ITS AMERICA

Future of V2X in 5.9 GHz Report

This document summarizes the Intelligent Transportation Society of America (ITS America) survey on the future of Vehicle-to-Everything (V2X) technologies, presents an updated 5.9 GHz application map, includes a summary of the 5G Automotive Association (5GAA) United States Vehicle-to-Infrastructure Communications; Day One Deployment Guide (Day One Deployment Guide), maps the Day One message set to the application map to determine Day One applications, provides an overview of FCC actions in the 5.9 GHz band, and lists the entities that have received a waiver to operate C-V2X technology in the 5.9 GHz band.

www.itsa.org

1100 New Jersey Ave SE Ste. 850
Washington, DC 20003

Introduction

This report provides an overview of efforts by the Intelligent Transportation Society of America (ITS America) and other organizations to identify a path forward to deploying Vehicle-to-Everything (V2X) technologies in the 5.9 GHz spectrum band. As the industry awaits a Second Report and Order from the Federal Communications Commission (FCC) action on *Use of the 5.850-5.925 GHz Band*, this document provides useful insight to the industry on stakeholder priorities and application mapping of the remaining spectrum reserved for V2X technologies.

In November 2020, the FCC released its First Report and Order reallocating the majority of the 5.9 GHz spectrum for use by unlicensed wireless devices, while reserving only 30 MHz for V2X technologies. The industry is still waiting for the FCC to issue a Second Report and Order, which will provide rules for operating V2X in the remaining 30 MHz of spectrum.

In 2022, ITS America conducted a survey of the transportation industry on V2X technologies. This survey was conducted to gather public and private sector input on: (1) how the 30 MHz should be utilized, (2) prioritization of applications within the 30 MHz, (3) the use of Channel 180, and (4) the need for additional spectrum for V2X technologies.

ITS America, its Future of V2X in 5.9 working group, and other public and private sector representatives decided that instead of simply publishing the findings of the survey, the survey would be incorporated into this broader document, which also discusses major activities that have occurred since the survey was conducted. Since that time, the 5G Automotive Association (5GAA) developed its United States Vehicle-to-Infrastructure Communications; Day One Deployment Guide (Day One Deployment Guide) and the FCC has issued waivers for operation of C-V2X in the 5.9 GHz band. Additionally, this document provides an update to ITS America's 30 MHz Application Map, initially released in February 2021.

The 5GAA Day One Deployment Guide was developed with input from associations, including ITS America, and significant contributions from companies, public agencies, and original equipment manufacturers (OEMs) who sought to define a multi-stakeholder view of what Day One deployments would look like with a focus on what messages would be necessary and uniform across deployments. The guide was released in October 2023.

Despite establishing a waiver process in its initial Report and Order, in May 2021, it was not until April 2023 that the FCC granted its first waiver. As of April 2024, 50 waivers have been granted.

This document summarizes the V2X survey and discusses the updated application map (*V2X Survey Synopsis and Updated V2X Application Map, pages 2-12*), provides the full ITS America V2X industry survey analysis (*ITS America Future of V2X Industry Survey Analysis, Appendix A, pages 13-32*), includes a 5GAA Day One Deployment Guide summary (*5GAA Message Set Guidance, Appendix B, pages 33-34*), provides an overview of FCC actions to date on the 5.9 GHz band (*FCC Actions on the 5.9 GHz Band, Appendix C, pages 35-39*), and lists the current C-V2X waiver recipients (*C-V2X Waiver Parties, Appendix D, pages 40-42*). This document will be supplemented as Day One deployment is further refined according to infrastructure owner operators (IOOs) and OEMs, and as Day Two messages and applications are identified.

V2X Survey Synopsis and Updated V2X Application Map

ITS America conducted a survey in 2022 to evaluate industry stakeholder views on the future of V2X technology and to gather community input on the reduction from 75 MHz to 30 MHz of dedicated spectrum available for V2X deployment. The results of the survey were organized into five categories:

- Experience with V2X: Provides an overview of the entities who responded to the V2X survey, summarizes the types of deployments they have undertaken (Question 10), the goals of those deployments (Question 11), and their plans to deploy C-V2X devices in the upper 30 MHz of the spectrum, including as a replacement to existing DSRC installations (Question 12).

- Flexibility of Deployment: Analyzes how the 30 MHz of spectrum should be used, evaluating whether applications in the 5.9 GHz spectrum should be limited to an agreed-upon set (Question 13), whether flexibility should be afforded to agencies and OEMs such that there would be some excursion from a core baseline (Question 14), and whether a core safety set of applications should be well-defined (Question 15).

- Application Prioritization: Provides information related to the prioritization of certain applications over others, based on an expectation that 30 MHz will not be enough spectrum to support all applications. This section provided stakeholders the opportunity to identify which applications are most important to them and their communities.

- Channel 180: Channel 180 (5.895-5.905 MHz) is located immediately adjacent to spectrum that the FCC has reallocated for use by unlicensed devices, and therefore is likely to experience interference due to out-of-band emissions (OOBE) from unlicensed devices. This section evaluates how Channel 180 should be best utilized to support or provide V2X services given these concerns. Additional information on how Channel 180 might be used is being developed SAE J3161/2 (LTE-V2X Deployment Profiles and Radio Parameters for PC5 Interface in 10 MHz Channel 180). Note this information report is currently work in progress.

- Additional Spectrum: Transportation industry stakeholders have called on the FCC to work with the U.S. Department of Transportation (USDOT) and the National Telecommunications and Information Administration (NTIA) to identify and allocate additional spectrum for use by V2X technologies, particularly for advanced applications. This section evaluates how any additional spectrum allocated for V2X direct communications should be used.

Survey Results

Experience with V2X

There were 64 responses to the set of questions focused on Experience with V2X, including 24 state and local agencies and 10 vehicle OEMs. The remaining respondents consisted of the vendor, consultant, and academic communities. There were consistent trends among the answers of these three types of respondents. Key results are:

- Safety is a focal point and the need to reduce crashes and fatalities is paramount.
- Regulatory uncertainty is a major concern.
- Without regulatory certainty, some respondents are taking a wait and see approach.
- Even with regulatory uncertainty, some IOOs are transitioning to and deploying C-V2X.

Other takeaways from the survey include general acceptance of using C-V2X in the 5.9 GHz band and focusing on solving issues and concerns so that when the final rules are provided, all parties will be ready to move forward. Finally, the survey shows that the V2X community, IOOs, OEMs, vendors, etc., need to collaborate to help achieve regulatory and market certainty.

Since this survey was conducted, the FCC has begun granting C-V2X waivers. To date, 50 waivers have been granted that include a variety of agencies, vendors, OEMs, and other private entities. A discussion of the FCC's activity over the years can be found later in this document. IOOs are positioned to ramp up V2X deployment but are hesitant to do so without commitment from the OEMs. One opportunity to induce commitment from OEMs is development of regulations mandating V2X technology in vehicles. See Appendix A below for more detailed survey results.

Flexibility of Deployment

This set of questions was premised on V2X being limited to 30 MHz, and respondents stated that a core set of safety applications should be prioritized to ensure adequate performance and, if possible, there could be additions to the core applications. While respondents felt that ensuring core safety applications can operate and perform as intended was the most important need, a few asked for additional flexibility in what applications can be provided. Finally, it will take a collaboration across the connected vehicle (CV) community to define a set of core safety applications.

IOOs will likely have other applications they want to deploy that they see as critical to managing the roadway network. The Day One Deployment Guide released in October 2023 may help define these applications. This guide provides a set of Day One recommended messages that can be used in the 30 MHz without performance degradation. From these messages, a set of applications can be identified that could be deployed as Day One applications. A summary of the Day One Deployment Guide can be found at Appendix B. The ITS America updated application map below shows the applications, using the Day One message set, that could be deployed Day One.

Application Prioritization

Respondents were asked to provide a list of prioritized applications for inclusion in the 30 MHz, with the expectation that there will not be enough spectrum to utilize all currently identified applications. The basis for the application list was ITS America's Application Map. Taking these lists of prioritized applications, one needs to determine which messages are required for the applications to function correctly. The Day One Deployment Guide from 5GAA recommends the messages for use in a Day One deployment. Taking the messages derived from the prioritized applications and comparing that to the guide is important to determine if any of the prioritized applications are not recommended for Day One deployment.

Safety applications, as in other categories, were prioritized as most important by respondents, with most being Vehicle-to-Vehicle (V2V) applications. The prioritized applications were organized into three categories: high, medium, and low priority. Focusing only on the high priority applications, there was general agreement on which applications should be in a Day One deployment. It is notable that Personal Safety Messages (PSM) are not currently a recommended message for Day One deployment. Further discussions about how to include the PSM in a Day One deployment message set are needed as the Federal government focuses on protecting Vulnerable Road Users (VRUs). However, PSMs are not the only messages that can support VRU safety; other messages, such as BSMs, can also be used to support VRU applications.

Furthermore, there was a tendency to identify non critical-safety, delay-tolerant Vehicle-to-Infrastructure (V2I) applications as potentially operating outside of the 5.9 GHz spectrum. Finally, some respondents identified missing applications which could impact commercial vehicles, school safety, and vulnerable road users.

Channel 180

Since C-V2X utilizes 20 MHz (Channel 183, 5905-5925 MHz), there is discussion about how Channel 180 (5895-5905 MHz) should be best utilized to support or provide V2X services. There were varying opinions on how to use Channel 180, ranging from a guard band to using it for applications. However, it was unclear which applications would or could operate in Channel 180. At the time of the survey, there were also some unknowns for C-V2X and Dedicated Short-Range Communications (DSRC) operating on adjacent channels. There was some consensus that Channel 180 could be used for non-safety applications if adequate testing was performed. It was noted that interference was likely to occur in this channel. If both C-V2X (Channel 183) and DSRC (Channel 180) were used, two radios would also be required.

Additional Spectrum

There has been a movement by the V2X community for the FCC to work with USDOT and NTIA to identify and allocate additional spectrum for use by V2X technologies. Respondents supported the allocation of an additional reserved spectrum for V2X applications. If a new spectrum is allocated, it is important the FCC put in place sufficient protections to restrict interference in the spectrum. Once a new spectrum is allocated, the V2X community must quickly make use of the spectrum to prevent the future possibility of losing part or all the spectrum. The spectrum applications should focus on

advanced safety, VRUs, and some mobility applications for V2I, as well as supporting V2V cooperative sensors and data sharing.

