BEFORE THE
U.S. DEPARTMENT OF TRANSPORTATION
NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION
WASHINGTON, D.C. 20590

In the Matter of	)	
	)	
Proposed Changes in the Commission's	)	ET Docket No. NHTSA–2016–0126
Rules Regarding Federal Motor Vehicle	)	
Safety Standards; V2V Communications	)	

COMMENTS OF THE 5G AUTOMOTIVE ASSOCIATION

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EXECUTIVE SUMMARY

The 5G Automotive Association (5GAA) supports the goal of the National Highway Traffic Safety Administration (NHTSA) to increase motor vehicle safety through the use of communications solutions. 5GAA is a new global cross-industry association of automotive, technology and telecommunications companies. 5GAA includes 42 members, of which 8 are founding members (AUDI AG, BMW Group, Daimler AG, Ericsson, Huawei, Intel, Nokia, Qualcomm). Our mission is to enable communications solutions that address society's connected mobility and road safety needs.

5GAA, like the U.S. Department of Transportation (USDOT) and National Highway Traffic Safety Administration (NHTSA), values safety first and foremost; this is what makes the immediate proceeding so important to us and why we are moved to offer the sum of our expertise in providing comments. To realize the full safety benefits of vehicle communications, NHTSA's guiding principle must be one that allows for not only the best technology of today, but also for the best technologies of tomorrow. Such an approach will promote innovation and competitive market-based outcomes, ensuring that American drivers and passengers benefit from the best and most advanced safety solutions available as technology evolves. This is particularly essential for regulations touching the communications industry, which has witnessed rapid technological innovation over the past two decades – with 4G cellular prevalent today and 5G on the horizon. By contrast, rigid technology mandates, whether direct or *de facto*, freeze technology solutions to a past point in time. With the communications market rapidly evolving, any technology NHTSA mandates today will be outdated by the time the mandate goes into effect, if not already outdated. This will significantly impede the innovation and evolution path for Vehicle-to-Vehicle (V2V) safety, and positions the US to lag behind the rest of the world in V2V communications specifically as well as V2X broadly.

For this reason, 5GAA respectfully cannot support the proposed V2V technology mandate predicated on the use of dedicated short-range radio communications (DSRC), a technology originally designed in the 1990s. The proposed direct technology-specific mandate, by definition, is on its face not technology neutral. Similarly, the one-way interoperability requirement in the alternate "if equipped" proposal, where "alternative" technologies would be required to be backwards interoperable with DSRC, is flawed in that it would impose no reverse interoperability requirement on DSRC to ensure backwards interoperability with other technology solutions, including today's Cellular Vehicle-to-Everything (Cellular-V2X) solutions for V2V safety. In effect, the "path" for compliance is not a path at all, but instead a dead-end for other technologies, as it creates a non-level playing field in the US V2V market.

The implications of the proposed mandate are significant. First and foremost, the proposed regulation would prevent consumers from benefitting from the best and most advanced safety solutions available. Notably, today's Cellular-V2X technology for V2V safety not only meets all of the NPRM's proposed performance requirements, but exceeds the capabilities of DSRC on many of these same requirements. As explained in detail in our comments, cellular technology offers the following benefits:

- Similar to DSRC, Cellular-V2X technology for V2V safety can transmit BSM in an ad hoc manner without cellular network coverage.

- Cellular-V2X technology for V2V safety communications can operate without a SIM card and offers the tools to adopt, evolve or innovate any privacy-preserving security management system including SCRM.

- Cellular-V2X technology for V2V safety benefits from a significantly larger link budget than DSRC (e.g., 8 dB at high speeds), corresponding to twice the range of DSRC and higher reliability.

- Cellular-V2X technology for V2V safety can support up to 50 messages per second with less than 20 msec latency.

- Cellular-V2X enables V2V, and for that matter Vehicle-to-Infrastructure (V2I), Vehicle-to-Pedestrian (V2P) and Vehicle-to-Network (V2N), safety applications to take advantage of the widespread cellular network coverage in the US.

Moreover, the impending launch of 5G will only widen the performance gap between Cellular-V2X and DSRC.

In addition, the proposed mandate would impose unprecedented and unnecessary costs on American taxpayers. The estimated regulatory costs of the proposed DSRC mandate is expected to be the second most expensive regulation in more than a decade, with total costs reaching $108 billion by year 2060. By comparison, deployment of Cellular-V2X is being achieved at a fraction of that cost by leveraging decades of multi-industry investment in cellular LTE and new investment in 5G.

Rather than moving forward with the proposed regulation, NHTSA should instead undertake an updated, comprehensive technology neutral analysis of V2V solutions, including DSRC and Cellular-V2X, against the performance requirements in the NPRM. If this review indicates that regulatory action is necessary, the U.S. Department of Transportation should move forward with a technology neutral regulation that sets forth minimum V2V safety performance requirements only. Consistent with a technology neutral guiding principle, any such regulation should not require one-way interoperability with a specific technology, or in any way pick technology winners and losers.

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COMMENTS OF THE 5G AUTOMOTIVE ASSOCIATION

I. INTRODUCTION

The 5G Automotive Association (5GAA) Board hereby submits comments in response to the Notice of Proposed Rulemaking in the above-captioned proceeding.[1] The 5GAA is a multi-industry association with expertise in communications solutions, including the focus of this NPRM, Vehicle-to-Vehicle (V2V) safety applications.[2] Cellular communication technologies have been a resounding success and over the last couple of decades have delivered substantial societal benefits. The next stage in the evolution of cellular is addressing the challenges of delivering more data volume, connecting many more devices, significantly reducing latency and bringing higher levels of reliability. These developments provide unprecedented support for safety-critical communications for safer driving through a set of features that we denote as Cellular Vehicle to Everything (Cellular-V2X). An immediate benefit of this evolution is support for V2V safety.

