# Workshop Detailed Summary

Enhancing Interoperable Connectivity for Safe Transportation:
*Continuing The Momentum Toward National Deployment*

U.S. Department of Transportation

# Contents

# Background

On April 28, 2023, the U.S. Department of Transportation (U.S. DOT) hosted the second Interoperable Connectivity Workshop, formerly the Vehicle-to-Everything (V2X) Communications Summit. This workshop was held in Grapevine, Texas, with approximately 475 registered attendees, including 175 in-person and more than 300 virtual. Discussions, presentations, panels, and breakout sessions focused on creating a path towards achieving national interoperable connectivity and gathering input for the development of a National Interoperable Connectivity Deployment Plan.

## Workshop Purpose

The purpose of the Interoperable Connectivity Workshop was to reconvene a broad array of intelligent transportation system (ITS) community stakeholders to brief them on U.S. DOT's progress since the August 2022 summit and gather input for the development of a National Interoperable Connectivity Deployment Plan (the Plan).

## U.S. DOT Leadership Discussion

The workshop kicked off with welcome remarks from U.S. DOT Leadership, including:

- Egan Smith, Acting Director, ITS Joint Program Office (JPO)
- Dr. Robert Hampshire, Deputy Assistant Secretary for Research and Technology and Chief Science Officer (U.S. DOT)
- Shailen Bhatt, Administrator, Federal Highway Administration (FHWA)
- Dr. Morteza Farajian, Executive Director, Build America Bureau, Office of the Secretary of Transportation
- Martin Knopp, Associate Administrator for Operations, FHWA, and
- Valerie Briggs, Director, Office of Transportation Management, FHWA

The welcome remarks were followed by an open question and answer session with the audience. Key highlights from this panel session included:

- Safety can be improved by deploying interoperable connectivity devices. Driving challenges such as wrong-way driving can be solved.
- While funding may be a challenge, projects can be funded through existing mechanisms like the Build America Bureau[1].
- The Plan will be written based on stakeholder engagement, which is the purpose of the April 28 workshop.
- Interoperable connectivity deployments are important for solving safety challenges, especially for vulnerable road users (VRUs).
- The recently-announced Intersection Safety Challenge is a perfect opportunity to fund projects that improve intersection safety.

### Open Q&A

- How should we funnel funding into interoperable connectivity projects to propel deployments?
  — The national vision is to get to scale. Multiple mechanisms will be needed, such as standards, financing, and many more. The U.S. will need to use all the tools in the toolbox to get to scale, which will also involve finding the right use cases.

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[1] https://www.transportation.gov/buildamerica/

- — Locations with high crashes and fatality corridors would be ideal locations for seeking funding for interoperable connectivity deployments.
  - — The Bipartisan Infrastructure Law allocated $1.2 trillion to transportation, the most funding transportation has seen.
  - — Technology will need to become mainstream in transportation.
- How do we motivate agencies around the country to identify the problem and need, and find funding, especially considering the uncertainty of the 5.9 gigahertz (GHz) spectrum and communication technology?
  - — Agencies should try to concentrate their resources and deployments in a way that highlights the benefits. Once the benefits are realized, other projects and agencies will follow. Each agency needs to be aware and understanding of the state of the spectrum and technology.
- What can professional groups and associations do to help bring the National Highway Traffic Safety Administration (NHTSA) to the table?
  - — The U.S. DOT is meeting weekly with the Federal Communications Commission (FCC) and the National Telecommunications and Information Administration (NTIA) to help build a partnership. The U.S. DOT is working internally, collaborating with our colleagues as we work with our external partners, making the case of why and what kind of data we may need to be shown to continue making the case for interoperable connectivity deployments.
- Is the U.S. DOT moving forward with an intersection-first model? Would this model be enough?
  - — The development of the proposed plan will consider input from all stakeholders regarding strategies to undertake and establish foundational interoperable connectivity deployments.
  - — Stakeholder feedback indicates a need to focus on establishing working deployments in the 30 MHZ of the 5.9 spectrum not excluding additional innovative use of other spectrum and communication technology.
- Is it possible to commit funding to interoperable connectivity deployments like the National Electric Vehicle Infrastructure Formula Program for electric vehicles?
  - — There is abundant formula money that can be used for interoperable connectivity deployments. The return on investment for these technology deployment projects is generally quite good.
- Most of the discussion has not addressed Long Term Evolution (LTE) deployment models. Is there a plan to balance saving lives and technology deployments?
  - — Interoperability between LTE and other technologies is important. However, the U.S. DOT is focusing on advancing deployments in the dedicated 30 MHz band since this spectrum is out there to use now to establish use of the spectrum and technology.
- Is there any advice for getting the FCC to approve waivers that are in the queue?
  - — The U.S. DOT is meeting with both the FCC and NTIA. The U.S. DOT is working with the FCC and having technical discussions to help the FCC work through this queue but there do not appear to be major hurdles.

