Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	
Revision of Part 15 of the Commission's	)	
Rules to Permit Unlicensed National	)	ET Docket No. 13-49
Information Infrastructure (U-NII) Devices in	)	
the 5 GHz Band	)	

COMMENTS OF THE

TOYOTA MOTOR CORPORATION

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SUMMARY

Toyota Motor North America, Inc., on behalf of Toyota Motor Corporation (collectively, "Toyota") hereby submits Toyota's initial comments in connection with the above-captioned Notice of Proposed Rulemaking.[1] Toyota generally supports the Commission's efforts to find more spectrum for innovative unlicensed uses. However, Toyota believes that the Commission's proposal to open the 5.850-5.925 MHz ("5.9 GHz" or "UNII-4") band to unlicensed U-NII devices is premature. This portion of the 5 GHz band already has been assigned for dedicated short range communication ("DSRC") systems, and is critical to the development of next-generation safety-of-life applications, as well as other connected vehicle functionalities. While Toyota is not conceptually opposed to sharing this spectrum with unlicensed U-NII devices in the future, the Commission must work with other federal agencies and all affected private sector

[1] In the Matter of Revision of Part 15 of the Commission's Rules to Permit Unlicensed National Information Infrastructure (U-NII) Devices in the 5 GHz Band, ET Docket No. 13-49, *Notice of Proposed Rulemaking* (2013) ("Notice").

constituencies to ensure that there is minimal interference risk attending the co-existence of DSRC systems and U-NII devices at any given moment.

It is unclear at this juncture whether current rules governing unlicensed operations at 5 GHz can or should be extended to the U-NII-4 band, and more generally, the technical issues surrounding any proposals to share this spectrum with U-NII devices will require much additional study. Given the stakes involved in terms of protection of life and property, Toyota strongly urges the Commission to take a cautious and deliberate approach that is focused on building a thorough empirical record to avoid harmful interference with DSRC systems before considering the implementation of sharing rules in the U-NII-4 band.

I. BACKGROUND

In 1999, the Commission allocated 75 MHz of spectrum in the 5.9 GHz band to be used for DSRC by the Intelligent Transportation Systems ("ITS") community.[2] In 2003, the Commission adopted licensing and service rules for DSRC systems operating in the 5.9 GHz band.[3] The DSRC Service facilitates vehicle-to-vehicle ("V2V") and vehicle-to-infrastructure ("V2I") communications, and the Commission has expressly acknowledged the potential of DSRC systems "to protect the safety of the traveling public" and "save lives by warning drivers

[2] *See* In the Matter of 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, ET Docket No. 98-95, *Report and Order*, 14 FCC Rcd 18221 (1999).

[3] *See* 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, *Report and Order*, 19 FCC Rcd 2458 (2004).

of an impending dangerous condition or event in time to take corrective or evasive actions."[4]

Since 2002, the U.S. Department of Transportation ("DOT") has been conducting research and field testing with automotive manufacturers in order to demonstrate feasibility and prepare for widespread deployment of effective crash avoidance systems that use V2V and V2I communications.[5] These preparations have assumed there will be no harmful interference from other wireless systems.[6] Engineering prototypes have been developed at a level to support research, demonstration and large scale evaluation in connection with applications that address the most critical crash scenarios.

In 2010, as a result of the collaborative effort with automotive manufacturers described above, the National Highway Traffic Safety Administration ("NHTSA") issued a report entitled as "*Frequency of Target Crashes for IntelliDrive Safety Systems*."[7] The report estimates the frequency of different crash types that would be addressed using both V2V and V2I communications as part of the IntelliDrive SM safety systems program (now designated as the "Connected Vehicle" program). Analyses indicated that connected vehicle technology could potentially address approximately 80 percent of the crash scenarios involving non-impaired drivers. Specifically, NHTSA research shows that this technology could help prevent the majority of types of crashes that typically occur in the real world, such as crashes at intersections or while changing lanes. Additionally, NHTSA's analysis of communication alternatives

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[4] *See* http://www.wireless.fcc.gov/services/index.htm?job=service_home&id=dedicated_src.