The members of 5GAA are closely collaborating to realize the full potential of the technology by addressing key technical and regulatory issues, leveraging next generation mobile networks and integrating vehicle platforms with advanced cellular connectivity, networking and computing solutions. 5GAA is engaging in joint innovation projects worldwide, which will include V2V safety deployments in North America similar to trials already demonstrated by 5GAA members and other ecosystem partners in globally competitive countries like Germany and

[1] Federal Motor Vehicle Safety Standards; V2V Communications, 82 Fed. Reg. 3854 (Jan. 12, 2017) ("NPRM").

[2] For additional information about 5GAA, please see Appendix A.

China. In all these activities, 5GAA, like the U.S. Department of Transportation (USDOT) and National Highway Traffic Safety Administration (NHTSA), values safety first and foremost; this is what makes the immediate proceeding so important to us and why we are moved to offer the sum of our expertise in providing comments.

II. FOUNDATIONAL WORK TO THE NPRM

5GAA recognizes and commends the work by the government, automotive research and standardization communities to invent, develop, test and standardize V2V communications, with emphasis on safety use cases. We are cognizant and appreciative of the work that builds a foundation to the NPRM. In particular, we are aware of antecedent work conducted by Vehicle Safety Communications consortia under the umbrella of the Crash Avoidance Metrics Partnership (CAMP) and in more recent years, CAMP LLC. We observe that this work contributed on-board minimum performance requirements, largely reflected in SAE J2945/1, which NHTSA heavily references in the NPRM.

We do not aim to duplicate this work; our current activities and various working groups (described in Appendix B) are building upon the engineering and test procedures described in the DOT HS 811 492 final report[3] and its technical appendices along with SAE J2945/1 and SAE J2735 standards.

We realize that V2V safety applications start from the basis of hard work and the safety impetus. Furthermore, we believe that Cellular-V2X technology – built upon decades of multi-industry efforts and hundreds of billions of dollars of global investment – will drive important growth as we jointly expand the ecosystem and utility of V2V safety and V2X more broadly.

III. TECHNOLOGY NEUTRALITY

5GAA supports technology neutrality and market competition. Any technology-specific mandate, by definition, is not technology neutral. One-way interoperability where "alternative" technologies would be required to be backwards interoperable with dedicated short-range radio communications (DSRC) but not vice versa, is de facto not technology neutral. Technology mandates, whether direct or de facto, problematically freeze technology

[3] USDOT, NHTSA DOT HS 811 492A, Vehicle Safety Communications Applications (VSC-A) Final Report (Sept. 2011).

solutions to a past point in time (in this case, a technology designed in the pre-mobile broadband/pre-3G era). The market is evolving very fast, such that any technology USDOT mandates today will already be outdated by the time the mandate goes into effect, if not already outdated. This significantly impedes the technology innovation and evolution path for V2V safety.

Moreover, while V2V is by no means a prerequisite or precursor to the safe deployment of autonomous vehicles (*i.e.*, self-driving vehicles being successfully tested on America's roads today do not include DSRC), Cellular-V2X has distinct capabilities that can be complementary to automated vehicle technologies and enable an enhanced experience. In this regard, it is important to note the inability of dated communication technologies like DSRC to support certain advanced features of automated driving. As USDOT and industry work together to advance Intelligent Transportation Systems (ITS), the advantages of utilizing Cellular-V2X will become increasingly important.

5GAA's technology neutral position is consistent with the explicit Congressional intent stated in the Conference Report accompanying the Fixing America's Surface Transportation Act (FAST Act), enacted into law in December 2015. It states:

> The FAST Act ensures that [USDOT] programs are implemented and Intelligent Transportation Systems (ITS) are deployed in a technology neutral manner. The Act promotes technology neutral policies that accelerate vehicle and transportation safety research, development and deployment by promoting innovation and competitive market-based outcomes, while using federal funds efficiently and leveraging private sector investment across the automotive, transportation and technology sectors.[4]

Just last year, the Chairman of the House Transportation and Infrastructure Committee sent a letter to then-USDOT Secretary Foxx quoting this Conference Report language and "strongly urg[ing]" USDOT to act "consistent with the FAST Act platform-neutral technology provisions."[5] Notably, no other country is imposing a V2V technology safety mandate (thereby picking technology winners and losers) as proposed in the NPRM. These

[4] *See* H.R. Rep. No. 114-357, at 507 (2015) (Conf. Rep.), http://www.gpo.gov/fdsys/pkg/CRPT-114hrpt357/pdf/CRPT-114hrpt357.pdf.

[5] Letter from Chairman Bill Shuster and Rep. Garrett Graves, House Transportation and Infrastructure Committee, to Anthony Foxx, USDOT Secretary, at 1 (July 12, 2016).

other countries instead recognize that the global trend is toward Cellular-V2X. A V2V technology mandate in the US would put our country at a competitive disadvantage and prevent US consumers from benefitting from the best and most advanced safety solutions.

For all the above reasons, 5GAA respectfully cannot support a V2V DSRC technology mandate.