Updated V2X Application Map

The table below shows how the applications prioritized in the survey of industry stakeholders, as shown in columns two and three, correspond to the messages recommended in the Day One Deployment Guide, developed by multiple organizations representing the broad deployment community.

The applications have messages that are required for the application to function between vehicles for V2V and with infrastructure for V2I and I2V, but sometimes there are multiple messages that can deliver the same functionality. If the functionality requires multiple message types, the application must include all those messages, or it will not function. If multiple messages can deliver the same functionality for an application, those may also be listed under the “AltMsg” column. In addition, some applications do not have a corresponding message defined in standards and are denoted as “No Msg”.

In the Day One Deployment Guide, technical rules for V2X messages, which are combined to deliver applications, are provided. Those applications that are supported according to the Day One Deployment Guide are listed as “included”, and those that are not supported are listed as “missing”.

Note that the Personal Safety Message (PSM) is not listed in the Day One Deployment Guide. During the development of the Day One Deployment Guide, an important criterion for inclusion of messages was the maturity of the associated standards and whether there were certification tests available. In short, if applications requiring PSM are deemed important, the V2X standardization and certification communities have clear objectives to meet.

The table below also includes a delay-tolerant field to help in planning how applications will communicate between participants. While all these applications are designed to be deployed on C-V2X, efforts are underway to deliver these applications through other mechanisms. The messages and application stack may support a different mechanism, but the latencies involved may not be sufficient to deliver a responsive application and could compromise confidence in the application itself.

It is important to note that a number of these applications operate based on the same message types, allowing numerous applications to be operated without requiring additional spectrum. However, different applications using the same message types can have vastly different spectrum needs due to differing message sizes and frequency of message transmission, so there are likely scenarios in which some applications using the same message types could not be deployed.

Additionally, the available spectrum will be dependent in part on the number of vehicles within communication range and the types of applications operating in a specific area. Because of this, it will likely be necessary to establish a scheme that prioritizes safety-critical applications while dropping non-safety-critical applications in such situations.

The table below is an illustrative example of deployment messages, though not all deployers may choose to deploy in a standardized way.

Column Descriptions

1. **Percentage of IOO with Priority:** Represents the percentage of Department of Transportation agencies that prioritize a particular application or service. The value indicates how critical the application is considered across the industry.
2. **Total IOO Votes:** Indicates the total number of votes or recommendations made by agencies for a specific application. This metric helps gauge the level of interest or consensus for each application.
3. **ReqMsg1:** Denotes the first required message type necessary for an application to function. For instance, this could represent a Basic Safety Message (BSM) for safety-related applications.
4. **ReqMsg2:** Denotes the second required message type necessary for the application. If an application requires two message types, the second message type will be included here.
5. **ReqMsg3:** Denotes the third required message type, if applicable. Some applications require three message types to function effectively.
6. **AltMsg:** Denotes a message type that can deliver the functionality for the application in addition to, or in place of, the ReqMsg fields.
7. **Day 1 Deployment Message Set:** Specifies the collection of V2X messages that are recommended for immediate deployment in the US according to the Day One Deployment Guide. These messages form the basis of foundational applications as listed in the table.
8. **Delay Tolerant:** Indicates whether an application is tolerant to communication delays. If an application requires immediate responsiveness, it will be marked as non-delay tolerant. If an application is marked as “conditional”, some network-based communication mechanisms may be able to achieve the necessary latency requirements, while others may not.

Application	Percentage of IOO with Priority	Total IOO Votes	ReqMsg1	ReqMsg2	ReqMsg3	AltMsg	Day One Deployment Message Set	Delay Tolerant
Wrong Way Driver Warning	67%	55	TIM	BSM			Included	Yes
Intersection Collision Warning	63%	54	BSM				Included	No
Work Zone Warning	60%	55	TIM			RSM	Included	Yes
Emergency Vehicle Signal Preemption	48%	52	MAP	SRM	SSM		Included	Yes
Cooperative Collision Warning	47%	57	BSM				Included	No
Intersection Movement Assist (IMA)	47%	49	MAP	SPAT	BSM		Included	No
Approaching Emergency Vehicle Warning	46%	55	RSM				Included	No
Cooperative Forward Collision Warning	44%	54	BSM				Included	No
Forward Collision Warning (FCW)	44%	54	BSM				Included	Yes
Traffic Signal Violation Warning	44%	52	BSM				Included	Conditional
Left Turn Assist (LTA)	44%	50	BSM				Included	Conditional
Reduced Speed/Work Zone Warning	43%	53	TIM			RSM	Included	Yes
Emergency Electronic Brake Lights (EEBL)	42%	52	BSM				Included	Conditional
Blind Spot / Lane Change Warning (BSW/LCW)	42%	53	BSM				Included	No
Emergency Vehicle Preemption (PREEMPT)	39%	51	MAP	SPAT	SRM/SSM		Included	Yes
Pedestrian in Signalized Crosswalk Warning (Transit)	39%	51	TIM	PSM		RSM	Included	Conditional
Curve Speed Warning	39%	49	TIM			RSM	Included	Conditional
Stop Sign Violation Warning	39%	52	MAP	SPAT	TIM		Included	Yes
Blind Spot Warning	38%	53	BSM				Included	No

Application	Percentage of IOO with Priority	Total IOO Votes	ReqMsg1	ReqMsg2	ReqMsg3	AltMsg	Day One Deployment Message Set	Delay Tolerant
Emergency Communications and Evacuation (EVAC)	37%	49	TIM			RSM	Included	Yes
Incident Scene Work Zone Alert Driver Worker (INC-ZONE)	35%	51	TIM			RSM	Included	Conditional
Pedestrian Crossing Information	35%	54	TIM	PSM		RSM	Included	Conditional
Highway/Railroad Collision Warning	34%	53	BSM	RSM	TIM		Included	Conditional
Left Turn Assistant	33%	49	BSM				Included	No
Do Not Pass Warning (DNPW)	32%	53	BSM				Included	No
Work Zone Traveler Information	32%	53	TIM			RSM	Included	Yes
Blind Merge Warning	31%	52	BSM	RSM	TIM		Included	No
Road Condition Warning	31%	49	TIM			RSM	Included	Yes
Lane Change Warning	29%	51	TIM	BSM		RSM	Included	No
Signal Priority (Transit/Freight)	29%	49	MAP	SPAT	SRM		Included	Yes
Advanced Traveler Information System	28%	53	TIM			RSM	Included	Yes
Pre-Crash Sensing	28%	51	BSM				Included	No
Sensor Data Sharing	26%	53	BSM				Included	No
Intelligent Traffic Signal System (SIG)	24%	51	MAP	SPAT	BSM		Included	Yes
Queue Warning (Q-WARN)	24%	51	TIM			RSM	Included	Yes
Spot Weather Impact Warning	24%	51	BSM	TIM			Included	Yes
Vehicle Turning Right in Front of Bus Warning (Transit)	23%	48	BSM				Included	No
Traffic Signal Priority	23%	53	MAP	SPAT	SRM		Included	Yes

Application	Percentage of IOO with Priority	Total IOO Votes	ReqMsg1	ReqMsg2	ReqMsg3	AltMsg	Day One Deployment Message Set	Delay Tolerant
Stop Sign Movement Assistant	22%	50	BSM				Included	Conditional
Low Bridge Warning	21%	48	TIM			RSM	Included	Yes
Traffic Signal Timing	19%	52	MAP	SPAT	BSM		Included	No
Cooperative Adaptive Cruise Control (CACC)	19%	53	BSM				Included	Conditional
SOS Services	18%	49	TIM	BSM		RSM	Included	Yes
Highway Merge Assistant	16%	50	BSM				Included	No
Traveler Information	16%	51	BSM	TIM			Included	Yes
CV-enabled Turning Movement & Intersection Analysis	15%	52	BSM				Included	No
Post-Crash Warning	14%	49	BSM				Included	Yes
In-Vehicle Signage Warning	14%	50	TIM			RSM	Included	Yes
Mobile Accessible Pedestrian Signal System (PED-SIG)	14%	51	SRM	SSM	PSM		Missing	Conditional
Vehicle-to-Vehicle Road Feature Notification	13%	48	BSM	RSM			Included	No
Approach and Departure at Signalized Intersections	12%	49	BSM				Included	Conditional
Maneuver Sharing and Coordination	12%	49	BSM				Included	No
Incident Scene Pre-Arrival Staging Guidance for Emergency Responders (RESP-STG)	11%	47	TIM				Included	Yes
Motorist Advisories and Warnings (MAW)	10%	49	TIM			RSM	Included	Yes
Speed Harmonization	10%	50	BSM				Included	Conditional
Truck Height Detection	9%	44	TIM			RSM	Included	No
Visibility Enhancer	9%	45	No Msg				Not Included	No

Application	Percentage of IOO with Priority	Total IOO Votes	ReqMsg1	ReqMsg2	ReqMsg3	AltMsg	Day One Deployment Message Set	Delay Tolerant
Dynamic Transit Operations (T-DISP)	9%	46	MAP	SPAT	SRM/SSM		Included	Conditional
Cooperative Glare Reduction	9%	47	No Msg				Not Included	No
Wireless Inductive/Resonance Charging	9%	47	No Msg				Not Included	Conditional
Ramp Speed Warning	8%	48	TIM			RSM	Included	Conditional
Lanes Management	8%	49	No Msg				Not Included	No
Connected Driving	8%	50	No Msg				Not Included	No
Dynamic Speed Harmonization (SPDHARM)	8%	50	BSM				Included	No
In-Vehicle Amber Alert Warning	8%	50	TIM			RSM	Included	Yes
AFV Charging/Fueling Information	8%	51	BSM				Included	Yes
Cooperative Adaptive Cruise Control	8%	51	BSM				Included	No
Cooperative Vehicle-Highway Automation System (Platoon)	8%	53	BSM				Included	Conditional
Integrated Corridor Management Decision Support System	7%	45	BSM				Included	Conditional
Wireless Inspection	7%	45	BSM				Included	Yes
Adaptive Headlamp Aiming	6%	47	No Msg				Not Included	No
Probe-enabled Traffic Monitoring	6%	48	BSM				Included	Yes
Probe-based Pavement Maintenance	6%	50	BSM				Included	Yes
Smart Truck Parking	6%	50	TIM				Included	Yes
CV-enabled Origin-Destination Studies	6%	51	BSM				Included	Yes
Enhanced Maintenance Decision Support System	4%	45	No Msg				Not Included	Yes

