating the spectrum requirements and needs to guarantee that the full potential of traffic safety goals is met in order to save more lives. The US Department of Transportation (DoT) in its latest report “*Preparing for the Future of Transportation*” [[1](https://www.transportation.gov/av/3/preparing-future-transportation-automated-vehicles-3)] has highlighted the need for sufficient spectrum to enable V2X communications throughout the US. Moreover, an in-depth assessment made by the Car2Car Communication Consortium  [[2](https://www.car-2-car.org/fileadmin/documents/General_Documents/C2CCC_TR_2050_Spectrum_Needs.pdf)] has estimated the needs for V2X, regardless of the communication technology in the US.

IEEE 802 believe that further splitting the 30 MHz allocated in the NPRM to the ITS applications will maximize the damage to the existing deployment and diminish the benefit we can get from deploying ITS technologies in the band.

} the above is indicating all 75MHz for ITS, not following the silence on partitioning of the entire 75 MHz. {so will look at some editing in here.}

} how does this keep safety as part of the final plan?

(discussion was on fatalities, e.g. RR crossing and all)

} what about other bands to bring up, e.g. 4.9GHz.

# Comments on “… the transportation and vehicular-safety related applications that are particularly suited for the 5.9 GHz band as compared to other spectrum bands, and how various bands can be used efficiently and effectively to provide these applications.” [A], paragraph 19

# Comments on “… on the available technical studies on C-V2X that should inform our consideration of C-V2X, including any recent studies that provide information about how C-V2X would operate in the 5.9 GHz band.” [A], paragraph 26

## 5G connectivity benefits should not be coupled to C-V2X:

It is often wrongly assumed that the anticipated benefits of 5G connectivity are uniquely associated with the PC5 side link interface of C-V2X. Furthermore, the capability of 5G in terms of Vehicle-to-Network (V2N) communication achieved through the (Uu) communication interface is widely confused with C-V2X using PC5 for Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I). It is important to clarify that the V2N capability is a distinct function using separate frequency resources, usually in the spectrum below 3 GHz. We agree that cellular V2N connectivity in terms of (Uu) communication could complement V2V and V2I to achieve a longer range. However, these benefits of V2N can be achieved regardless of whether the V2V and V2I communications are based on C-V2X or DSRC. The SCOOP project with a fleet of 3000 vehicles already demonstrates that cellular 4G connectivity for V2N can be successfully and efficiently combined with DSRC for V2V [3] {this reference seems to be broken}.

## Vehicle-to-Pedestrian Communications (V2P)

In its waiver request, the 5GAA states that “C-V2X enables **direct, peer-to-peer mode** communications […] between vehicles and pedestrians, cyclists and other vulnerable persons (“V2P”) […]” (emphasis added). This statement is false. Mobile phones of cyclists or pedestrians are not compatible with the C-V2X PC5 sidelink interface for direct peer-to-peer communication with vehicles at 5.9 GHz. Due to many technical difficulties, for example creating antennas that operate in both the cellular band and 5.9 GHz, it is very unlikely that they will do so in the future. Instead, the underlying assumption is that vehicles and pedestrians communicate **indirectly**, i.e., over the regular cellular network. We agree with the 5GAA about the value of such communications, but as we have noted in the previous comment, such a cellular communication interface can be combined with either C-V2X PC5 or DSRC, and is therefore not a reason to rededicate parts of the 5.9 GHz band for C-V2X.

On the contrary, V2P communications provide a very strong argument for using DSRC over C-V2X. Except for very low-end models, all modern mobile phones are now equipped with IEEE 802.11ac/ax WiFi modules, which operate in the 5 GHz frequency band and support channels up to 5835 MHz. The corresponding antennas and analog RF frontends could therefore easily support the 5850 to 5925 MHz spectrum, meaning that moderate changes to existing WiFi chips will allow direct peer-to-peer communication from DSRC-capable vehicles to mobile phones, enabling safety messaging to warn pedestrians and cyclists about oncoming vehicles.

} need to define Uu

} more editing will be looked at. e.g. C-V2X is not the only technology. with 5G.

} need to watch not to promote 5G, need to soften more.