IV. CELLULAR V2X SAFETY

5GAA is encouraged that NHTSA seeks information on non-DSRC technologies that might "meet or exceed the proposed performance requirements."[6] We describe below salient aspects of Cellular-V2X technology, which address safety use cases with V2V (direct messaging), as specified in 3GPP[7] Release 14 standards, all of which meet or exceed the proposed performance requirements of DSRC. We note that these cellular standards have undergone the same rigorous, extensive and objective peer review and scientific testing by the global telecommunications industry as all cellular technologies to date, starting with Code Division Multiple Access -based devices in 1999 through successive variants of LTE in devices today like 3G and 4G/LTE. In fact, Cellular-V2X builds upon the long evolution of LTE specifications that have and will remain the global standard and is therefore uniquely future proof. Cellular V2X also reuses the safety and other innovations developed by the ITS community, including Intersection Movement Assist, Left Turn Assist, Emergency Electronic Brake Light, Forward Collision Warning, Blind Spot Warning, Lane Change Warning and Do Not Pass Warning.[8]

We begin with three general, important performance considerations which are not possible to achieve with DSRC, but are fundamental to cellular as the technology to transmit Basic Safety Messages (BSM) and other V2X

[6] NPRM, 82 Fed. Reg. at 3896.

[7] The 3rd Generation Partnership Project (3GPP) unites seven global telecommunications standard development organizations and covers cellular telecommunications network technologies, including radio access, the core transport network, and service capabilities and thus provides complete system specifications.

[8] Do not pass warning is not a use case described in SAE J2945/1, however the range afforded by Cellular-V2X permits its inclusion.

messages. We then comment on how Cellular-V2X addresses the broad performance parameters for V2V safety described in the NPRM, as well as other related topics.[9]

A. CELLULAR V2X PRIORITY AND PRE-EMPTION FOR V2V SAFETY

Critical to V2V safety messaging, Cellular-V2X enables up to eight priority levels for the transmission of a data packet (message) and, unlike DSRC, cellular standards assure that higher priority status for BSM is protected. To explain: Cellular technology manages time and frequency slot resource blocks that enables granular partitioning of spectrum, and, therefore, the resource used to transmit higher priority packets like BSM is protected in the design of Cellular-V2X. Utilizing cellular technology, if a device (vehicle) is ready to send a packet with higher priority like a BSM V2V safety message associated with an emergency event, the system design prevents transmission of a lower priority packet using that resource. The net effect is that Cellular-V2X is able to avoid interference to higher priority packets. Moreover, Cellular-V2X can further control the level of protection attached to a message based on the application; *e.g.*, the critical safety applications identified in the NPRM (Intersection Movement Assist, Left Turn Assist, and Electronic Emergency Brake Light), as well as additional applications like control loss warning, or forward collision warning, can have guaranteed priority. Furthermore, if there is channel congestion (*i.e.*, data packets are crowding the 10 MHz safety channel), access to the channel is controlled as a function of priority, thereby protecting access and reliability of high priority packets like a BSM V2V safety message associated with an emergency event.

Such detailed ability to achieve granularity of prioritization of V2V safety messaging is a unique property of Cellular-V2X that enables safety application designers to deterministically change priority, unlike the probabilistic and coarse Enhanced Distributed Channel Access (EDCA) technique described in SAE J2945/1 and referenced in the NPRM which does not enable this level of exactness. This cellular feature also diminishes the need for the complex channel congestion protocol inherent in DSRC, as described in SAE J2945/1. This complex channel congestion protocol is not needed for Cellular-V2X prioritization and pre-emption (described above) or the ability to

[9] *See infra* Section IV.C.

leverage the cellular network (described below). These performance indicators make cellular technology ideal for V2V safety messaging.

B. ABILITY TO LEVERAGE THE CELLULAR NETWORK FOR V2V SAFETY MESSAGING

Cellular network coverage is not needed for V2V safety messaging or other V2X applications; indeed, similar to DSRC, Cellular-V2X can successfully transmit BSM in an ad hoc way without cellular network coverage. This ad hoc operation without a network is inherent in the design of Cellular-V2X.

In addition, Cellular-V2X has an added unique benefit in that it also enables V2V, and for that matter Vehicle-to-Infrastructure (V2I), Vehicle-to-Pedestrian (V2P) and Vehicle-to-Network (V2N), safety applications to take advantage of the widespread cellular network coverage in the US. Specifically, the cellular network can be used to achieve centralized resource allocation which can allow for much better system level performance than other technologies; *e.g.*, the cellular network resources can serve as a message "traffic cop" at congested traffic intersections, assigning higher priority to, for example, cars approaching at higher speeds or any other set of criteria the safety algorithm is designed to achieve.

The cellular network can also allow for better prioritization of more important messages in case of channel congestion. In practical terms, this means that low latency V2V BSM messages are given quick passage and other less urgent messages are routed through appropriate other routes. Yet another feature is that, depending on the congestion level or other criteria the application is designed to achieve, a vehicle can transmit a data packet (message) over the cellular network rather than the direct (device-to-device or V2V) link. Network assistance for resource management or for packet routing can be provided today with network delays in the order of tens of milliseconds, making cellular infrastructure an exemplar means for responding to safety related use cases.