Application	Percentage of IOO with Priority	Total IOO Votes	ReqMsg1	ReqMsg2	ReqMsg3	AltMsg	Day One Deployment Message Set	Delay Tolerant
Drayage Optimization	4%	47	TIM				Included	Yes
Vehicle Classification-based Traffic Studies	4%	47	BSM				Included	Yes
Vehicle Data Translator (VDT)	4%	46	BSM				Included	Yes
Weather Response Traffic Information (WxTINFO)	4%	47	TIM			RSM	Included	Yes
Low Emissions Zone Management	4%	48	TIM			RSM	Included	Yes
Low Parking Structure Warning	4%	48	TIM			RSM	Included	No
Freight-Specific Dynamic Travel Planning and Performance	4%	49	BSM				Included	Yes
Ramp Metering	4%	50	BSM				Included	Conditional
Smart Parking	4%	52	BSM	MAP			Included	No
Dynamic Ridesharing (D-RIDE)	2%	46	No Msg				Not Included	Yes
Dynamic Routing (Light Vehicle/Transit/Freight)	2%	48	BSM				Included	Yes

Conclusion

As has been the case over the last several years, the state of V2X remains in flux. While the FCC has issued several waivers in 2023, the Second Report and Order and final rules for the spectrum are still lacking. To date, there is no set time by which these rules will be finalized. Many OEMs are delaying deployment until such a time that the FCC provides clear direction for using the 5.9 GHz spectrum.

In April 2023, ITS America released its ITS America V2X National Deployment Plan – an infrastructure and automaker collaboration. This plan proposes a National V2X Deployment Plan from the perspective of both IOOs and OEMs and includes a call to action for state and local transportation agencies and related federal agencies, and outlines expectations for OEM deployment. The most expeditious starting point for a national roll-out on the infrastructure is at signalized intersections. The plan presents guidelines on how to achieve interoperability, goals to achieve a rapid nationwide infrastructure rollout of the technology, an associated cost estimate, and a discussion on proposed sources of funding for infrastructure installation.

In October 2023, 5GAA, OEMs, IOOs, and others released the Day One Deployment Guide. The goal of this guidance was to identify the messages that could be used as part of a Day One deployment. This guidance is meant to encourage OEMs and IOOs to prepare for Day One deployment. That said, additional messages not in the Day One deployment, such as PSM, are being identified by OEMs as needed. OEM focus is turning to VRUs, working with IOOs to deploy standardized infrastructure. Taking this approach could allow for quicker deployment and would not depend on ubiquitous deployment in all vehicles.

In October 2023, USDOT released a draft version of its Saving Lives with Connectivity: A Plan to Accelerate V2X Deployment plan. This plan, which is currently being updated with feedback from stakeholders, lays out USDOT's vision of how national deployment should occur. In summary, the USDOT plan identifies the following deployment approach:

- Short Term (2024–2026) – 12 interoperable, cybersecure deployments
- Medium Term (2027–2029) – 25 interoperable, cybersecure deployments
- Long Term (2030–2034) – 50 interoperable, cybersecure deployments

These are four examples of entities attempting to move V2X forward. While there is overlap in developing these plans as well as sharing the goal of expediting V2X deployment, close collaboration will be required to ensure the successful rollout of V2X and the use of the 5.9 GHz Spectrum. When we consider IOOs, who are moving forward with C-V2X deployments in anticipation of the FCC finalizing rules for the 5.9 GHz spectrum, there is momentum to deploy V2X, but all parties must collaborate more closely to obtain a full and ubiquitous deployment.

Appendix A
ITS America Future of V2X Industry Survey

The Intelligent Transportation Society of America (ITS America) conducted a survey in the Spring of 2022 to evaluate industry stakeholder views on the future of vehicle-to-everything (V2X) technology considering recent regulatory developments, namely the reduction of dedicated spectrum available for V2X deployment from 75 MHz to 30 MHz. This document provides the results of that survey and indicates additional steps that need to be taken to advance the deployment of V2X in 30 MHz of spectrum.

The results of the survey are organized into five categories:

- Experience with V2X: Provides an overview of the entities who responded to the V2X survey and summarizes the types of deployments they have undertaken (Question 10), the goals of those deployments (Question 11), and their plans to deploy C-V2X devices in the upper 30 MHz of the spectrum, including as a replacement to existing DSRC installations (Question 12).

- Flexibility of Deployment: Analyzes how the 30 MHz of spectrum should be used, evaluating whether applications in the 5.9 GHz spectrum should be limited to an agreed-upon set (Question 13), whether flexibility should be afforded to agencies and OEMs such that there would be some excursion from a core baseline (Question 14), and whether a core safety set of applications should be well-defined (Question 15).

- Application Prioritization: Provides information related to the prioritization of certain applications over others, based on an expectation that 30 MHz will not be enough spectrum to support all applications. This section provided stakeholders the opportunity to identify which applications are most important to them and their communities.

- Channel 180: Channel 180 (5.895-5.905 MHz) is located immediately adjacent to spectrum that the FCC has reallocated for use by unlicensed devices, and therefore is likely to experience interference due to out-of-band emissions (OOBE) from unlicensed devices. This section evaluates how Channel 180 should be best utilized to support or provide V2X services given these concerns. Additional information on how Channel 180 might be used is being developed SAE J3161/2 (LTE-V2X Deployment Profiles and Radio Parameters for PC5 Interface in 10 MHz Channel 180). Note this information report is currently work in progress.

- Additional Spectrum: Transportation industry stakeholders have called on the FCC to work with USDOT and NTIA to identify and allocate additional spectrum for use by V2X Technologies, particularly for advanced applications. This section evaluates how any additional spectrum allocated for V2X communications should be used.

In each section, we provide explanatory information, the questions asked, an analysis of the survey results, and high-level conclusions or takeaways. This document concludes with a discussion of the results and identifies additional steps to be taken to advance V2X deployment.

Additional Background Information

In the summer of 2020, ITS America established a Future of V2X Working Group made up of ITS America members representing various aspects of the industry, including infrastructure owner operators, automotive original equipment manufacturers, and other industry stakeholders.

The Working Group was tasked with evaluating the impacts of the FCC's proposal to reallocate 45 MHz of spectrum in the 5.9 GHz band on the deployment of V2X technologies, including which message types and applications could or could not be operated effectively in a limited 30 MHz spectrum environment.

The main product of the Working Group's efforts at that point was a preliminary application map that identifies which applications ITS America and its industry members believe would be able to operate within 30 MHz.

To develop the Application Map, the Working Group evaluated around 90 ITS applications based on spectrum requirements, stakeholder priority, and likely safety benefit. The main conclusion of the application map is that several message types and applications would likely fit in 30 MHz of spectrum, but several key message types and applications would be lost.

Messages that Could Likely Be Deployed:

- BSM – Basic Safety Message
- MAP – intersection Mapping.
- SPaT – Signal Phase and Timing message.
- RSM – Road Safety Message
- SRM – Signal/Service Request Message
- SSM – Signal Status Message
- RTCM – GNSS Correction Messages
- PVD – Probe Vehicle Data
- TIM – Traveler Information Message

It is important to note that a number of these applications operate based on the same message types, allowing numerous applications to be operated without requiring additional spectrum. However, different applications using the same message types can have vastly different spectrum needs due to differing message sizes and frequency of message transmission, so there are likely scenarios in which some applications using the same message types could not be deployed.

Additionally, the available spectrum will be dependent in part on the number of vehicles within communication range and the types of applications operating in a specific area. Because of this, it will likely be necessary to establish a scheme that prioritizes safety-critical applications while dropping non-safety-critical applications in such situations.

Messages that could likely not be deployed:

- SDSM – Sensor Data Sharing Messages
- MSCM – Maneuver Sharing/Coordinating Messages
- PSM – Personal Safety Messages

Notably, these message types support important advanced V2X applications that are necessary to fully realize the potential transportation safety benefits of a connected transportation system. These include applications related to the deployment of automated vehicles (AVs), allowing vehicles to share sensor data, create messages for vehicles that are not equipped with V2X, coordinate movements rather than acting individually, and deploy applications intended to protect vulnerable road users, such as pedestrians and bicyclists.

The Future of V2X in 5.9 Working Group sought to further develop and refine the 30 MHz Application Map, including by soliciting feedback on a broader set of issues related to the use of 30 MHz and from additional V2X stakeholders. This resulted in the Future of V2X Survey which was conducted in the Spring of 2022 and the results of which are summarized in this document.

Experience with V2X

This section of the report describes a general overview of the entities who responded to the V2X survey and summarizes the types of deployments they have undertaken (Question 10), the goals of those deployments (Question 11), and their plans to deploy C-V2X devices in the upper 30 MHz of the spectrum, including as a replacement to existing DSRC installations (Question 12).

Survey Questions

Question 10: *Have you deployed V2X devices (please indicate the type of deployment: commercialization, operational use, testing, etc.)? If so, what types of devices (DSRC/C-V2X; RSUs/OBUs/Aftermarket) have you deployed? How many devices have you deployed? How many vehicles are involved in the deployment? What applications are included in the deployment?*

Question 11: *What is your organization's primary goal for the deployment of V2X technologies?*

Question 12: *Do you expect to deploy C-V2X devices in the upper 30 MHz of the 5.9 GHz spectrum? If so, please elaborate on your expected C-V2X deployment (including scale, scope, and timeline). Will this deployment replace existing DSRC devices?*

Analysis

There were 64 responses to the survey, including 24 agencies (state and local) and 10 OEMs. The other respondents, about half of the total, included equipment vendors, consultants, vehicle developers, universities, technical companies (such as software developers), and communications

companies. The respondents reported about 18 infrastructure deployments (RSUs installed). Three agency respondents indicated that they had not deployed any RSUs. The number of respondents (10 OEMs and 18 agencies with deployments) represent a significant proportion of the relevant population.