[5] Toyota has been actively involved in the Vehicle Safety Communications ("VSC") consortium consisting of eight original equipment manufacturers, under Cooperative Agreement between the Crash Avoidance Metrics Partnership ("CAMP") and U.S. DOT.

[6] Indeed, we note that just last year the IEEE Standards Association ratified IEEE Std. 802.11-2012, which prohibits non-DSRC Wi-Fi usage of the 5.9 GHz band in the US and Europe (Annex E.2.3 of 802.11-2012).

[7] *See* "Frequency of Target Crashes for IntelliDrive Safety Systems," DOT HS 811 381 (October 2010).

concluded that DSRC at 5.9 GHz is "the only communication option at this time capable of effectively and reliably providing this safety-of-life capability."[8]

Toyota's philosophy with respect to the development of connected vehicle technology is dictated by Toyota's overall Global Vision, which places safety as Toyota's number one priority. Toyota believes that its role as a responsible corporate citizen is to provide customers with three core values – Safety, Environment and Driving Pleasure. Toyota is passionately pursuing the Global Vision towards our mobile society's ultimate goal: "Zero Casualties from Traffic Accidents."[9] Toyota firmly believes that safety applications supported by V2V, V2I and I2V communication, based on 5.9 GHz DSRC technology, will be a significant enabler in accomplishing Toyota's Global Vision. DSRC is a critical technology for existing and future systems to provide omni-directional safety.

In this regard, the major automobile manufacturers have been working together in a 5.9 GHz study with the U.S. DOT to develop common standards for 5.9 GHz DSRC technology. Toyota was actively involved in the preliminary technical assessment of a national 5.9 GHz DSRC-based system within the Vehicle Infrastructure Integration ("VII") Consortium, under a cooperative agreement with DOT.[10] Automakers around the world already have a high level of confidence in 5.9 GHz DSRC,[11] and believe it has great potential to improve the safety and

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[8] *See* "USDOT Connected Vehicle Research Program Vehicle-to-Vehicle Safety Application Research Plan," DOT HS 811 373 (October 2011).

[9] *See* http://www.toyota-global.com/innovation/intelligent_transport_systems/ultimategoal/.

[10] The VII Consortium is a non-profit corporation composed of ten major vehicle manufacturers, and Toyota supports the VIIC Consortium's position identified in the past public comments that 5.9 GHz DSRC should clearly be identified as the communication media to support active safety applications, which will help provide driver assistance in mitigating and preventing collisions.

[11] It should be noted that ITS systems in Europe and Japan refer to the DSRC/IEEE 802.11p (WAVE: wireless access in vehicular environment) standard.

mobility functionalities of vehicle systems.

II. CONGRESS RECOGNIZED A NEED TO MOVE CAUTIOUSLY WITH RESPECT TO SHARING PROPOSALS AT 5.9 GHz AND HAS NOT REQUIRED THE COMMISSION TO IMPLEMENT SHARING RULES FOR THIS BAND

As described above, there has been a decade of work already invested by the automotive industry, working cooperatively with the federal government, to develop DSRC technology for deployment. Those efforts are ongoing. In at least implicit recognition of this work, Congress made an important distinction in encouraging the Commission to open up the 5 GHz spectrum further for use by U-NII devices.

Specifically, Section 6406(a) of the Middle Class Tax Relief and Job Creation Act of 2012 expressly required the Commission to initiate this proceeding to modify Part 15 of title 47, Code of Federal Regulations, to allow unlicensed devices to operate in the 5.35-5.47 GHz band ("U-NII-2B band"). Even then, the Commission may only implement sharing rules upon findings that (i) existing Commission licensees can be protected by technical solutions and (ii) the primary mission of federal users of the band will not be compromised.[12]

By contrast, there is *no requirement* by Congress for the Commission to include the U-NII-4 band in this proceeding. Here, the Spectrum Act requires only that the National Telecommunications and Information Administration ("NTIA"), in consultation with the Department of Defense and other affected agencies, conduct a study to evaluate known and proposed spectrum sharing technologies and the risk to federal users if unlicensed U-NII devices