Finally, while a cellular network is not necessary for transmitting V2V safety messages, using the cellular network for BSM can allow a message to be (re)transmitted over a longer range, an additional advantage of cellular V2X over other technologies. The impact to traffic safety in an end-to-end cellular V2X system is thereby extended well beyond the important V2V interaction. In the cellular V2X system, messages can also be sent to the core

network, and delivered to vehicles further away and to the traffic operations to respond to emergencies or to help manage incidents. Clearly, there is benefit and synergy to the system integration inherent in the cellular V2X solution for V2V safety, as well as other applications.[10]

C. PERFORMANCE OF CELLULAR V2X FOR V2V SAFETY

While it may have been true over eighteen years ago in the 2G cellular (pre-mobile broadband) era that there was only one communication technology envisioned capable of meeting the V2V Key Performance Indicator (KPI) requirements set forth in the NPRM, this is no longer true and has not been true for years. Today's Cellular-V2X technology already is capable of meeting and exceeding the V2V KPIs proposed in the NPRM, and the gap is only widening by orders of magnitude with the launch of 5G in 2018-2020. The following addresses Cellular-V2X capability as well as related topics.

1. TRANSMISSION RANGE AND RELIABILITY

Message transmission range (lateral, longitudinal and elevation) performance can be succinctly described by link budget, *i.e.*, an accounting of the aggregate gains and losses from the transmitter, through the air interface to the receiver in a telecommunication system. 5GAA notes that in the direct V2V mode, Cellular-V2X benefits from a significantly larger link budget than DSRC (*e.g.*, 8 dB at high speeds), corresponding to twice the range of DSRC,[11] depending on the scenario. This link budget is due to the modern waveform and associated techniques specified by the 3GPP cellular standard: frequency division multiplexing, superior coding, two receive antennas, modern error control techniques such as hybrid Automatic repeat request to improve reception reliability and ability to transmit at

[10] *See* 3GPP TS 36.213 V14.2.0, *3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer procedures (Release 14)*, at 385-386, 392-399, 400-405, 406-407 (Mar. 2017); 3GPP TS 36.331 V14.2.0, *Radio Resource Control (RRC); Protocol specification (Release 14)*, at 191, 193-201, 208-214, 217-220, 226-317, 400-419, 496-518, 578-582, 583-584, 591-595 (Dec. 2016); 3GPP TS 36.321 V14.1.0, *Medium Access Control (MAC) protocol specification (Release 14)*, at 50-54, 55-58, 84-86, 93-98 (Dec. 2016). 3GGP Specification series available at http://www.3gpp.org-/DynaReport/36-series.htm (last visited Apr. 5, 2017). Zeeshan Hameed Mir & Fethi Filali, *LTE and IEEE 802.11p for vehicular networking: a performance evaluation*, EURASIP Journal on Wireless Communications and Networking (May 30, 2014), http://jwcn.eurasipjournals.springeropen.com/articles-/10.1186/1687-1499-2014-89.

[11] 3GPP TS 36.785 V14.0.0, *3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Vehicle to Vehicle (V2V) services based on LTE sidelink; User Equipment (UE) radio transmission and reception (Release 14)* (Oct. 2016).

higher power (for the same equivalent isotropically radiated power requirements) using Single Carrier-Frequency Division Multiplexing (SC-FDM).[12] Moreover, if available, the network – or V2N where "N" is the network managed by the cellular core network – can be part of the V2V safety solution. This enables transmission ranges well beyond just the V2V direct communication and opens different and better concepts of operations for safety use cases such as Forward Collision Warning (ability to "see" around a curve) or Emergency Brake Light (ability to "see" through vehicles and over longer ranges) than described in the NPRM.

2. TESTING THE EVALUATION TRANSMISSION RANGE AS WITH DSRC

Cellular-V2X would use a very similar software implementation stack as DSRC, easily adapted from SAE J2945/1 and IEEE 1609 (and in particular IEEE 1609.2) standards. Hence, test devices, locations and protocols would be virtually identical to those developed to test DSRC devices. Additionally, within 3GPP, there are even more cellular V2X test cases and performance requirements than in the NPRM, including detailed test definitions.[13]

3. RELIABILITY

Cellular-V2X, including V2V safety messaging, is more reliable than DSRC at any given range.[14] This high reliability is achieved by combining the link budget advantage discussed above with an advanced resource allocation protocol,[15] which enables cellular to quickly and efficiently seek the "best" resource to transmit, taking into account the entire system performance. This contrasts with DSRC, which selects the first 'good enough'

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[12] *See* 3GPP TS 36.213, *supra* note 10; 3GPP TS 36.212 V14.1.1, *3rd Generation Partnership Project; Technical Specification Group Radio Access Network;Evolved Universal Terrestrial Radio Access (E-UTRA); Multiplexing and channel coding (Release 14)*, at 7-8, 131, 138, 139-140 (Jan. 2017); 3GPP TS 36.211 V14.1.0, *Physical channels and modulation (Release 14)*, at 140-141, 142, 143-144, 147-149 (Dec. 2016), 3GPP TS 36.331, *supra* note 10, 3GPP TS 36.321, *supra* note 10, Ricardo Blasco et al., *3GPP LTE Enhancements for V2V and Comparison to IEEE 802.11p*, 11th ITS European Congress (June 6-9, 2016); Hameed Mir & Filali, *supra* note 10.

[13] *See* 3GPP TS 36.101 V14.3.0, *3rd Generation Partnership Project; Technical Specification Group Radio Access Network;Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio transmission and reception (Release 14)* (Oct. 2016) (some additional requirements); 3GPP TSG-RAN WG5 Meeting #74 (R5-170988), *Work plan for Support for V2V services based on LTE sidelink (LTE_SL_V2V-UEConTest) – Status after RAN5#74*, Athens Greece (Feb. 13-17, 2017) (lists of tests being defined).

[14] *See* 3GPP TS 36.785, *supra* note 11.