## Panel Discussion from Valerie Briggs (moderator), King Gee, Hilary Cain, Steve Kuciemba, Timothy Drake, John Kwant

An Industry Panel, moderated by Valerie Briggs of FHWA, followed the welcome panel. Panelists included King Gee (American Association of State Highway and Transportation Officials), Hilary Cain (Alliance for Automotive Innovation), Steve Kuciemba (Institute of Transportation Engineers), Timothy Drake (Intelligent Transportation Society America), and John Kwant (5G Automotive Association). The members of the panelists' organizations represent a diverse group of stakeholders. This section contains a summary of the questions and discussion points.

What are a few accomplishments you would like to highlight since the last summit (August 2022)?

- The U.S. DOT has accomplished many of its promises and continues to make progress on those remaining, such as hosting this workshop. This workshop demonstrates that states remain involved.
- The original equipment manufacturers (OEMs) are excited by the progress made but feel that right now is one of the last opportunities to deploy.
- Many agencies and organizations wear multiple hats. They are being conservative with interoperable connectivity deployments to avoid losing their investment.
- The FCC has started to grant the waivers but most are still outstanding.
- Organizations such as ITS America have sent the U.S. DOT a list of discussion topics to kickstart conversations, including the statement, "2023 is the year of V2X deployment." ITS America has released a national V2X deployment plan created with infrastructure owner operators (IOO) and OEM input.
- Addressing applications and messages that can be deployed in the spectrum has started and progress has been made in advancing interoperable connectivity deployments outside of the 5.9 GHz spectrum for a comprehensive network of devices.
- Connected vehicles (CVs) have always felt the most achievable technology for improving roadway safety. However, allocating funding is key.

What needs to happen to advance interoperable connectivity?

- One of the first steps is developing a national plan and vision.
- Safety-focused Day 1 applications are needed.
- The deployments will happen at a local level. There are deployment-leading and lagging states, but they all understand safety benefits. As waivers are granted, states that have deployed should share their lessons learned with states that are behind, whether they are waiting on waivers or just being cautious.
- OEMs know that they are an essential part of this ecosystem. Many automakers want to deploy but they need certainty that the devices being put in vehicles are wanted by the vehicle passengers and that the devices will be around in the vehicles in the future.
- State DOTs will need to connect with localities. It's the smaller governments with smaller budgets that will require the most assistance, whether it's receiving funding or providing training for local staff.
- All federal agencies who play a part in interoperable connectivity need to be at the table, like NHTSA and the FCC. For example, the FCC will need to issue its Final Rule and Order, which will help protect the remaining bandwidth in the 5.9 GHz spectrum.
- There is no other technology that is more ready to deploy that saves lives that is sitting on the shelf. 2023 is the year to deploy so we need to take steps to start deploying.
- Many state and local DOTs are committed to a vision that focuses on advancing to the next generation of transportation. There are two next-generation goals related to interoperable connectivity:
  — Work towards a transportation network with zero fatalities (vision zero).
  — Change how DOTs operate and manage the transportation system.

What is in the plan to advance interoperable connectivity?