[12] *See* Middle Class Tax Relief and Job Creation Act of 2012, Pub. L. No. 112-96, §6406, 126 Stat. 156, 231 (2012), 47U.S.C. § 1453 ("Spectrum Act"), § 6406(a).

were allowed to operate in the U-NII-2B and U-NII-4 bands.[13]

This Congressional distinction is critical. It is reflective of the notion that the U-NII-4 band is simply not ready for the Commission to impose any kind of sharing regime in the near term and that Congress did not expect the Commission to do so. Instead, Congress required further study of interference effects, and the conclusion that far more technical work must be done recently has been validated by NTIA, as noted below.

III. NTIA HAS CONCLUDED THAT THERE IS A LIKELIHOOD OF HARMFUL INTERFERENCE FROM THE INTRODUCTION OF U-NII DEVICES INTO THE UN-NII-4 BAND AND HAS RECOMMENDED FURTHER STUDY OF THE ISSUE

NTIA earlier this year issued the report required by the Spectrum Act,[14] which presents the result of its initial study on the potential for U-NII devices to share the U-NII-2B and U-NII-4 bands with incumbent federal operations. As the *Notice* itself acknowledges, the report "concludes that additional analysis is needed to determine the feasibility of introducing U-NII devices into [the U-NII-2B and U-NII-4] bands and includes a tentative schedule and milestones for quantitative study."[15] The *Notice* further notes that NTIA identified specific risk elements with respect to the co-existence of unlicensed U-NII devices with DSRC systems in the U-NII-4 band.[16] NTIA identified these risk elements "due to the likelihood of harmful interference from

[13] *Id.* § 6406(b).

[14] *See* Department of Commerce, "Evaluation of the 5350-5470 MHz and 5850-5925 MHz Bands Pursuant to Section 6406(6) of the Middle Class Tax relief and Job Creation Act of 2012," available at http://www.ntia.doc.gov/files/ntia/publications/ntia_5_ghz_report_01-25-2013.pdf ("NTIA 5GHz Report").

[15] *Notice* ¶ 103.

[16] *Id.* ¶112.

large numbers of U-NII devices"[17] operating in the 5.9 GHz band, and summarized the element as follows: Existing U-NII regulations were not developed to detect DSRCS signals;

- U-NII signal detection technologies may not be capable of detecting DSRCS signals;
- Current U-NII regulations were not developed to protect transmitters and receivers in different locations; and
- Changes to U-NII DFS detection parameters may not protect DSRCS systems from serious performance degradation.[18]

Toyota supports NTIA's recommendation of further study regarding the suitability of opening the U-NII-4 band to unlicensed U-NII device operations, as well as that agency's proposed collaboration with federal and industry stakeholders, and the Commission, to assess the feasibility of existing, modified and new spectrum sharing technologies and approaches.[19] Toyota below elaborates on some initial specific technical concerns that should be incorporated into analysis of the interference environment with respect to the co-existence of U-NII devices and DSRC systems.

IV. FURTHER STUDY OF THE U-NII-4 BAND SHOULD ENCOMPASS A NUMBER OF TECHNICAL CONCERNS

As noted above and by NTIA, it is premature to begin any implementation of specific sharing rules until the feasibility of sharing between U-NII devices and DSRC systems can be conclusively established, and findings that there will be absolutely no harmful interference

[17] *NTIA 5 GHz Report* at ii.
[18] *Id.* at 6-2.
[19] *See id.*

between them. There are fundamental technical challenges that must be considered thoroughly before determining next steps.

A. GENERAL DETECTION CHALLENGES

There are at least three general challenges in terms of detecting the DSRC devices, as follows:

1) Mobility of DSRC devices (space): U-NII devices currently operating in some bands are required by the Commission to detect primary users whose position is most often fixed, for example radar installations. In these cases a geo-location database of primary user locations may be sufficient to establish certain areas as safe for U-NII operation. By contrast, DSRC devices are inherently mobile and can operate almost anywhere. So, even if a U-NII device knows its location, the information will not meaningfully assist the device in avoiding harmful interference to DSRC.