[15] *See* 3GPP TS 36.213, *supra* note 10; 3GPP TS 36.321, *supra* note 10.

resource and transmits, without regard to system performance as a whole. Being able to select the 'best' resource to transmit is very important when transmitting safety-critical messages like BSM.

4. ASPECTS OF TRANSMISSION RANGE PERFORMANCE INDIRECTLY TESTED

Transmit power test protocols for Cellular-V2X safety can be nearly identical to those employed to determine DSRC transmit power. Cellular-V2X can transmit at the same power as DSRC, but notably cellular V2X employs the SC-FDM waveform, which means that, for a given power amplifier, Cellular-V2X can transmit at a higher average power compared to DSRC, which uses Orthogonal Frequency Division Multiplexing.[16] With DSRC, SAE J2945/1 specifies a congestion control protocol where power and transmission rate are diminished. In contrast, Cellular-V2X can be configured to modify transmission to not diminish latency. In sum, DSRC trades off range and latency with the congestion control protocol specified by SAE; however, Cellular-V2X does not require this tradeoff. The end result is a more reliable method of vehicle safety communication with Cellular-V2X.

5. CHANNEL AND DATA RATE

The channel use and data rates described in the NPRM for DSRC are all supported by Cellular-V2X; however, cellular offers additional advantages for V2V safety because Cellular-V2X offers much more granularity in the data rates, allowing BSM priority to be fine-tuned. This data rate advantage is due to allowance for coding rates and the higher number of frequency slots that can be used by a transmitter.[17] In short, Cellular-V2X data rates can be tuned to the application and/or local needs for V2V safety, *e.g.*, changed at intersections, giving the safety application an additional tuning parameter that improves the result.

6. TRANSMISSION TIMING

Currently, Cellular-V2X can support up to 50 messages per second.[18] Also, Cellular-V2X can meet transmission timing requirements and therefore does not need to randomly stagger transmissions in time to avoid

[16] *See* 3GPP TS 36.211, *supra* note 12.
[17] *See* 3GPP TS 36.213, *supra* note 10; 3GPP TS 36.212, *supra* note 12, 3GPP TS 36.321, *supra* note 10.
[18] 3GPP TS 36.331, *supra* note 10.

congestion as DSRC does.[19] As a consequence, DSRC transmissions may experience large delays in the presence of high load, necessitating a complex channel congestion protocol described in SAE J2945/1. In practical terms, this means that the nominal 10 messages per second specified in SAE J2945/1 can be delivered by Cellular-V2X without complicated rules in the standards that can slow DSRC messages down to as few as one message every 0.6 sec.

7. LATENCY

In an earlier stage of the rulemaking proceeding, NHTSA set forth a latency requirement of 100 msec[20] to support vehicle communication based crash avoidance. Cellular latency today already meets or exceeds this requirement, with 4G LTE already achieving a latency of approximately 10 msec, and the gap is only continuing to widen. Cellular (3GPP Release 14) enhancements to LTE enable direct communications, such as robust V2V connectivity at distances up to hundreds of meters at very low alert latency – about a few millisecond or a few 100ths of a second of the NPRM-proposed latency requirement; crucially, this latency is for both in-coverage and out-of-coverage of standard cellular infrastructure.[21] This very low latency has already been demonstrated in road tests of cellular safety-critical V2V applications.[22] Moreover, the deployment of next generation cellular technologies like 5G will dramatically reduce latency even further to less than 1 msec – making it 1/100th of the NPRM-proposed latency requirement.

Cellular-V2X achieves significantly lower latency than other technologies because of time synchronization either with or without a base station, whereas Wi-Fi-based technologies like DSRC will use a "listen before talk" principle that severely degrades latency as more nodes (or vehicles) enter the network – *i.e.*, as the traffic

[19] 3GPP TS 36.213, *supra* note 10; 3GPP TS 36.321, *supra* note 10.

[20] *See* NPRM Version on USDOT/NHTSA Website at 148 ("Configure the RSE to send a WSA on the control channel every 100 msec, including channel information"), https://www.nhtsa.gov/press-releases/us-dot-advances-deployment-connected-vehicle-technology-prevent-hundreds-thousands.

[21] *See* Sam Lucero, *C-V2X offers a cellular alternative to IEEE 802.11p/DSRC*, HIS Markit Technology (June 9, 2016).

[22] *See infra* Section V and Appendix B below for details.

environment becomes more crowded. Thus, cellular enables a much more desirable approach for mission critical network traffic like V2V safety-critical messages.

8. SECURITY AND PRIVACY

While 5GAA recognizes that DSRC security is work in progress, the Security Credential Management Systems envisioned in the NPRM relies on "periodic" (intermittent) connection between the vehicle and infrastructure to revoke certificates with the assistance of a Certificate Authority. An intermittent connection, depending on its frequency, can allow for interruptions and cause large delays in revoking security certificates and therefore can erroneously permit non-secure and unauthenticated messages (*e.g.*, from malfunctioning or malicious devices) to be transmitted to vehicles. Cellular networks use persistent connections to help accelerate certificate revocation – making certificate management much more effective, secure and reliable.

Cellular V2X offers the tools to adopt, evolve or innovate any privacy-preserving security management system because of a key 3GPP technical specification that enables V2V communications to operate without a SIM card.[23] As acknowledged by the telecommunications industry, this standard will allow security concepts from other standards to be adopted "as is" (*e.g.*, IEEE or ETSI ITS).[24] The combination of leveraging lessons learned from the ITS community and enabling telecommunications practices will spur innovation to improve and/or simplify security and privacy.