- One of the first steps is to lay out the reason for the plan with steps to achieve the vision. All groups, from OEMs and IOOs, have different actions they need to take that should be included in the Plan.
- The industry needs to move beyond the discussion phase and start getting deployments on the ground. People and communities will see the benefits of interoperable connectivity once there are working deployments.
- A noticeable market penetration of interoperable connectivity devices is needed to make a dent in specific safety use cases.
- Public fleets will play an important early role in showing interoperable connectivity benefits. All stakeholders will need to push their use cases forward, too. Communities will see the benefits when there are deployments.
- Leadership is needed to advance interoperable connectivity. A national policy is needed along with a national strategy and vision that focuses on safety.
- An emphasis on creating a safe, sound, and smart transportation system is needed.
- All stakeholders, such as NHTSA, should be at the table when having conversations about advancing national interoperable connectivity.
- A U.S. DOT plan shows dedication and commitment to the technology. This commitment is invaluable for all stakeholders, especially OEMs. OEMs are appreciative of the leadership but need NHTSA at the table.
- For OEMs, robust infrastructure would help support and justify investment decisions that OEMs would have to make. The OEMs also need other items outside of U.S. DOT control, such as the FCC Final Rule and Order, so that it is clear that their investments will be there in the future.
- Giving credit to first movers, as the national roadway strategy did, will encourage other agencies to deploy because there is an understanding that agencies are already going through the deployment lifecycle process. The Plan needs to acknowledge that all players come from different starting points.
- The Plan needs to focus on both infrastructure and vehicles.

## Open Q&A

- Funding is always a challenge because questions about the best investments are always being asked. A dedicated source of funding would be helpful because grants are competing with other types of projects.
  — A dedicated source of funding would help but data that shows the benefits is needed. We need to start deploying and show success stories to get the ball rolling.
  — One area of focus is on low-latency crash avoidance in the 30 MHz band. The aim is to use the dedicated spectrum.
- VRUs have been mentioned during the discussion. Where are the VRU representatives?
  — Many professional organizations like ITS America have members from a variety of groups, including VRU groups and emergency medical services (EMS) and first responder providers.
  — Local agencies who are here also consider safety and accessibility for all road users, including VRUs.
  — The FHWA has also previously shown the importance of including VRUs when making decisions about the transportation network.

## Open Comments

- A reference architecture would be helpful so that there is a vision of the future.
- There is some confusion about cellular versus C-V2X. There needs to be a clear vision so that messaging about safety to state and local governments is clear and uniform.
- There have been significant investments in the technology standards. Tools should be put in place that help with issues like intersection verification and device certification. The national plan should discuss these tools.
- What's critical to be in the 30 MHz and what can be moved to another spectrum should be figured out to determine how to use the spectrum most effectively.

## Developing a National Interoperable Connectivity Plan and Workshop Charge

John Harding (FHWA) and Govind Vadakpat (ITS JPO) provided an overview of the collaborative process U.S. DOT is implementing to develop a plan and strategy for national interoperable connectivity.  The presentation covered the following elements:

- Background information collected through dialogues since August 2022
- Definitions (e.g., Interoperable Connectivity)
- A working framework for the plan
- A process moving forward to develop the plan in a collaborative fashion with stakeholders
- Discussion of the two breakout sessions to follow

The presentation also featured the newly-created Interoperable Connectivity page on the ITS JPO's Smart Community Resource Center (SCRC). This online tool includes over 100 resources that states, tribal governments, and local communities can use to support interoperable connectivity deployment. The resources are organized by the systems engineering process.

The breakout sessions were intended to further define and get feedback on the plan goals (Session 1: Design a Plan) and to develop and then prioritize the needed activities in a roadmap (Session 2: Design a Roadmap).

Figure 1 contains an overview of the initial strategy roadmap that reflects a plan toward achieving the goals.  The roadmap contains basic V2X safety enablers, applications, foundational enabling elements such as security, standards, testing, certification, and other resources. While this roadmap was presented all attendees, breakout groups were provided blank rows with activity area categories for their use in developing a roadmap.