2) Non-persistence of DSRC devices (time): From the perspective of a detector, a DSRC device may appear suddenly. While some locations will experience a more or less constant presence of DSRC devices, others will not and the intervals between periods of DSRC activity will be unpredictable. So, detection of DSRC should be considered a continual requirement, regardless of past activity.

3) Bandwidth mismatch between Wi-Fi and DSRC: Wi-Fi devices currently detect a transition from idle channel to busy based on a 20 MHz Clear Channel Assessment (CCA)[20] function. DSRC signals use a similar waveform, but in a 10 MHz channel such that the

[20] CCA is a standard function built into all 802.11 devices, which determines if a channel is busy or idle. CCA could be a basis for U-NII detection of DSRC. Non-802.11 U-NII devices will not routinely have CCA.

"signature" is spread out compared to Wi-Fi. This signature can be detected using a modified form of the 20 MHz CCA function. CCA-based DSRC detection implies that a Wi-Fi device would need dedicated 10 MHz CCA detectors (one per DSRC channel).

B. SPECIFIC DETECTION CHALLENGES

In the *Notice*, the Commission assumed that the dynamic frequency selection ("DFS") mechanism will be used to avoid any interference between U-NII devices and DSRC devices, in the same manner as interference avoidance between U-NII devices and radar systems. Since a DSRC system has many different characteristics from a radar system, technical requirements (*e.g.*, detection bandwidth and detection interval) and test procedures must be investigated further. The following three items should be considered in connection with such an investigation.

1) Proxy Detection: While a typical radar system is static and radiates a continuous wave, DSRC devices are very dynamic and can be transmitting packets anywhere at any time. Furthermore, radar signals tend to be transmitted with high power over long ranges, while DSRC typically uses low-to-moderate power (10 to 20 dBm) over several hundred meters. Therefore, detecting DSRC systems will bring significantly different challenges as compared to radar detection. An example is proxy detection, in which an access point ("Master") has the responsibility to detect the primary user and notify associated U-NII stations ("Clients"). The topology of a Wi-Fi network may be such that the Master device does not detect any DSRC users at a time when one or more Client devices are interfering with DSRC transmissions, and thus the proxy detection mechanism fails (see Figure 1).