- Among the 18 agencies that reported deployments, the deployment sizes ranged from 2 RSUs to over 1000. Among those, there were:
    - Six “large” deployments with over 100 RSUs
    - Three “medium” deployments with between 26 and 100 RSUs
    - Nine “small” deployments with 25 or fewer RSUs
- Several of the large and medium deployments represented among the respondents are USDOT-initiated, connected vehicle pilots or test beds (the Safety Pilot, CV Pilots, and Smart Cities), largely funded by federal funds, but four of the largest deployments represented were state and local-government initiated projects, some of which also leveraged federal funds.

Most large and medium deployments have begun to move toward C-V2X testing or installation.

A few of the deployments, mostly in the small category, have turned their DSRC deployments off. Two of the larger CV Pilot sites have also turned off their DSRC units with no plans for conversion to channel 180 or replacement with C-V2X, due to lack of funding for the effort to modify or replace their RSUs.

When asked about applications currently being tested or deployed, agencies with deployments listed a broad variety of applications, including both V2I and V2V applications. The most prevalent applications in use are:

- signal priority for transit.
- freight or emergency vehicles
- applications that can be deployed using fleet vehicles to achieve short-term benefits.

Agencies also indicated experience with

- Forward Collision Warning
- Reduced Speed Warning around schools and work zones
- Other work zone applications, including a focus on worker safety.
- Eco-driving applications
- To a lesser degree
    - Intersection Movement Assist
    - Blind Spot Warning, Emergency Electric Brake Light
    - Curve Speed Warning
    - Spot Weather Impact Warning
    - Wrong Way Driving
    - Pedestrian Safety

Some agencies deployed RSUs to broadcast SPaT, MAP, and sometimes PSM, TIM and RTCM, but didn't develop applications, likely in direct response to the SPaT Challenge. In these cases, the agencies often noted that they were waiting for the OEMs to step in with applications.

OEMs and their suppliers also mentioned a broad variety of applications in use or under current development, including nearly all the applications that were mentioned by the agencies. The most mentioned applications by this group were Intersection Movement Assist, Forward Collision Warning, Emergency Electric Brake Light, Left Turn Assist, Red Light Violation Warning, and Emergency Vehicle Warning or Preemption. Work zone safety applications, transit signal priority, pedestrian safety applications, and curve speed warning were also noted.

The broad variety of applications being developed by both agencies and OEMs for current testing and use focuses mostly on safety, a fact that emphasizes the promise that these entities see in V2X communication. The safety motive is clear from these responses.

Only a few of the infrastructure deployments included more than a few vehicles with OBUs. The exception was often the federally initiated pilot projects. Agency vehicles used after-market, in-vehicle installations, not OEM-integrated devices.

Survey responses were provided by 12 OEMs or vehicle developers. Of these:

- Most have a few test vehicles.
- A few have no deployment experience with V2X.
- Those working in this area are developing V2V safety applications but also have efforts focused on V2I applications.
- Two OEMs have significant deployment experience – General Motors with their Cadillac DSRC deployment over two model years (later discontinued) and Toyota with equipped vehicles in Japan (still active).

The overwhelming number of respondents noted that their primary focus was toward safety – crash prevention, etc. Some added secondary goals of mobility and environmental impacts. Only a few respondents listed mobility as their primary goal.

When responding about future plans, most (but not all) respondents indicated that they would move to C-V2X technology. However, there were several comments about the use of C-V2X, including some concerns over whether C-V2X systems are fully proven, whether there is yet certainty over the selection of C-V2X as the platform choice, and exploration of other alternatives: virtual RSUs, network cellular systems, or continued use of DSRC in the lower 45 MHz as an unlicensed device.

Several of the agencies expressed concern with the uncertainty in the regulatory environment or a lack of a C-V2X waiver for deployment permission. It is important to note that the FCC has granted 3 waivers in 2023. This is discussed in more detail in the FCC section below. Some OEMs echoed that sentiment. Regulatory uncertainty seems to be the primary concern prohibiting more aggressive deployment in both the infrastructure and the vehicles. This is keeping some entities from moving forward or making decisions. Phrases used in responses from both IOOs, and OEMs included:

- "Not able to commit to any deployments at this time."
- "When it becomes consensus."

- "Not until the federal government signals a clear and unambiguous intention to support deployment."
- "When it appears that everything is settled."
- "Uncertainty of out of band emissions from Wi-Fi and limited spectrum"

A couple of responses from agencies noted their dependence on actions from the OEM community, such as these:

- "All V2X deployments are on hold until OEMs adopt the technology in-vehicle."
- "Operating under a reactive stance dependent on the automotive industry."

At least one OEM suggested the need for a high level of certainty in the regulatory environment with this comment:

- "Public commitment to deployment plans is challenging without US regulations in place."

Vendor respondents generally indicated intent to support the needs of their clients – OEMs and IOOs – getting the equipment and support that they require and need. Many of them mentioned regulatory uncertainty and evolution of technology as issues that hinder deployments.

Conclusions and Takeaways

A summary of the trends noted in these responses include:

- While there is considerable variety in the responses received, there are some consistent trends within the three types of respondents – the OEMs, the IOOs, and the vendor / consultant / academic community.
- There is intentional effort being undertaken toward the promise of reduced crashes, reduced fatalities, and improved safety with V2X systems.
- Regulatory uncertainty is a significant hurdle to deployments by both agencies and OEMs and is stifling current action.
- Agencies are ready to deploy once the automakers commit to deploying V2X technology in their vehicles.
- While there is interest, and some continued deployment activities, among the infrastructure agencies, an effective and beneficial V2X system needs OEM deployments; many agencies are waiting for that commitment and action before moving ahead.
- Regulations requiring the deployment of V2X systems on vehicles would be a certain motivator for OEMs.
- Despite regulatory uncertainty, some agencies are moving forward with C-V2X deployment, based on the FCC selection of this technology.

Looking beyond the specific responses, some general inferences can be made based on the trends noted above. These include:

- After years of debate over technology platforms, there appears to be a broad acceptance that C-V2X technology is the path forward in the low-latency, 5.9 GHz band. Most agencies are poised to move ahead with this technology.

- There is an urgent need to resolve the issues causing uncertainty so that the benefits of these systems can be realized in the near term.
- The SPaT Challenge, issued in 2016, revealed an interest in deployment of V2X systems. Provided with a deployment plan and objective, albeit quite simple, agencies responded enthusiastically with installations of RSUs. Similarly, the responses in this survey suggest a strong belief in the promise of V2X to save lives and improve mobility, and pent-up demand for action. Given regulatory and market certainty and consensus, it appears that many organizations are ready to move forward. If OEMs take positive steps, IOOs are willing to follow.
- A mandate for V2X deployment on vehicles, similar to the 2016 NHTSA Notice of Proposed Rulemaking, would provide the unambiguous certainty needed by the industry to move forward.
- During this time of uncertainty, the industry needs to continue working to solve technical issues and move the marketplace to a condition where deployments can move forward quickly once the regulatory issues are resolved.

Flexibility of Deployment

This section of the report analyzes how the 30 MHz of spectrum should be used, evaluating whether applications in the 5.9 GHz spectrum should be limited to an agreed-upon set (Question 13), whether flexibility should be afforded to agencies and OEMs such that there would be some excursion from a core baseline (Question 14), and whether a core safety set of applications should be well-defined (Question 15).

Survey Questions

Question 14: *On a scale of 1-10, should the transportation industry focus on allowing a limited number of messages/applications in the 30 MHz, with the goal of reducing the risk that some messages/applications may be unavailable or may experience performance degradation (1), or should the industry focus on allowing as many messages/applications to operate as possible, potentially increasing the likelihood that some messages/applications may be unavailable or may experience performance degradation (10)? (The lower the response number, the greater the preference for fewer messages/applications; the higher the response number, the greater the preference for more messages/applications.)*

Question 15: *Should stakeholders be provided flexibility to choose which applications operate in a given geographical area? If so, should there be a minimum set of message types and applications that are always supported?*

Question 16: *Should definitions be established for which applications are 'core safety' applications vs. other types of applications?*

Analysis

In formulating this series of questions for the survey, we provided one hard constraint: that 30 MHz – and no more – would be allowed for direct, short-range applications in the foreseeable future. On

top of that, in posing the question, we included two hypotheses, namely that: (a) a concept of core safety applications operating in the remaining dedicated spectrum could prevail in order to provide some assurance of performance, and (b) there could be local or situational determination to add to the core applications.

The responses were by and large consistent. In order to best convey what the community means by flexibility of deployment; we re-pose the questions in simpler form and offer a synthesis and conclusions.

- Should applications for 5.9 GHz be limited to an agreed-upon set?
- Should flexibility be afforded to agencies and OEMs such that there would be some excursion from a core baseline?
- And should a core safety set be well-defined?

Question 14: *On a scale of 1-10, should the transportation industry focus on allowing a limited number of messages/applications in the 30 MHz, with the goal of reducing the risk that some messages/applications may be unavailable or may experience performance degradation (1), or should the industry focus on allowing as many messages/applications to operate as possible, potentially increasing the likelihood that some messages/applications may be unavailable or may experience performance degradation (10)? (The lower the response number, the greater the preference for fewer messages/applications; the higher the response number, the greater the preference for more messages/applications.)*

While individual responses varied, the universal consensus indicated that safety is paramount and should have full and priority use within the remaining 30 MHz at 5.9 GHz. On a scale of 1 to 10, with 1 being a strong preference for allowing fewer messages, 52% of respondents indicated a 1 through 4 answers. Only 22% of the responses were between 6 and 10. There was some variation, however, when evaluating the responses from OEMs versus IOOs. The OEM responses ranged from 1 to 5 and averaged 2.4. There were no OEM responses above 5. The IOO responses ranged from 1 to 10 and averaged 4.9. The explanations provided by the OEMs indicated that they believed there is only room in this limited spectrum for the safety critical message sets and that allowing more messages would “overwhelm the systems”; fewer messages will “minimize performance degradation”. While more than half of the IOO respondents provided a score of less than 4, the higher scores – indicating a need for more messages and applications – were focused on two lines of thinking: 1) we need to aggressively use the spectrum today by employing multiple “day-one” use cases and then scale those applications back over time as we get higher vehicle penetration and spectrum use, and 2) agencies need flexibility and options for the use of the spectrum, especially for applications that might be limited to their own geographic area. A couple of university respondents who support agency deployments noted that they have been broadcasting multiple messages without performance degradation but admitted that the number of vehicles was small.