# Comments on “We propose to modify existing DSRC licenses to allow operation in only the 5.895-5.925GHz sub-band to the extent that licensees want to operate a C-V2X system or only in 5.895-5.905 GHz to the extent this sub-band is retained for DSRC systems and the licensees want to continue their DSRC operations.” [A], paragraph 34

## V2X Channel Needs

The currently proposed NPRM cites preliminary studies submitted by the 5GAA that have shown that a single 20 MHz channel provides sufficient throughput for many anticipated V2X features. However, we strongly advise against the use of a single channel for both basic safety messages (BSMs) and non-safety-critical messages. Despite the use of intelligent prioritization of BSMs, there is a possibility that BSM suffer from interference by hidden nodes, i.e., vehicles and RSUs that did not understand that a BSM is being transmitted, which can ultimately lead to traffic collisions. The probability for such interference will only increase with increasing market adoption of V2X. Therefore, non-safety critical messages must not be allowed to transmit on the same channel as BSMs.

On the other hand, non-safety critical messages may constitute the major economic driver for market adoption of V2X. For example, platooning of trucks on highways was shown to improve average fuel efficiency by up to 13% for the involved vehicles [3a], potentially leading to billions of dollars in savings for the trucking industry and thus providing a major investment incentive. However, it was shown that the involved vehicles must exchange information at very a high rate of up 30 messages per second [2, p. 14] }check this reference} in order to maintain speed and distance, thus creating frequent potential interference of BSMs.

We conclude that a single channel will be insufficient to support both safety-critical V2X communication as well as V2X features that accelerate market adoption. Instead, we anticipate that at least 2 or 3 different parallel channels will be required for successful adoption of V2X, regardless of whether these channels will use C-V2X or DSRC technology.

**OOB performance/requirements:**

} need contribution text for this section, or will drop out.

# Comment on “… on the extent to which our proposal would make ITS based technologies either more or less effective.” [A] paragraph 66

## Need for common V2X safety format/broadcast type:

### International frequency bands harmonization for ITS applications

ITU-R have studied on international frequency bands harmonization for the current and future ITS applications according to Question ITU-R 205-5/5. Through ITU-R working group study, Recommendation M.2121[3b] provides guidance on harmonized ITS frequency bands to use 5.850~5.925GHz for the current and future ITS applications. And it takes into considerations of regional harmonized frequency bands by referring the examples of the current ITS frequency bands, potential coexistence issues between ITS stations and other applications of the mobile service [1].

### V2X communication technology standards

ITU-R also have studied on radio interface standards of vehicle to vehicle and vehicle to infrastructure two-way communications for the current and planned ITS applications considering Recommendation M.2121. Recommendation M.2084 provides information on V2X standards and technical specifications which have developed by SDOs such as ETSI, IEEE, ARIB, TTA, IMDA, CCSA, 3GPP and ATIS [3c]. It states that V2V/V2I communication technologies for ITS applications should apply industrial standards.

### DOT position on interoperability and robust safety/public safety

Quoted from [AA]: “We note that DOT envisions DSRC units in every new motor vehicle for life-saving communications.  To ensure interoperability and robust safety/public safety[[1]](" \l "_ftn1) communications among these DSRC devices nationwide, we adopt the standard supported by most commenters and developed under an accredited standard setting process (ASTM E2213-03 or “ASTM-DSRC”).”

[[1]](" \l "_ftnref1) We refer herein to “safety/public safety” communication interchangeably because DSRCS involves both safety of life communication transmitted from any vehicle, *e.g.,* vehicle-to-vehicle imminent crash warnings, as well as communication transmitted by public safety entities, *e.g.*, infrastructure-to-vehicle intersection collision warnings.



**Need for compatibility/backwards compatibility:**

} need contribution text for this section, or will drop out.

# Comments on “… how to evaluate the benefits and costs of our proposal given the evolving nature of transportation and vehicular safety-related technologies, both within and outside of the 5.9 GHz band.”, [A] paragraph 66

## IEEE 802 vision of V2X technology evolution:

The IEEE 802 vision for V2X technology evolution is documented in the approved Project Authorization Request for the IEEE NGV amendment4, which requires that:

“This amendment shall provide interoperability, coexistence, backward compatibility, and fairness with deployed OCB (Outside the Context of a BSS) devices.”5

In other words, IEEE next generation V2X technology (NGV) will have fair same-channel coexistence with DSRC and will be interoperable and backward compatible with DSRC.