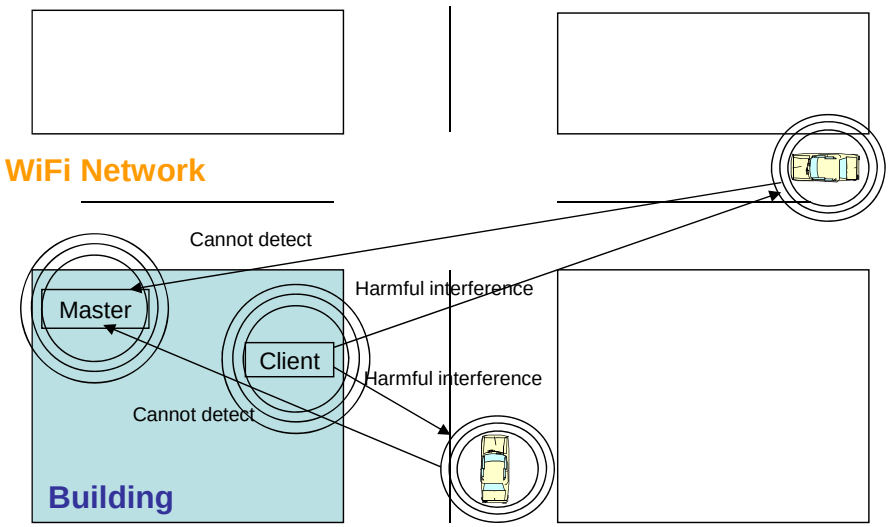

Figure 1: Proxy detection – Intersection example

2) Range Asymmetry: The interference range of U-NII device transmissions may be higher than the range over which DSRC devices operating in the vicinity can be detected, for example due to transmit power asymmetry or channel asymmetry. Harmful interference to DSRC transmissions can be expected to accompany range asymmetry due to a lack of detection or a delay in detection of DSRC devices. Figure 2 illustrates this challenge in the highway scenario. The Commission invites comments on a proposal that in the U-NII-4 band "maximum output power is the lesser of 1 Watt and 17 dBm + 10Log(B) where B is the 26 dB emission bandwidth."[21] This would permit 500 milliwatts in a 10 MHz DSRC channel, compared to a typical DSRC transmit power of 100 milliwatts. While the transmit power, power density, antenna gain and out-of-band emissions of U-NII devices all require further investigation, Toyota believes that the maximum power spectral density should not exceed 10 dBm/MHz, the density typically used by DSRC devices.

[21] *Notice* ¶ 97.

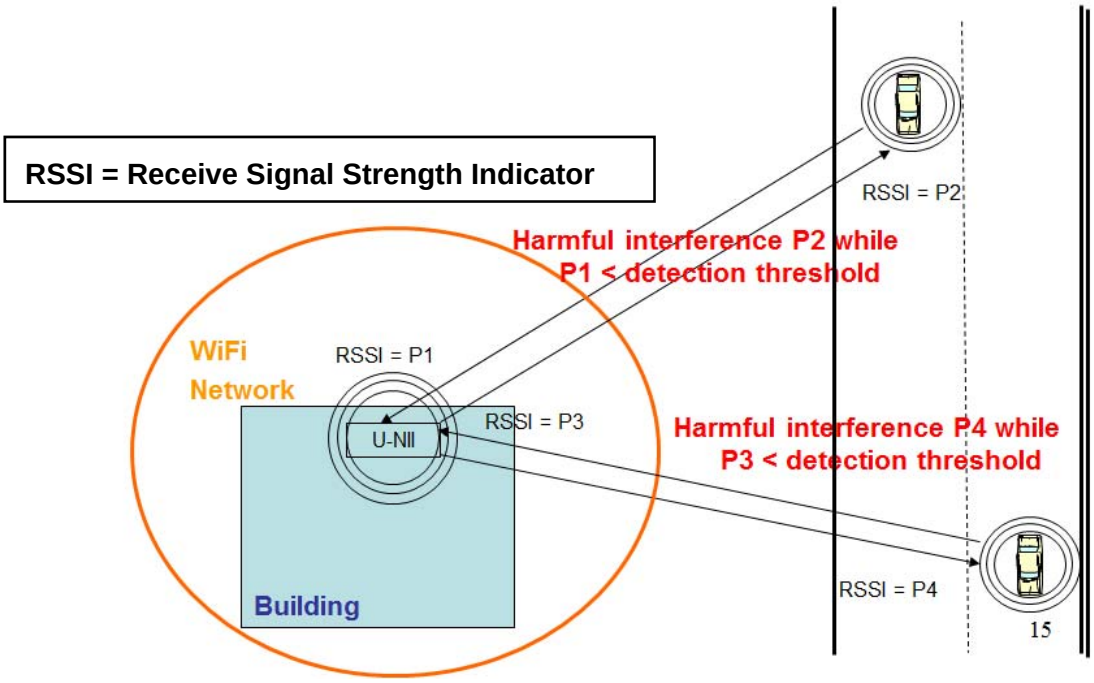

Figure 2: Range Asymmetry – Highway example

3) Carrier Sense Multiple Access ("CSMA") Transmission Delay: In cases where vehicles equipped with DSRC devices drive into a region with an active Wi-Fi radio local area network ("RLAN"), DSRC transmissions may be delayed indefinitely, thus preventing or delaying detection of the DSRC device. The DSRC channel access protocol requires the DSRC device to defer transmission while the channel is busy. Wi-Fi devices may concatenate an unlimited number of frames in a single aggregate frame transmission, during which time the channel is busy and DSRC transmissions are prevented. Furthermore, even when one Wi-Fi device completes its transmission, the Wi-Fi channel access protocol defines the channel as available after a short interframe space ("IFS"), and another Wi-Fi device can then begin transmission. The DSRC access protocol requires a longer IFS before recognizing the channel as