Full use of 30 MHz was invoked by about a quarter of all responses, and piques questions as we try to analyze what this could mean. C-V2X is designed to work with separate 10 or 20 MHz radios, so using up 30 MHz necessitates two on-vehicle and two roadside C-V2X radios. Would OEM stakeholders implement multiple radios? Perhaps a subset of vehicle-based stakeholders could use two radios to facilitate certain applications, such as platooning. It was noted in several responses

that some road infrastructure owner operators have moved DSRC operations to 10 MHz at CH180, so with C-V2X at 20 MHz in CH183, full use of the spectrum is provided in the near term. We note that the possibility of having no cars with two radios would in effect limit safety applications to one 20 MHz channel. (There is another set of questions addressing the applicability of CH180, so in this section we chose not to interpret the viability of this any further.)

Question 15: *Should stakeholders be provided flexibility to choose which applications operate in a given geographical area? If so, should there be a minimum set of message types and applications that are always supported?*

Most responses were positive in defining a core set of standard safety messages and applications; furthermore, many did want flexibility on top of the core set. Many respondents noted that a core set of safety messages should be defined and supported to facilitate a uniform, nationwide deployment and to avoid a patchwork. Several respondents proposed that SPaT, MAP, BSM, TIM, SRM and SSM should be supported everywhere. There was a slight but important difference between IOO and OEM responses. While both classes of stakeholders agreed that there should be a minimum set of safety messages, IOOs generally wanted some flexibility for additional messages.

Example quotes are:

- IOO: “There should be a national standard for minimum set of applications/messages. If a geographical area wants to add more than that would be allowed.”
- OEM: “There should be a minimum set of messages that need to be supported - BSM, SPaT and MAP messages.

Some respondents indicated that flexibility or excursion could be a function of facility type. This distinction should be important, as facility type would be a better differentiator to safety needs than to assign a set of core safety messages to state agencies and a potentially different set to local agencies.

There were some inputs that warned that “flexibility” should still be well-bounded since there would likely still be the need to make judgement. Other inputs indicated that getting to a core set of safety messages might be a challenge. A case in point would be tolling in CH183, which could be delineated by categorizing tolling facilities separate; however, most would regard the that tolling messages are not safety critical.

In assessing the responses, we note that while flexibility should be viewed as an opportunity, it is important to the road user and OEM that there is an expectation of nationally consistent services. Therefore, putting bounding rules in place, probably by industry consensus, is important.

It is important to consider the relationship between “Applications” and “Messages”. There was general agreement that it is essential that a set of “core” applications be identified; those applications will establish the message content and performance requirements necessary to support those core applications. It is likely that those messages will also support a wider variety of applications and, depending on available channel capacity, may permit flexibility in supporting future applications.

Question 16*: Should definitions be established for which applications are 'core safety' applications vs. other types of applications?*

This question is admittedly closely coupled to the prior questions, so indeed, the concept of core safety messages and applications was consistently supported. Various consistent responses support that an industry definition and application of core safety in the remaining portion of the 5.9 GHz spectrum be given priority.

One responder summarized their thoughts as:

> *"... these definitions will be necessary. And, since safety is my goal (and likely most IOOs goal) and achieving safety requires OEM deployment, those definitions must be based on which applications OEMs will support."*

It is important to note that the nature of this question does not preclude the existence/permitting of other non-safety applications in the spectrum. Also worth mentioning is that while the surveyors unanimously supported the focus on safety there was a thread of concern regarding the prioritization of the need to showcase full use of the spectrum.

The authors summarizing this survey do caution that there may be unintended limitations placed on the future flexibility of application development and that the Society of Automotive Engineers has attempted in the past to define a core list however was forced to pause because it became too polarizing of an issue.

In summary, yes, a set of core safety applications should be defined. It is anticipated that the continuation of that question is who and how should these be defined lest they all be identified as "safety".

Conclusions and Takeaways

Based on our analysis of stakeholder response to these questions, there are a few key conclusions:

- Core safety should be paramount. Several respondents requested flexibility but not to the detriment of core safety, with facility-specific variations allowed.
- Effective operations of safety-related applications, as long intended for V2X systems, without the risk of performance degradation, is of paramount importance throughout the industry.
- It will take broad industry coalition to define the core safety applications, and it should be done expeditiously as safety use of this spectrum is the priority.

Application Prioritization

This section provides information related to the prioritization of certain applications over others, based on an expectation that 30 MHz will not be enough spectrum to support all applications. This section provided stakeholders the opportunity to identify which applications are most important to them and their communities in the context of only 30 MHz of spectrum.

A key to a successful deployment in the upper 30 MHz is the identification of which applications can successfully be implemented. More specifically, this identification boils down to the number of messages and their frequency that can be broadcast over 30 MHz.

Survey Questions

Question 22*: Please provide a priority ranking (1 through 5) for each of the V2X applications below. A ranking of "5" indicates the application is a high priority to your organization, while a ranking of "1" indicates that the application is a low priority. Please limit the number of "5" and "4" rankings to no more than 15 applications each. If you are unfamiliar with an individual application, please leave it blank.*

For more information on individual applications please feel free to consult the following resources: https://www.arc-it.net/ and https://transportationops.org/connected-fleet-challenge/cvapplications.

Question 23*: Are there applications that are not included on the list that should be included?*

Question 24: *Please feel free to further explain your priority selections or otherwise provide comment on application prioritization here:*

Analysis

Question 22*: Please provide a priority ranking (1 through 5) for each of the V2X applications below. A ranking of "5" indicates the application is a high priority to your organization, while a ranking of "1" indicates that the application is a low priority. Please limit the number of "5" and "4" rankings to no more than 15 applications each. If you are unfamiliar with an individual application, please leave it blank.*

Question 22, the actual prioritization exercise, identified almost 90 connected vehicle applications. This list of applications was compiled from three sources to ensure a comprehensive list, but it did result in some duplications. The sources are:

- https://local.iteris.com/cvria/html/applications/applications.html
- https://www.arc-it.net/html/servicepackages/servicepackages-areaspsort.html
- https://transportationops.org/connected-fleet-challenge/cvapplications

Respondents were to indicate the priority they associated with each application on a scale from 1 to 5; with 1 being the lowest priority and 5 being the highest priority. It is worth noting that no definitions for the applications were provided. Respondents either had to be familiar with the application, research the application functionality or infer the application functionality from the application name. Respondents were also told to try and not rate more than 15 applications with level 5 priority as well as no more than 15 applications with a 4 priority. It was decided to combine the top two priority levels (i.e., 4 and 5) and use the combined prioritization to rank and assess the highest priority applications. As well, the list of highest-priority applications was limited to those with a combined highest prioritization of at least 50% - that is, at least 50% of the respondents' prioritized applications at either a "4" or a "5."

Finally, in reviewing the applications and comments made by some respondents concerning duplication of applications, applications were reviewed to identify those which were duplicates of one another. For example, there were 4 work zone applications listed. These applications were considered similar enough to be classified as a single application. In all cases, but two, the similar applications were all ranked above 50%, so further quantitative reduction of the data associated with these "duplicate applications" was not performed.

Table 1 lists the highest priority applications identified by Vehicle to Infrastructure (V2I) and Vehicle to Vehicle (V2V).

Table 1: Highest Priority Applications

V2I	V2V
Wrong Way Driver Warning	Approaching Emergency Vehicle Warning[1]
Emergency Vehicle Signal Preemption / Approaching Emergency Vehicle Warning[1]	Intersection Collision Warning
Work Zone Warning	Cooperative Collision Warning
Pedestrian in Signalized Crosswalk Warning (Transit)	Cooperative Forward Collision Warning
Traffic Signal Violation Warning	Emergency Electronic Brake Lights (EEBL)
Queue Warning (Q-WARN)	Do Not Pass Warning (DNPW)
Curve Speed Warning	Blind Spot/Lane Change Warning (BSW/LCW)
Signal Priority (Transit, Freight)	
Highway/Railroad Collision Warning	
Stop Sign Violation Warning	

Table 1 shows that ten V2I and seven V2V applications made the list of high priority applications. These "high priority" applications are ones that are familiar to the CV community and there were generally no surprises as to which applications were, or were not, included in the list.

For these seventeen applications, the message(s) required for each application were identified and are shown in Table 2 below.

[1] Approaching Emergency Vehicle Warning application could be either V2I, or V2V. Most implementations are V2V.

Table 2: Messages for High Priority Applications

Safety App / In Spectrum	Message
Approaching Emergency Vehicle Warning	RSM
Intersection Collision Warning	BSM
Cooperative Collision Warning	BSM
Cooperative Forward Collision Warning	BSM
Emergency Electronic Brake Lights (EEBL)	BSM
Do Not Pass Warning (DNPW)	BSM
Blind Spot/Lane Change Warning (BSW/LCW)	BSM
Wrong Way Driver Warning	TIM/RSM
Emergency Vehicle Signal Preemption	SRM/SSM
Pedestrian in Signalized Crosswalk Warning (Transit)	PSM
Traffic Signal Violation Warning	MAP/SPaT
Signal Priority (Transit, Freight)	SRM/SSM
Highway/Railroad Collision Warning	ICA/CPM
Stop Sign Violation Warning	Map (cloud-based deliver)

All messages except for the Personal Safety Message (PSM) were identified by ITS America in their 2021 study of messages which can fit into the 30 MHz. Additionally, lower priority applications that utilize these same messages could be considered for inclusion in the application list as these lower-priority applications do not require any additional messages outside what has been defined as fitting in the 30 MHz; thus, these applications will not require additional traffic on the 30 MHz.

Question 23*: Are there applications that are not included on the list that should be included?*

For question 23, respondents were asked to identify what if any applications were missing from the question 22 list. For the most part, respondents said the list was complete. But a summary of additional responses is listed below:

- Two-wheel vehicles such as bicycles, e-Scooter, and e-Bikes applications were noted as missing. Note that there was no explicit mention of motorcycles.
- Noncritical V2I applications can run in unlicensed spectrum.
- Additional V2I applications were identified (see below).
- There were several comments about duplicate applications.