Furthermore, this vision is extensible to further generations. A future extension of IEEE 802.11p and IEEE P802.11bd will also be able to achieve fair, same-channel co-existence, interoperability, and backward compatibility with previous generations. Backward compatibility across generations of IEEE 802.11 technology is fundamentally based on use of a common packet preamble and channel access mechanism.

The IEEE 802 vision of V2X technology evolution ensures that investments in DSRC are protected over the long lifetimes of automotive on-board units (OBUs) and roadside units (RSUs). This protection is critical for encouraging DSRC deployments today and in the near future. By contrast, any proposals that threaten to impair these investments will discourage deployment and delay the realization of societal benefits from this spectrum.

## 3GPP vision of V2X technology evolution:

By contrast, the 3GPP vision for technology evolution appears to be that none of these attributes will apply between two V2X technologies or two generations of the same technology. LTE V2X PC5 has been specified in a way that it does not achieve fair same-channel coexistence with incumbent DSRC technology, nor does it interoperate with DSRC, nor is it backward compatible with DSRC.

3GPP is now specifying a new generation of cellular V2X (i.e. New Radio, NR). The study item phase of NR V2X PC5 is complete and the terms for the specification phase have been agreed. It is now clear that NR V2X PC5 will fail to achieve any of these key evolution characteristics not only with DSRC but also with the previous generation cellular V2X (LTE V2X PC5). To be clear, NR V2X PC5 will not be able to coexist in the same channel, interoperate, or be backward compatible with LTE V2X PC5.

## Implications of different evolution models:

The 3GPP V2X technology evolution model implies a high societal cost, a cost that is completely avoided in the IEEE 802 V2X evolution model. The 3GPP model implies that V2X spectrum must be fragmented into sub-bands associated with every different V2X technology.

Band fragmentation carries significant costs. First, it disrupts the Commission’s vision of uniformly interoperable communication among all V2X devices based on a single technology family. With multiple non-interoperable technologies operating in different sub-bands, some devices will not be able to communicate with others. For example, if two automakers choose different technologies and different sub-bands for sending Basic Safety Messages (BSMs), vehicle collisions that could have been prevented if those BSMs were successfully exchanged will not be prevented, leading to unnecessary loss of life and property. Many vehicles are already equipped to send BSMs with DSRC. Allowing some automakers to send BSMs using only DSRC, LTE V2X PC5 or NR V2X PC5 will cause a loss of interoperability and attendant increase in road fatalities is a direct result of the fragmentation evolution model. This also extends to all other use cases supported by DSRC and by non-interoperable cellular V2X technologies. V2X evolution under the IEEE 802 model does not suffer this cost. Every vehicle will be interoperable with every other vehicle, whether the vehicles are DSRC-capable or NGV-capable.

# Comment on IEEE 802.11 standards referencing }need to find an NPRM reference to tie this comment to}

## Incorporation by reference to IEEE 802.11 standards

In Paragraph 44 the FCC seeks comment on the proposed change to the incorporation by reference from ASTM E.2213-03. The NPRM proposes changing that to IEEE 802.11p-2010.

We respectfully request that the reference not be made to the superseded 802.11p-2010 standard, but instead to the current IEEE 802.11-2016. In addition, we suggest not incorporating the entire standard, but only the relevant RF performance aspects that are applicable. A reference to IEEE 802.11-2016 Annex D.2 and D.5 would be appropriate to cover radio regulations for IEEE 802.11p and IEEE 802. This suggested change will cover the necessary technical aspects of the IEEE 802.11p radio, as well as be inclusive of the IEEE P802.11bd radio design and potential future backwards compatible IEEE 802.11-based ITS radio designs.

IEEE 802.11 Working Group has a long history of innovation and we expect the same principles of backwards compatibility and same-channel coexistence can be applied in the 5.9GHz ITS band starting with 802.11p, and continuing with P802.11bd and future amendments as technology evolves.

} still open on best reference to use. we do have questions on how to answer the NPRM and where we want the FCC to go.

} backward compatible vs. co-existence and interoperability.

in earlier filings we have text on this, we should consider.

co-existence is not the term to use, since not equivalent services, safety/Wi-Fi

in this context it was 11p to 11bd, then it is valid.

} general input was they will only publish a specific std, not and all future updates.

or does IEEE 802 internally request to keep the old stds current, after a rollup.