available. So, DSRC transmissions can be deferred indefinitely, even while Wi-Fi devices share the channel with each other. An additional source of DSRC detection delay is that when a DSRC device accesses the channel its transmission may overlap in time with a Wi-Fi transmission (i.e. frame collision), making it unlikely that the DSRC device will be detected by Wi-Fi devices (Figure 3).

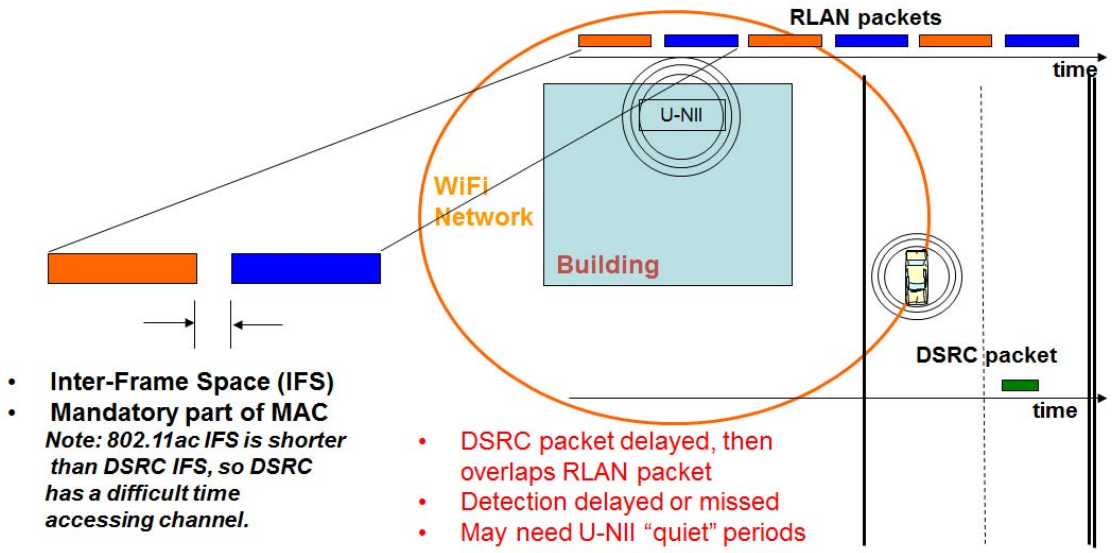

Figure 3: CSMA Transmission Deferral – Highway example (1)

Another example of CSMA Transmission Delay can occur if a DSRC-equipped vehicle is in a region where it can sense transmissions from Wi-Fi devices in overlapping RLANs, but the Wi-Fi devices in one RLAN do not detect those in the other RLAN. In this case the DSRC device will not transmit unless both RLANs are idle, which can result in even longer access delays (see Figure 4).

It may be necessary for Wi-Fi devices to adopt more deferential channel access rules to prevent unlimited or substantial DSRC access delays, like those described in this section, which lead to equivalent DSRC detection delays.