9. OTHER ASPECTS

Cellular-V2X supports message reception requirements over 10MHz (and 20 MHz). However, the minimum performance requirements for cellular[25] are typically higher than those for DSRC. Additionally, the age

[23] 3GPP TS 23.285 V14.2.0, *3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Architecture enhancements for V2X services (Release 14)*, at 15 (Mar. 2017) ("The provisioning parameters for V2X communications over PC5 may be configured in the UICC, in the ME, or in both the UICC and the ME.").

[24] 3GPP TR 33.885 V1.1.0, *3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Study on security aspects for LTE support of V2X services (Release 14)*, at 46 (Feb. 2017) ("The security requirements applicable to V2X communications . . . are all satisfi[ed] by employing application-layer security as defined in other SDOs.").

[25] 3GPP TS 36.101, *supra* note 13.

of BSM transmission for cellular V2X can be determined by the same specification as described in SAE J2945/1. Together, this means that Cellular-V2X can, at minimum, deliver all the V2V capabilities of DSRC – while having the distinguishing performance characteristic of being able to evolve to future iterations like 5G in a smooth and efficient manner while maintaining compatibility with prior cellular iterations.

In addition to meeting the basic NPRM performance requirements, Cellular-V2X offers a path to very significant advantages in payload size that are paramount to automated vehicle technologies. Cellular also supports exchange of (i) sensor data for collective perception (*e.g.*, video data), (ii) control information for platoons from very close driving vehicles (only a few feet gap), and (iii) vehicle trajectories to prevent collisions (cooperative decision making). Short-range ad hoc broadcast systems developed for the exchange of "stateless object information" for vehicle tracking, as proposed in the NPRM, have limited safety benefits in comparison.

V. CELLULAR V2X FOR V2 SAFETY TRIALS

As detailed in Appendix B, a growing number of road tests across the globe are demonstrating Cellular-V2X for V2V safety applications, most recently at Mobile World Congress in Barcelona.[26] 5GAA looks forward to conducting cellular V2V safety trials in the US this year, and would welcome USDOT partnership.

VI. COST EFFECTIVENESS

The regulatory costs of the proposed V2V/DSRC mandate are expected to be the second most expensive regulation in more than a decade, with annual costs of $5 billion and total costs in year 2060 (100% penetration) of $108 billion.[27] In addition to device costs ($341-$350 per vehicle in 2020), the cost of infrastructure for DSRC will fall on US taxpayers. By contrast, industry has historically borne the cost of telecommunications network deployments and upgrades and has invested for decades hundreds of billions of dollars (in CapEx and R&D) in deploying and improving cellular networks, and continues to make these significant investments today. Leveraging such investments yields dividends for both in-vehicle technology (required to enable V2V communication), as well

[26] *See* Appendix B.

[27] *See* Roger Lanctot, *HERE Brings the Network Effect*, Strategy Analytics (Feb. 15, 2017).

as roadside networks (required to support the V2V and V2I functions). In this regard, 5GAA notes that when comparing technology solution costs, the appropriate comparison is that of a Cellular-V2V safety solution, not the "hybrid" cellular/WiFi/satellite solution suggested in the NPRM.

The cost of in-vehicle development required to enable V2V functions can be reduced considerably if engineering know-how, resources and solutions are reused by leveraging cellular technology that is synergistic with existing automotive cellular-based connectivity platforms. The hardware and software cost will be lower as well if the new functions are just new features added to existing cellular modules as opposed to brand new parts for new radio technologies like DSRC, particularly when having to consider multiple vehicle architectures. The additional benefit is overall system robustness, which is paramount to any safety application and is unfortunately often overlooked in cost analysis. Moreover, the use of cellular for V2V safety also avoids unique lifecycle and technology obsolescence actions (and costs) necessary to keep unique, custom-built technology relevant, and therefore enables significant cost benefits over the life of the technology.

The cost of building and deploying unique road-side infrastructure and covering all necessary rural and urban areas is estimated to be approximately $7,000 per intersection.[28] More importantly, the timeframe in which this new network infrastructure could be built is likely to be very slow compared to other market-driven (*e.g.*, cellular) infrastructure investments, thus putting the proposed schedule and assumed benefits at significant risk. Moreover, LTE and 5G are being adopted globally, significantly adding to the economies of scale. With appropriate software upgrades, this can be achieved at a fraction of the cost compared to building brand new networks from ground up. Telecoms are already making these investments (and will continue to make them) as they upgrade their networks enabling a smooth and economic transition to 5G.

VII. REGULATORY ACTION

A V2V system as currently envisioned by NHTSA would include a proposed three-year phase-in period, which would require 50 percent of new vehicles to be V2V capable by 2021 (using DSRC), 75 percent by 2022, and

[28] *See* U.S. Department of Transportation, *National Connected Vehicle Field Infrastructure Footprint Analysis* (June 2014).

100 percent by 2023 – pursuant to a mandate, as NHTSA recognizes that the marketplace otherwise is unlikely to adopt DSRC on its own. It is important to note that cellular technology will be widely deployed in US vehicles and capable of V2V safety messaging in the next few years. Cellular is not a "future" or "alternative" technology. Absent any regulation or mandate, automobile manufacturers are planning to voluntarily equip nearly all new models by 2023 with cellular embedded connectivity. For example, SBD predicts that by 2023 about 80% of new vehicles in the US and 90% of new vehicles in the European Union (EU) will have embedded cellular modems.[29] These modems will have V2V performance equal to or better than what is proposed in the NPRM. Moreover, as the NPRM notes, with the proposed mandate, NHTSA does not expect DSRC penetration to hit above the 90% needed for V2V to have a meaningful impact until 2040, and does not expect DSRC penetration to hit 100% until 2060. By the 2040-2060 timeframe, cellular will have evolved even further to utilize technology well beyond even the 5G iteration that we are designing today.