Of the 64 total respondents, 26 responded to question 23. Of those 26, the response most often provided was that the list was complete or no additional applications could be identified.

These applications identified by respondents as "missing" in the question 22 list are identified in Table 4.

Table 3: Missing Applications

Missing Applications	
Red Light Violation Warning (likely Traffic Signal Violation Warning)	School Bus Ahead
Emergency Vehicle Approaching Warning (could be implemented in combination with Emergency Vehicle Signal Preemption)	Alert School Zone
Weight Limit Alert	Variable Speed Light
High Wind Warning	Bridge Width Limit
Fog / Visibility Alert	Vulnerable Road User Awareness Message
Motorcycle, e-Bike, e-Scooters, and Bicycle Applications	

Question 24: *Please feel free to further explain your priority selections or otherwise provide comment on application prioritization here:*

For question 24, respondents were asked to explain their prioritization methods or provide further comments on the application priority. A summary of the responses is listed below.

- Safety applications were the focus of several of the responses.

- Observations that some V2I applications must be in the 30 MHz while others could use other form of communication media, like LTE. However, no one identified which applications were candidates for these other media.
- At least one self-identified IOO noted that V2I applications needed to be in the 30 MHz.
- While not specifically identifying specific applications, respondents noted that some applications do not require low latency.
- A point was raised that OEMs have/are addressing some of the applications using existing vehicle-housed technology such as Forward Collision Warning.
- One comment encouraged making use of the spectrum now. One can assume that this is due to the FCC previously stating the 5.9 GHz spectrum originally allocated was underutilized.
- There was one respondent that was interested in monetizing all the applications.

Of the 64 respondents, 31 responded to question 24. The most notable theme in the comments was a focus on safety.

Conclusions and Takeaways

Based on our analysis of stakeholder response to these questions, there are a few key conclusions:

- The identified "high priority" applications are ones that have been piloted at deployments and test beds. With this common set of applications, there is general agreement on what are the most important applications to deploy first. These high priority applications use the messages identified in ITS America's 2021 message study. Only one message, the PSM, was not part of ITS America's list. This leads to a discussion about how vulnerable road users are going to participate in the CV environment.
- Safety applications were deemed most important with most being V2V.
- There were some diverse opinions as to whether all V2I apps needed to run within 30 MHz. V2I applications that do not require low latency were pointed out as not needing to be in the 30 MHz.
- Applications identified as missing could be grouped into three categories: commercial vehicles, school safety, and vulnerable road users (including 2-wheel vehicles).

Channel 180

Channel 180 (5.895-5.905 MHz) is located immediately adjacent to the spectrum that the FCC has reallocated for use by unlicensed devices. Due to this proximity and the FCC's proposed power limitations on unlicensed devices, it is highly likely that unlicensed devices will cause out-of-band emissions (OOBE) on Channel 180. The questions in this section asked how Channel 180 should be best utilized to support or provide V2X services.

Survey Questions

Question 17*: Should Channel 180 be used to deploy V2X applications that may be more tolerant to interference?*

Question 18*: Should Channel 180 be used to provide critical service needs, such as over-the-air support for certificate top-off, certificate revocation lists, misbehavior detection and reporting, and device management?*

Question 19*: Should Channel 180 be used for a different purpose not contemplated by the previous options?*

Analysis

Question 17*: Should Channel 180 be used to deploy V2X applications that may be more tolerant to interference?*

The FCC revised plan for the 5.9 GHz band provided authorization for unlicensed use in the lower 45 MHz of the band (5.850 – 5.895 GHz) and retained the upper 30 MHz of the band (5.895 – 5.925 GHz) for the Intelligent Transportation System (ITS) radio. The revised FCC plan provided the use of DSRC in Channel 180 (5.895 – 5.905 GHz) using 10 MHz and C-V2X in the Channel 183 (5.905 – 5.925 GHz) using 20 MHz for a transition period until DSRC is phased out of Channel 180 and the 30 MHz of the band for ITS operations must use C-V2X technology.

With Channel 180 being adjacent to Channel 177 (5.850 – 5.895 GHz) that is used with unlicensed radio (U-NII) there is a high probability of Channel 180 receiving out-of-band interference from Channel 177. The question was asked if Channel 180 should be used to deploy V2X applications that can possibly tolerate the out-of-band interference coming from Wi-Fi in Channel 177. The respondents to the question included members from IOOs, Industry, Consultants, and automotive OEMs.

The consensus from the respondents was positive when answering the question by agreeing on the possibility of using Channel 180 for non-safety application only if rigorous testing provided positive results. The respondents also noted that testing must be done in real-life scenarios to understand the potential risks and limitations of using Channel 180 for non-safety purposes. One consideration was that based on the answers the majority of IOOs did not consider the fact that in order to utilize Channel 180 and 183 in C-V2X, a second RSU radio will be required. The additional expense of an additional device to broadcast in Channel 180 can potentially change the consensus from the IOOs.

After reviewing the answers, the following items are left to discuss and/or clarify:

- Additional Testing Needed: It is clear from all respondent stakeholder groups that the assessment of whether a guard band is necessary, or interference is a real concern is required before fully being able to justify using Channel 180.
- Deployment Location: Rural areas are less prone to having out-of-band interference but urban areas with high density of devices are going to be more prone to interference from adjacent Channels. This distinction should be considered when deciding the functionality of Channel 180 as a guard band becomes a higher priority.
- Out-of-band Interference Upper Spectrum: With the release of Wi-Fi 6E, which uses the lower 45 MHz of the 6 GHz band, there might be companies that are developing hardware that historically tend to not tightly follow the specifications of tolerances on their equipment and the signal coming from those devices may create out-of-band interference from the

lower 45 MHz of spectrum. The out-of-band emissions from Wi-Fi 6E devices can potentially create a critical interference on the upper 30 MHz of the 5.9 GHz band where C-V2X will communicate.

Question 18*: Should Channel 180 be used to provide critical service needs, such as over-the-air support for certificate top-off, certificate revocation lists, misbehavior detection and reporting, and device management?*

After the FCC reallocation of the 5.9Ghz band that reduced the spectrum of the ITS band a consensus was reached to utilize the available spectrum for safety critical messages. The capacity of the C-V2X 20 MHz channel is focused on applications that provide priority for safety messages. Due to the limited spectrum bandwidth, the functionality listed in survey question 18 cannot be provided in the 20-MHz bandwidth allocated for C-V2X. The question asked the stakeholders if Channel 180 should be used for certificate top-off, certificate revocation lists, misbehavior detection and reporting, and device management.

The respondents did not reach the same consensus, and industry respondents had doubts about using Channel 180 for the functionalities listed in survey question 18. The wording of the question and the definition of "critical" reflected negatively on the responses. Automotive OEMs stakeholders had a consensus and understanding that C-V2X will use Vehicle-to-Network (V2N) either by using 5G or Wi-Fi to provide some of the functionality proposed in the question.

IOOs and consultants had the same consensus by having a general positive response on using Channel 180 for the functions listed in survey question 18 with the requirement that data from testing provides favorable results. Based on the answers, IOO respondents were not clear on the requirement of a second radio or secondary communication medium needed to accomplish the proposed functionality. The additional information could change the IOOs response based on additional financial costs needed of purchasing and installing the additional device.

Question 19: *Should Channel 180 be used for a different purpose not contemplated by the previous options?*

Question 19 essentially asks what other applications might be useful in this spectrum that may have not been previously considered.

Based on the IOO responses, there was no consensus or any specific suggestions as some did not feel qualified to respond as to what applications might be suitable for Channel 180. Some felt it should be a guard band while some just felt setting it aside for applications that could tolerate the expected interference and associated signal delays.

About half of Industry stakeholders who responded felt that there are potential optional uses for Channel 180 with some of those suggesting it be used as a guard band from the lower unlicensed frequencies. Some other ideas include sensor sharing, using it as a research development Channel and other non-critical applications.

The consensus from the consultants was also to create a guard band using Channel 180 or in one suggestion also using a portion of the spectrum to create a guard band on the upper end, above Channel 183.

The OEMs were evenly split indicating that the spectrum should be used as a guard band, and others said it should be used and maintained for safety purposes. One did suggest Channel 180's use as a guard band while one suggested that its use be predicated on a 'critical mass' of deployers.

Conclusions and Takeaways

Based on our analysis of stakeholder response to these questions, there are a few key conclusions:

- There is not a clear consensus on the use of Channel 180. Some want to use it as a guard band to adjacent channels. While others want to continue to use it for applications. What applications those would be are not clear as most do not know what the real-world operating conditions might look like – safety in keeping with original intent or high latency mobility applications. At least one OEM noted that for usage of Channel 180 to be successful there needs to be much broader support for deployment.
- Channel 180 for non-safety application is acceptable if rigorous testing shows positive results.
- Rural areas are less prone to having out-of-band interference than urban areas.

Additional Spectrum

Transportation industry stakeholders have called on the FCC to work with USDOT and NTIA to identify and allocate additional spectrum for use by V2X technologies. These questions ask how any additional spectrum allocated for V2X communications should be used.

Survey Questions

Question 20*: Should that spectrum be reserved for 5G NR V2X or another next generation technology?*

Question 21*: Which applications that might not fit within 30 MHz would be first on your list to include in that additional spectrum?*

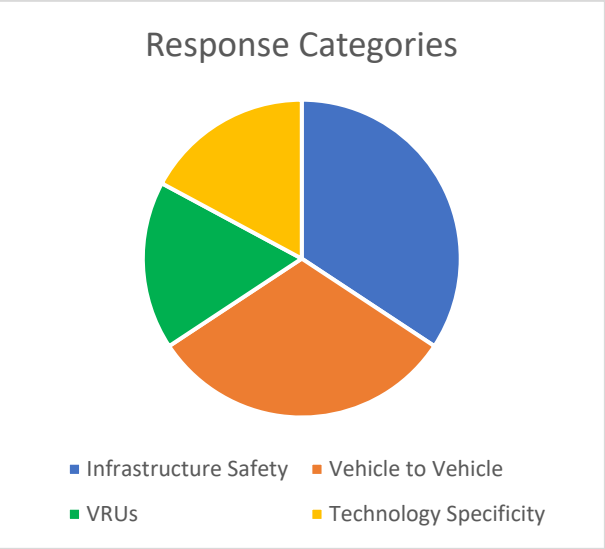
Analysis

These questions build upon the earlier presumption that the lower 45 MHz would be allocated to unlicensed wireless devices and the only spectrum available for ITS would be the upper 30 MHz. We established throughout the Survey that it is a known fact that all applications would not fit into the allocated 30 MHz, and that 10 MHz of that spectrum is at increased risk of interference, potentially making it unusable. It was then asked if additional spectrum should be allocated, what would be the preferred use of the additional spectrum.