# Comments on on the state of DSRC-based deployment and the extent to which existing licensees currently operate on some or all of the existing.” [A] Paragraph 18

## Choosing LTE-V2X as a V2X technology does not address the slow market adoption of V2X:

While it is true that the adoption of DSRC has not moved as quickly as it was originally anticipated, we believe that the reasons are not due to a shortfall of DSRC as a technology or to its maturity for mass deployment. On the contrary, there is strong evidence coming from the US-DoT pilot programs, of which many have already started their operation phases, and showing that the technology is ready for mass market rollout. In fact GM, Toyota, and other automotive manufacturers [[[4](https://media.gm.com/media/cn/en/gm/news.detail.html/content/Pages/news/cn/en/2018/June/0606_Cadillac-Lineup.html)], [[5](https://innovation-destination.com/2018/05/16/toyota-lexus-commit-to-dsrc-v2x-starting-in-2021/)], [6]] made prior commitments to mass deployment of DSRC based system across their respective brands. It is in our belief that the slow adoption of DSRC is more related to the lack of incentive and motivation from road operators scaling up their deployments as well as a reluctance of automotive manufacturers to voluntarily invest in a technology whose benefits are only evident once a significant level of penetration of the technology is reached. This is in contrast to other safety technologies such as radars, lidars, where such dependency on other vehicles to have similar systems is not necessarily needed to achieve a safety benefit. This situation will also be valid for C-V2X and there is no reason to believe that choosing this technology will accelerate the deployment rate. If anything, it should be expected that the immaturity of the C-V2X technology will lead to further delays and uncertainty.

**Conclusion:**

Thank you for consideration of this information. If there are any questions, please contact me.

}need addition content for the conclusion

Regards,

By: /ss/ .

Paul Nikolich

IEEE 802 LAN/MAN Standards Committee Chairman

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**References:**

[A] “In the Matter of: Use of the 5.850-5.925 GHz Band, ET Docket No. 19-138, NOTICE OF PROPOSED RULEMAKING”, Released: December 17, 2019, FCC 19-129

[1] “Preparing for the Future of Transportation: Automated Vehicles 3.0 (AV 3.0)”, U.S. Department of Transportation, October 2018, <https://www.transportation.gov/av/3/preparing-future-transportation-automated-vehicles-3>

[2] “Road Safety and Road Efficiency Spectrum Needs in the 5.9 GHz”, CAR 2 CAR Communications Consortium, 21 February 2018, <https://www.car-2-car.org/fileadmin/documents/General_Documents/C2CCC_TR_2050_Spectrum_Needs.pdf>

[3] <http://www.scoop.developpement-durable.gouv.fr/en/>

[3a] “Influences on Energy Savings of Heavy Trucks Using Cooperative Adaptive Cruise Control”, SAE International, 03 April 2018, <https://www.nrel.gov/docs/fy18osti/70868.pdf>

[3b] Recommendation ITU-R M.2121-0, harmonization of frequency bands for intelligent transport systems in the mobile service, January 2019.

[3c] Recommendation ITU-R M.2084, radio interface standards of vehicle to vehicle infrastructure two way communications for intelligent transport systems, November 2019.

[AA] The REPORT AND ORDER, adopted: December 17, 2003, Released: February 10, 2004,

In the Matter of: Amendment of the Commission’s Rules Regarding Dedicated Short-Range Communication Services in the 5.850-5.925 GHz Band (5.9 GHz Band), Amendment of Parts 2 and 90 of the Commission’s Rules to Allocate the 5.850-5.925 GHz Band to the Mobile Service for Dedicated Short Range Communications of Intelligent Transportation Services, WT Docket No. 01-90, ET Docket No. 98-95, RM-9096

[4] “Cadillac to Expand Super Cruise Across Entire Lineup”, GM Corporate Newsroom, 06 June 2018 <https://media.gm.com/media/cn/en/gm/news.detail.html/content/Pages/news/cn/en/2018/June/0606_Cadillac-Lineup.html>

[5] “Toyota, Lexus Commit to DSRC V2X Starting in 2021”, Innovationdestination Automotive, 16 May 2018, <https://innovation-destination.com/2018/05/16/toyota-lexus-commit-to-dsrc-v2x-starting-in-2021/>

[6] This link seems to be missing in the contributed material. (TBS)