Thus, a mandate to ensure high levels of penetration for V2V safety capability is not needed. With such a significant percentage of cellular V2X equipped vehicles, manufacturers will continue to voluntarily deploy embedded cellular V2X technology on all models to maintain competitiveness in the US, EU and globally – thereby also positioning their fleets for a smooth evolution path to a 5G future for V2V safety specifically and V2X broadly. A technology neutral "if-equipped" regulation that sets forth only minimum V2V safety performance requirements could ensure consistency of performance across manufacturers and provide a standard for liability. Consistent with the technology neutral objective, any such regulation should not require one-way interoperability with a specific technology, or in any way directly or indirectly pick technology winners and losers.

VIII. CONCLUSION

5GAA is of the opinion that a technology neutral approach is the best approach to realizing the need for critical V2V safety applications. Based on our analysis, Cellular V2X for V2V Safety meets and/or exceeds the expressed KPIs in the NPRM and significantly enhances vehicle safety, now and in the future. A technology neutral

[29] *See* Blasco, *supra* note 12.

"if-equipped" regulation that sets forth only minimum V2V safety performance requirements could ensure consistency of performance across manufacturers and provide a standard for liability.

The 5GAA respectfully proposes that USDOT undertake an updated, comprehensive technology neutral analysis (DSRC, LTE and 5G) of the Key Performance Indicators in the NPRM, in collaboration with 5GAA and other industry experts, before moving forward with this proceeding. 5GAA looks forward to working with USDOT on this important task.

Respectfully submitted,

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5G Automotive Association

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APPENDIX A

DESCRIPTION OF 5GAA

5GAA is a new global cross-industry association of companies from the automotive, technology and telecommunications industries. Created to collaborate on end-to-end solutions for future mobility and transportation services, 5GAA includes 42 members, of which 8 are founding members (AUDI AG, BMW Group, Daimler AG, Ericsson, Huawei, Intel, Nokia and Qualcomm Incorporated).[1] Board Members, in addition to these 8 companies, include Ford Motor Company, China Mobile, SAIC Motor and Vodafone. The association's mission is to develop, test and promote communications solutions, initiate their standardization and accelerate their commercial availability and global market penetration to address society's connected mobility and road safety needs with applications such as autonomous driving, ubiquitous access to services and integration into smart city and intelligent transportation.

Since its inception in September 2016, 5GAA has rapidly expanded to include key players with a global footprint in the automotive, technology and telecommunications industries, including car manufacturers, tier-1 suppliers, chipset/communication system providers, mobile operators and infrastructure vendors. Diverse both in terms of geography and expertise, 5GAA's members are committed to contribute to the definition and development of next generation connected mobility and automated vehicle solutions.

While 5GAA is a relatively new association, we are actively pursuing our mission. Along those lines, we currently have established the following working groups:

- WG1 on Use Cases and Technical Requirements: Defining automotive use cases for V2X, focusing on end-to-end view on use cases, requirements and performance

[1] A complete list of 5GAA's members can be found on 5GAA's website at: www.5GAA.org.

indicators. In doing so, it will produce a series of documents such as strategic position papers, technical white papers or requirement specifications on V2X technologies.

- WG2 on System Architecture and Solution Development: Will define, develop and recommend system architectures and interoperable end-to-end solutions to address use cases and services of interest. To do so, it will review currently available solutions in technical areas such as wireless air interface technologies (including LTE, LTE-V2X, 5G and ITS-G5), and identify gaps towards end-to-end solutions and specifications for the use cases and services of interest as defined by WG1.
- WG3 on Evaluation, Testbeds and Pilots: Evaluating and validating end-to-end solutions through testbeds and promoting commercialization and standardization via pilots and large scale trials. WG3 will describe the selected use cases and technical requirements, proceed to test the method and benchmark a definition and then test and evaluate with respect to driving KPI parameters for different applications.
- WG4 on Standards and Spectrum: Acting as an industry specification group towards standards and spectrum bodies. It will agree on spectrum requirements for V2X in ITS, and represent the association vis-à-vis other industry organisations.
- WG5 on Business Models and Go-To-Market Strategies: Will agree on criteria for business models, collect business models from involved parties and ultimately act as a reality check to prove the value of the technologies and projects developed by the other working groups by demonstrating their technical and economic feasibility.

In turn, the following working items already have been approved for each of these working groups:

Working Group 1

Use Case and KPI requirements: Prioritization and Timeline

Working Group 2

Regional V2X application specification alignment with ITS-Cellular lower layers
Study on sensor data sharing for sensor sharing V2X applications
WID on V2X Definitions
C-V2X Network Architecture
Broadband Communication in C-V2X
Preparation of an E2E Study and C-V2X Architecture and Solution Development for Cooperative Autonomous Driving

Working Group 3

Survey on ITS Testbeds, Trials, Simulation Frameworks
C-V2X North American Trial Planning

Working Group 4

Study of spectrum needs for safety related intelligent transportation systems
Promotion of ITS spectrum for C-V2X to regulatory and standards organizations and industry associations

Working Group 5

Commercial Use Cases – (Identifying Non-Safety Use Cases and Business Proposition for Commercial and IMT-2020 Spectrum

APPENDIX B

CELLULAR V2X TRIALS

A growing number of road tests across the globe are demonstrating Cellular-V2X for V2V safety applications. Below is a description of those tests in which 5GAA members are participating. 5GAA looks forward to conducting cellular V2V safety trials in the US this year, and would welcome USDOT partnership.