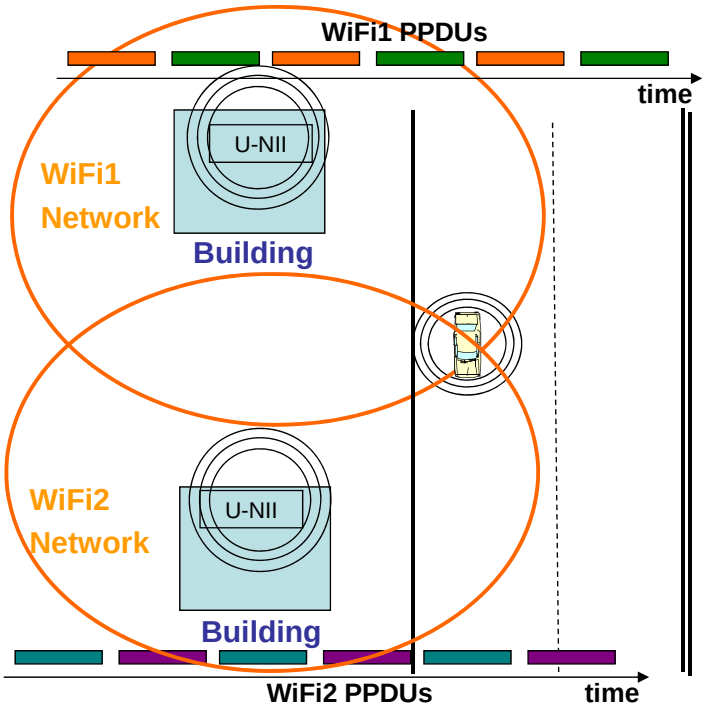

Figure 4: CSMA Transmission Deferral – Highway example (2)

C. INTERFERENCE MODELS

In order to realize co-existence among DSRC devices and U-NII devices without harmful interference, interference models need to be defined, especially for the worst cases.

If a U-NII client device is in a vehicle, the U-NII client may cause harmful interference to On Board Unit ("OBU")-to-OBU (*i.e.*, V2V) and Road Side Unit ("RSU")-to- OBU (*i.e.*, I2V) communications (see Figure 5). The propagation loss difference between a desired link and an undesired link is approximately 43 dB under a free-space propagation model, i.e. the desired link experiences 43 dB of additional loss.

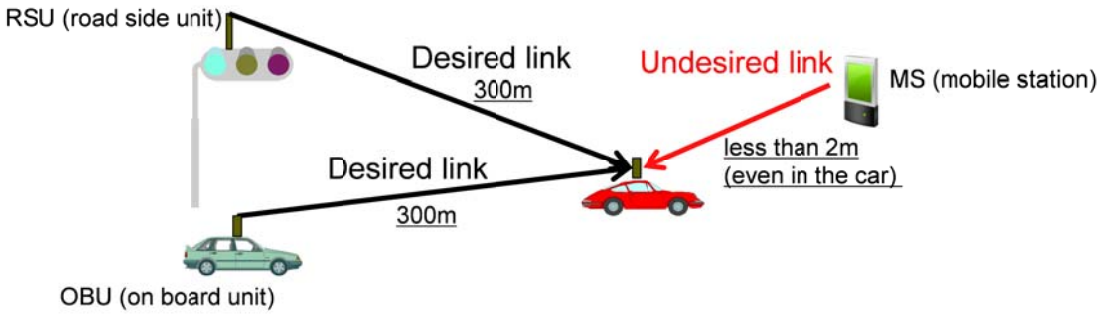

Figure 5: Interference model between DSRC devices and U-NII mobile station

If U-NII access points are installed on the roadside, U-NII access points may cause harmful interference to OBU-to-OBU, RSU-to-OBU, and OBU-to-RSU communications (see Figure 6). The propagation loss difference between a desired link and an undesired link is about 29 dB under a free-space propagation model.