Question 20 overwhelmingly shows the desire of IOOs and commercial enterprises to reserve this additional spectrum for the latest technology to address V2X, 5G NR V2X. These answers 78% for, and 22% against with 54 total respondents, are further explained in answers to Question 21. It provides more insight as to what the "Yes" respondents would like to see in this proposed, yet to be defined, new spectrum.

Question 21 responses can be separated into 4 separate categories.

- Infrastructure Safety Applications – 34%
- Vehicle to Vehicle Applications – 31%
- Vulnerable Road Users Applications – 17%
- Technology Specificity – 17%



First, we look at the last category, Technology Specificity. Concerns in 17% of the responses were directed toward question 20, which identified a specific technology. There was no response in question 21 that aligned with not needing additional spectrum but instead indicated that a regulatory body should not designate a single technology to the spectrum. This is where a small handful of respondents to Question 21 focused their efforts. The concerns in question 20 focus on the fact that the original 75 MHz of spectrum was allocated to DSRC and if there is any hesitation on the ability to consume a technology, assumptions might be made that the spectrum is not needed and it could be reallocated, as happened as we transitioned between DSRC and C-V2X.

Infrastructure Safety Applications are the largest group of supporting responses. These outline the IOO applications around work zones, wrong way, weather advisories, and other road condition applications. In the analysis, it appears as though this question has little support out of the responsibilities of the respondents. It seems that if a respondent represented an IOO, then this was the category they supported. This was consistent in the applications and locality of the deployment as it related to the respondents' responsibilities.

Vehicle to Vehicle Applications similarly were supported by commercial entities, and OEMs. These respondents are working on the capabilities of the vehicles, and as such, favored the cooperative maneuver sharing and sensor sharing type applications.

The outliers of the responses were the Technology Specificity, previously discussed, and Vulnerable Road Users (VRU) applications. Support for these applications spanned both IOO and OEMs as interaction with the roadway users, such as pedestrians and bicyclists, that are not in a vehicle has become a priority for both the vehicle manufacturers, autonomous vehicle developers, and Infrastructure Owner Operators.

Conclusions and Takeaways

The overall summary of these two survey questions is that additional spectrum reserved for ITS applications needs to be allocated.

- Once allocated, it is important that the spectrum not reference a specific technology such as DSRC, C-V2X, or 5G NR V2X. This allows for technology to evolve and applications to be added over time to the spectrum.
- It is also important the spectrum be used quickly and effectively to avoid reallocation.
- Governing should be done at a standards level to guide communication over the spectrum.
- Applications on the spectrum should focus on secondary safety, VRU, and some mobility applications for V2I, while also supporting V2V cooperative sensor/data sharing.

Conclusion and Next Steps

Three types of respondents were identified, IOOs, OEMs, and the vendor/consultant/academic community. Each of these groups has different application priorities. IOOs are focused on V2I applications, OEMs are focused on V2V, and the remainder identified a mix of priorities. However, all groups believed the safety is paramount.

Regulatory uncertainty is hindering IOO deployments and OEM adoption. While many IOOs are ready to deploy once the regulatory uncertainty is resolved, they want assurance from the OEMs they will adopt V2X before deploying infrastructure. Mandating the technology is one way to provide IOOs assurance.

There is agreement that V2X applications are important, and respondents mostly see the same set of applications as being a priority. That said it will require a broad partnership to establish the core safety applications. Entities involved in the partnership need to include, but not be limited to, USDOT, NTHSA, FCC, NTIA, IOOs, OEMs, and V2X vendors. This group needs to be established now in order to protect the remaining 30 MHz of spectrum. This group could work from a subset of the “high priority” safety-oriented applications that received broad support in the survey.

Appendix B

5GAA Message Set Guidance

The following discussion of the 5G Automotive Association (5GAA) United States Vehicle-to-Infrastructure Communications; Day One Deployment Guide, found here, provides a short high-level overview of the guide and does not represent the entire content of the guide. This summary is meant to provide the reader with enough understanding to be able to relate the guide's message set recommended profiles to what Day One applications are possible and how those applications relate to the ITS America application map and the USDOT Draft Deployment Plan.

The Day One Deployment Guide is meant to provide Day One guidance for Infrastructure Owners Operators (IOOs) to deploy Vehicle to Everything (V2X) using C-V2X direct communications. The working group consisted of V2X deployment stakeholders, including the Crash Avoidance Metrics Partners (CAMP), 5GAA, the Utah Department of Transportation, the National Electrical Manufacturers, infrastructure owners and operators, NEMA, Omni Air, ITS America, and University of Michigan researchers. The goal of this document is to provide IOOs with directions of what V2V and V2I messages are possible on Day One and therefore what V2X applications will be available on Day One. IOOs will be most interested in V2I applications as these are the applications IOOs can use to communicate with drivers.

The Day One Deployment Guide discussed guidelines, standards, and lessons learned from previous deployments. The document will emphasize the need for rapid V2X RSU deployments. It is worth noting that the USDOTs Draft Deployment Plan released in October 2023 has stated goals for the number of interoperable deployments between now and 2034. The plan states goals of 12 interoperable deployments by 2026, 25 interoperable deployments by 2030, and 50 interoperable deployments by 2034. The document identifies the set of existing messages and associated requirements to implement these messages. The document identifies three vehicle categories of Day One messages. These vehicle categories are listed below and are taken directly from the guide.

- Mass Use Production Vehicle (MUPV) – These messages are expected to be supported broadly across automotive OEM private passenger vehicles but may also be supported less broadly by other vehicle types. Given this, it is anticipated that a wide set of IOOs across the US will likewise provide support for these messages. These messages are the Basic Safety Message (BSM), Signal Phase and Timing (SPaT), Map Date (MAP), Radio Technical Commission for Maritime Services (RTCM) Corrections, Traveler Information Message (TIM), and Road Safety Message (RSM).
- Limited Use Fleet Vehicle (LUFV) – These messages are expected to be supported by vehicles within the purview or authority of individual IOO agencies, as opposed to mass-produced private passenger vehicles. The messages in this category necessarily include many of those involving MUPVs. These messages are Signal Request Message (SRM) and Signal Status Message (SSM).

- Limited Use Mixed Vehicle (LUMV) – These messages are likely to happen under bound circumstances and be supported by potentially only a subset of the MUPVs and LUFVs. These messages are Toll Advertisement Message (TAM), Toll Usage Message (TUM), Toll Usage Message Acknowledgement (TUMack), and WAVE Service Advertisement (WSA).

NOTE: It is important to note that for a host of deploying agencies, Day One LUFV and LUMV message support might occur before Day One MUPV message support. Should these agencies also support the Day One MUPV messages, it is essential for the corresponding messages to be broadcast in accordance with the Day One Deployment Guide, to establish an interoperable V2I ecosystem warranting automotive OEM and customer investment in C-V2X deployments.

Appendix C

FCC Actions on the 5.9 GHz Band

To better understand the FCC's most recent actions for the ITS Band, it is useful to briefly review the FCC's prior actions.

Background Phase 1: 1997-2012

Phase 1A: FCC activity for an ITS Band began in 1997 when ITS America petitioned the FCC to create the band. The FCC produced a Notice of Proposed Rulemaking (NPRM) in June 1998. On **October 10, 1999, the FCC issued a Report & Order (R&O)** creating the 75-MHz ITS Band[2] at 5850-5925 MHz.

Phase 1B: In November 2002, the FCC produced a second NPRM to define licensing and service rules for the ITS Band. They issued those rules, including the definition of seven 10-MHz channels, in an **R&O on December 17, 2003**. The FCC also agreed to suggestions that the rules include adherence to a single technical standard (ASTM E2213-03), to encourage rapid deployment and promote interoperability.

On **July 20, 2006, the FCC issued a Memorandum Opinion and Order (MO&O)** creating limited-use designations for Channels 172 and 184 within the ITS Band.

Background Phase 2: 2013-2017

In 2012 Congress passed the *Middle-Class Tax Relief and Job Creation Act of 2012*, one provision [6406(b)] of which required the National Telecommunications and Information Administration (NTIA) to study the possible sharing of the ITS Band between ITS devices and unlicensed devices[3] such as Wi-Fi™. NTIA published a report on Wi-Fi sharing on January 25, 2013. **On February 20, 2013, the FCC published an NPRM** exploring possible rules for sharing the ITS band between ITS devices and unlicensed devices.

Over the next several years, most FCC activity related to the ITS Band focused on two candidate Wi-Fi sharing proposals, known as Detect and Vacate (favored by most automotive industry stakeholders and some Wi-Fi stakeholders) and Re-channelization (favored by most Wi-Fi stakeholders).

On **June 1, 2016, the FCC issued a Public Notice (PN)** to "refresh the record" on the ITS Band and the Wi-Fi sharing NPRM and announced a plan for the FCC to work with US DOT and NTIA on a Wi-Fi sharing test regime in three phases. Only Phase 1 (FCC Lab) testing was completed. The Phase 1 testing report was released by the FCC on October 22, 2018.

[2] The ITS Band is often referred to as the 5.9 GHz band, including by the FCC

[3] Unlicensed devices are also known as Unlicensed-National Information Infrastructure (U-NII) devices and are sometimes referred to as Part 15 devices (a reference to FCC regulations in CFR 47 Part 15).

Background Phase 3: 2018-2022

On November 21, 2018, the 5G Automotive Association (5GAA) filed a Petition for Waiver with the FCC, advocating that the upper 20 MHz of the ITS Band (5905-5925 MHz) be designated for use by Cellular V2X (C-V2X).