RACC track, MWC 2017	Audi, Vodafone, Huawei @ MWC
ConVeX (A9), Germany	Audi, Ericsson, Qualcomm, Swarco, Kaiserslautern Univ.
Towards 5G, France	Ericsson, Orange, Qualcomm, PSA Group
Mobilifunk (A9), Germany	Vodafone, Bosch and Huawei
UK CITE, UK	Jaguar Land Rover, Vodafone, et al
DT (A9), Germany	Audi, Deutsche Telekom, Huawei, Toyota
Car2X at A9, Germany	Continental, DT/T-Systems, Nokia, Fraunhofer
Car2X in Wuzhen, China	CMCC, Continental, Nokia, Fraunhofer
MEC pilot project, Germany	Bosch, DT/T-Systems, Nokia

Audi, Vodafone and Huawei (February 2017, Barcelona): On the world famous Circuit de Barcelona-Catalunya race track at the Mobile World Congress 2017, Audi, Huawei and Vodafone demonstrated the use of 4G cellular to enhance safety by enabling rapid exchange of information between vehicles (V2V), other road users and infrastructure (V2I). They demonstrated "see through" (connected cars can see a video feed from a vehicle in front of them in situations where it will help them to have visibility of other traffic, upcoming entry roads or other issues to negotiate); a traffic light warning (traffic light is about to change alerting the driver to slow down), pedestrian in the roadway warning; and emergency braking warning (other connected vehicles suddenly braking or changing lanes).

Audi, Ericsson, Qualcomm, Swarco, Kaiserslautern Univ (January, 2017, ConVeX (A9), Germany): The goal of the trial is to demonstrate the benefits of a Cellular V2X connectivity platform, as defined by 3GPP Release 14, to showcase range, reliability and latency advantage for real-time V2V communications. Additionally, the trial aims to highlight new use cases that help support traffic flow optimization, and improve safety. ConVeX plans to use the results of the trial to inform regulators, provide important inputs to ongoing global standardization work and shape a path for further development and future evolution of Cellular V2X technology.

Ericsson, Orange, Qualcomm, PSA Group (February, 2017, Towards 5G, France): The initial phase of testing demonstrated Cellular V2X capabilities on the evolution towards 5G in a real environment over two use cases dedicated to the connected vehicles: "see through" between two connected vehicles on a road, and "emergency vehicle approaching," aiming at notifying drivers when an emergency vehicle is nearby in real-time. These two use cases have taken advantage of improved latency, and high throughput performance, using the network-based capabilities of Cellular V2X to deliver a high-resolution video stream between two vehicles, demonstrating reactivity to show real time event notification.

Vodafone, Bosch and Huawei (February, 2017, Mobilifunk (A9), Germany): Trial underway in the stretch of the A9 stretch between Nuremberg and Munich in Germany. During the trial, the consortium is demonstrating the viability of direct V2V communications and the ability to exhibit very low latency. In addition, the tests are intended to investigate how Cellular V2X differs from the IEEE 802.11p technology.

Jaguar Land Rover, Vodafone et al (June, 2016, UK CITE, UK): Connected Intelligent Transport Environment (UKCITE) is a project to create the most advanced environment for testing connected and autonomous vehicles. It involves equipping over 40 miles of urban roads, dual-carriageways and motorways with various V2V technologies including Cellular V2X. The project establishes how this technology can improve journeys; reduce traffic congestion; and provide entertainment and safety services through better connectivity.

Audi, Deutsche Telekom, Huawei, Toyota (July, 2016, DT (A9), Germany): The companies are conducting trials of Cellular V2V technology on a section of the “digital A9 motorway test bed" near Ingolstadt, Germany. Audi AG and Toyota Motor Europe research cars, and Deutsche Telekom infrastructure have been specially equipped with V2V hardware from Huawei to support the trial scenarios.

Continental, DT/T-Systems, Nokia, Fraunhofer (November 2015, Car2X at A9, Germany): The trial demonstrated how vehicles on the motorway can share hazard information using the LTE network of Deutsche Telekom. As extremely short transmission times are vital for this purpose, a section of the Deutsche Telekom network was equipped with innovative Mobile Edge Computing technology from Nokia Networks, and upgraded with position-locating technology developed by Fraunhofer ESK. This combination permitted signal transport times between two vehicles of less than 20 milliseconds.

CMCC, Continental, Nokia, Fraunhofer (November 2016, Car2X in Wuzhen, China): At the 2016 World Internet Conference in Wuzhen, China, the partners demonstrated Cellular V2V applications such as Emergency Brake Light that lets you know when traffic in front of you slows down and Cooperative

Passing Assistant, that determines whether it is safe to change lanes, advising oncoming traffic to slow down and warning vehicles in front not to change lanes.

Bosch, DT/T-Systems, Nokia (June 2016, MEC pilot project, Germany): The development partnership demonstrated the application of Cellular V2X utilizing local clouds for fast vehicle-to-vehicle communication for hazard warnings and for cooperative and coordinated driving maneuvers. The work included implementing driver assistance functions such as intersection assistance and electronic brake lights.