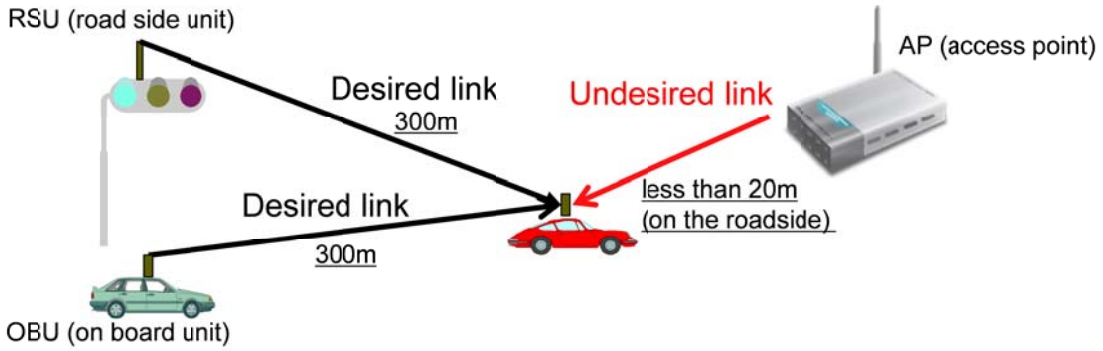

Figure 6: Interference model between DSRC devices and U-NII access point

When harmful interference occurs into a DSRC system, the packet reception rate degrades, which will increase inter-packet reception gaps and tracking errors, and as a result will cause the DSRC system to delay or fail to provide warning messages. This, in turn, can cause

safety application failure.[22] It thus is very important to verify the impact of interference on the application level.

Finally, DSRC devices use channel congestion control that reacts to channel load. Mixing with uncontrolled U-NII devices can cause DSRC devices to "over-react" by reducing message rates and/or transmit power too much. This point also must be investigated.

D. PARAMETERS

The transmitting power of U-NII devices can be as high as 1W (30dBm). This transmit power may be too large to avoid harmful interference, and should be addressed within reasonable interference models. Similarly, the spectral power density of U-NII devices (as high as 17dBm/MHz), antenna gain for point-to-point U-NII systems (up to 23 dBi), and EIRP related to out-of-band emissions (typically -17dBm/MHz @band edge ±10MHz), for example from devices operating below 5.850 GHz, must also be addressed within reasonable interference models.

V. IMPACT ON SAFETY

Toyota would like to reiterate the importance of safety and the fact that DSRC has been selected as the most appropriate communications medium for safety applications due to its "high-availability and low latency" characteristics. Determining next steps in the interference

[22] Under the CAMP-U.S. DOT VSC-A collaborative project, six V2V-based DSRC safety applications were implemented and tested – Emergency Electronic Brake Lights (EEBL), Forward Collision Warning (FCW), Blind Spot Warning + Lane Change Warning (BSW+LSW), Do Not Pass Warning (DNPW), Intersection Movement Assist (IMA), and Control Loss Warning (CLW), *See* Crash Avoidance Metrics Partnership, *Vehicle Safety Communications-Applications (VSC-A) – Final Report* (Report No. DOT HS 811 492A) (September 2011).

evaluation process without thoroughly considering all potential factors would likely result in two major adverse impacts in the safety area.

First, due to overlapping transmissions and frame collisions between DSRC and U-NII devices as a result of sharing, immediate adverse effects could be high signal-to–interference plus noise ratio ("SINR") and low packet reception. Overlapping transmissions and collisions would also lead to indirect consequences, including high inter-packet reception gaps ("IPG"), high tracking error, delayed or missed warnings, and most importantly, harm to safety applications.

Another critical adverse impact could be an increase in channel congestion as a result of the lack of congestion control. As mentioned, DSRC devices use congestion control that reacts to channel load, and intermingling with uncontrolled U-NII devices could cause a DSRC device to "over-react" by reducing message rates and/or transmit power too much. As in the previous concern, indirect consequences could include reduced message rates leading to high IPGs, reduced transmit power leading to reduced range, high tracking error, and delayed or missed warnings, any of which, may harm the functionality of safety applications.

VI. CONCLUSION

Toyota remains supportive of the Commission's efforts to free up more spectrum in the 5 GHz band for U-NII devices. However, as set forth above, the 5.9 GHz / U-NII-4 band is simply not ripe for the creation of a sharing framework, or the implementation of sharing rules, until many different interference-related issues are thoroughly explored regarding the feasibility of co-existence between U-NII devices and DSRC systems. Toyota will be pleased to work with the Commission and other federal and industry stakeholders to explore these issues constructively.

In the meantime, given the potential consequences to vehicular and consumer safety, the Commission should not take any precipitous action with respect to sharing until adequate evidence and data can be collected and studied.

Respectfully submitted,

– /s/ –

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