On December 12, 2019, the FCC issued an NPRM that effectively combined the previous question about Wi-Fi sharing with the new question about use of C-V2X for ITS. The main proposals in the NPRM were:

- Repurpose 5850-5895 MHz, removing it from the ITS Band and designating it the U-NII-4 band for unlicensed use. The ITS Band would be reduced from 75 MHz to 30 MHz (5895-5925 MHz). In effect, rather than define a mechanism for sharing between Wi-Fi and ITS, the FCC gave 45 MHz to Wi-Fi.
- Permit use of C-V2X in the upper 20 MHz of the band (5905-5925 MHz)

On **November 18, 2020, the FCC voted to approve the "First R&O" for the 5.9 GHz band, as well as a Further NPRM (FNPRM) for a "Second R&O"** to follow.

The main aspects of the First R&O were:

- Repurpose 5850-5895 MHz as U-NII-4, removing it from the ITS Band. Allow indoor use of U-NII-4 by unlicensed devices. Specify *Out Of Band Emissions* (OOBE) limits for indoor U-NII-4 devices, i.e. how much interference energy these devices are permitted to emit into the new 30-MHz ITS Band (5895-5925 MHz).
- Indicate that the new 30-MHz ITS Band would require use of C-V2X in the future, and that use by non-C-V2X devices would be phased out, though specific rules for the transition to C-V2X and for use by C-V2X would come in the 2nd R&O.
- Indicate that legacy ITS deployments in 5850-5895 MHz would have one year after the date on which the First R&O went into effect to cease operation or move to 5895-5925 MHz.
- Discussion of the need for a streamlined waiver process to allow stakeholders who wish to deploy C-V2X devices prior to the issuance of the 2nd R&O an opportunity to do so.

The FNPRM proposed several things, including:

- Allow use of the U-NII-4 band by outdoor devices, with specified OOBE limits.
- Define "C-V2X" as 3GPP Release 14 LTE V2X.

The FNPRM also asked for comments on key questions, including:

a) Should stakeholders who deployed under the original rules be compensated?

b) Should use of the new ITS Band be restricted to safety applications?

c) Should the FCC allocate additional licensed spectrum for ITS in a different spectral band, and if so which part?

The publication of the First R&O and of the FNPRM were delayed until May 3, 2021. The First R&O went into effect on July 2, 2021.

On August 6, 2021, the FCC issued a PN providing guidance for a streamlined waiver process to permit use of C-V2X in 5895-5925 MHz.

On December 13, 2021, a group of 14 stakeholders, including automakers, state DOTs, and equipment manufacturers, filed a waiver with the FCC requesting permission to deploy C-V2X immediately. This became known as **the "Joint Waiver Request"**.

See Appendix B for a list of the waiver request stakeholders. The request included proposed operation parameters including transmission power and OOBE limits.

During 2022 and 2023, many other entities filed waiver requests with the FCC. These generally requested waivers on the same terms as the Joint Waiver Request. See Appendix B.

Phase 4: FCC actions in 2023

Most of the FCC activity in 2023 has been in relation to waiver requests.

In 2022 and 2023, NTIA and USDOT cooperated to test potential interference that C-V2X transmissions in 5895-5925 MHz (based on parameters in the Joint Waiver Request) might have on federal incumbent users of the band. They consulted with federal stakeholders, including the Department of Defense and NASA. **On April 14, 2023, NTIA notified the FCC** that based on their tests, they conclude that federal incumbents would be protected if C-V2X devices limited operation to 5905-5925 MHz and if transmissions "limit the EIRP to 27 dBm at ± 5 degrees in elevation from the horizontal plane".

On **April 24, 2023, the FCC granted the Joint Waiver Request.** The FCC grant included the following key restrictions on operation:

C-V2X OBU and RSU Operations

Frequency Range	Channel Bandwidth	OBU Limits	RSU EIRP Limit
5905-5925 MHz	20 MHz	33 dBm EIRP*; 27dBm EIRP within 5 degrees of horizontal	33 dBm EIRP

*EIRP (equivalent isotopically radiated power)

C-V2X Out-of-Band Emissions (OOBE) Limits

Frequency Offset (MHz from Channel Edge)	OOBE EIRP Limits for C-V2X Transmissions (dBm/100 kHz)**
0.0	-16.0
1.0	-22.0
10.0	-30.0
20.0	-40.0

**See IEEE 802.11p-2010 Table I.8

Note: the waiver granted on April 24, 2023, included an additional constraint that OBU Transmitted Output Power be limited to 20 dBm, but that constraint was removed on July 5, 2023, when the FCC issued an amended grant order. Therefore, the table above reflects the amended requirements for OBUs and RSUs.

On **August 16, 2023, the FCC granted an additional set of 17 waiver requests**.

On **November 3, 2023, the FCC granted an additional set of 8 waiver requests**.

On **April 18, 2024, the FCC granted an additional set of 11 waiver requests.**

These additional waiver grants are based on the same conditions as the Joint Waiver Request grant.

Table: Key ITS Band documents with links

Description	Date	Docket	Document
Phase 1A			
ITS America Petition for Rulemaking	5-19-97	ET 98-95	1836410001
FCC PN seeks comments on ITSA Petition	5-28-97		DA 97-1106
FCC NPRM to Allocate 5.9 GHz ITS Band	6-11-98		FCC 98-119
FCC R&O Allocating 5.9 GHz ITS Band	10-21-99		FCC 99-305
Phase 1B			
FCC PN for ITS Band License & Service Rules	3-22-01	WT 01-90	DA 01-686
FCC NPRM ITS Band Lic. & Service Rules	11-7-02	ET 98-95 and WT 01-90	FCC 02-302/1 FCC 02-302/2
FCC R&O ITS Band Licensing & Service Rules	12-17-03		FCC 03-324/1 FCC 03-324/2 FCC 03-324/3
FCC Memorandum Opinion & Order designating Safety Channels 172 and 184	7-20-06		FCC 06-110
Phase 2			
NTIA Evaluation of sharing ITS Band	1-25-13	https://www.ntia.doc.gov/files/ntia/publications/ntia_5_ghz_report_01-25-2013.pdf	
FCC NPRM on 5 GHz, including 5.9 GHz sharing	2-20-13	ET 13-49	FCC 13-22
FCC PN Refresh Record for 5.9 GHz sharing	6-1-16		FCC 16-68
Global Automakers Petition Reconsideration U-NII-3 OOBE	5-1-14		7521101815
FCC R&O for 5 GHz, changed U-NII-3 OOBE	3-31-14		FCC 14-30
FCC Phase 1 Testing of Prototype U-NII-4 Devices	10-22-18		FCC 18-1111A2 [aka TR 17-1006]
Phase 3			
5GAA Petition for Waiver for 5905-5925 MHz	11-21-18	GN 18-357	5GAA Waiver
FCC NPRM on use of 5.9 GHz band	12-12-19	ET 19-138	FCC 19-129
FCC PN Temp. Freeze on License Applications	12-19-19		DA 19-1298
USDOT-NTIA Comment on FCC NPRM	3-9-19		USDOT Com
USDOT-NTIA request for draft 1st FCC R&O	11-6-20		USDOT Req
NTIA Report on U-NII/Federal System sharing	10-22-20		NTIA 21-551
FCC 5.9 GHz 1st R&O and FNPRM, as approved	11-18-20		FCC 20-164

FCC PN Guidance for C-V2X waiver process	8-6-21		DA 21-962
FCC PN Unfreeze License Applications	8-6-21		DA 21-963
C-V2X Joint Waiver Petition (14 parties)	12-13-21		Joint Waiver
C-V2X Joint Waiver Supplement	4-20-22		Jt. Supplement
2023 Activity			
NTIA Limits to protect federal incumbents	4-14-23	ET 19-138	NTIA limits
C-V2X Joint Waiver reply to NTIA limits	4-20-23		Joint Reply
FCC Grant Joint Waiver Request	4-24-23		DA 23-343
FCC Modification Joint Waiver Grant	7-5-23		DA 23-586
FCC Grant 17 Waiver Requests	8-16-23		DOC-396083A1
FCC Grant 8 Waiver Requests	11-3-23		DA 23-1048
2024 Activity			
FCC Grant 11 Waiver Requests	4-18-24		DA 24-363

Appendix D

C-V2X Waiver Parties

This appendix lists the parties whose waiver requests have been granted as of this document's publication. The most recent waiver grant listed is from April 18, 2024.

Joint Waiver Request Parties (Request Dec. 13, 2021, Waiver Grant April 24, 2023)

Audi of America, Inc.

Ford Motor Company

Jaguar Land Rover

Utah Department of Transportation

Virginia Department of Transportation

AAEON Technology, Inc.

Advantech Co., Ltd.

Applied Information, Inc.

Cohda Wireless Pty Ltd.

Commsignia, Inc. Audi

Danlaw Inc.

Harman International Industries, Inc.

Kapsch TrafficCom USA Inc.

Panasonic Corporation of North America

17 Parties whose waiver requests were granted on August 6, 2023 (requests made on various dates)

Colorado Department of Transportation

Georgia Department of Transportation

Maryland Department of Transportation

Nebraska Department of Transportation

DriveOhio

Texas Department of Transportation

Florida Department of Transportation

Hawaii Department of Transportation

Michigan Department of Transportation

New Jersey Department of Transportation

Oregon Department of Transportation

Wyoming Department of Transportation

City and County of Denver

P3Mobility

Macomb County Department of Roads

The Regents of the University of Michigan

Connex2X, LLC

8 Parties whose waiver requests were granted November 3, 2023 (requests made on various dates)

North Carolina Department of Transportation

Chattanooga, Tennessee

Denso International America, Inc.

Rolling Wireless S.àr.l.

New York City Department of Transportation

P3Mobility

Spoke Safety, Inc.

Yunex LL

11 Parties whose waiver requests were granted April 18, 2024 (requests made on various dates)

Pennsylvania Department of Transportation

Louisiana Department of Transportation

Illinois State Toll Highway Authority

Prince George's County, Maryland

Contra Costa Transportation Authority

Maine Department of Transportation

Battelle Memorial Institute

Continental Automotive Systems Inc.

Nissan Technical Center North America

Ettifos Co.

IT-Telecom Co., Ltd.

www.itsa.org

1100 New Jersey Ave SE Ste. 850
Washington, DC 20003