# STRATEGY FOR FOUNDATIONAL-to-SCALABLE NATIONAL INTEROPERABLE CONNECTIVITY

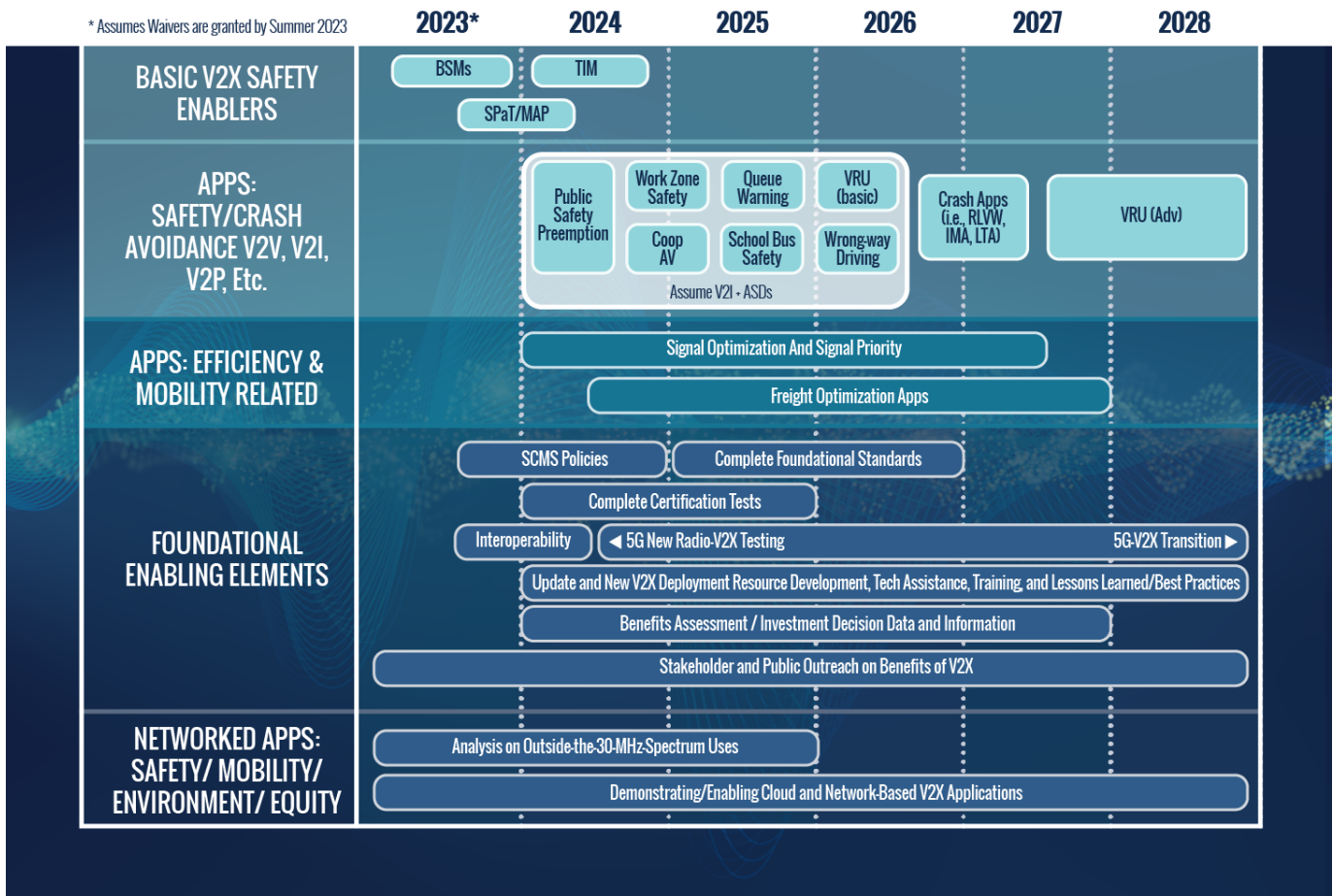* Assumes Waivers are granted by Summer 2023

|  | 2023* | 2024 | 2025 | 2026 | 2027 | 2028 |
|---|---|---|---|---|---|---|
| **BASIC V2X SAFETY ENABLERS** | BSMs / SPaT/MAP | TIM | | | | |
| **APPS: SAFETY/CRASH AVOIDANCE V2V, V2I, V2P, Etc.** | | Public Safety Preemption, Work Zone Safety, Coop AV, Queue Warning, School Bus Safety, VRU (basic), Wrong-way Driving (Assume V2I + ASDs) | | | Crash Apps (i.e., RLVW, IMA, LTA) | VRU (Adv) |
| **APPS: EFFICIENCY & MOBILITY RELATED** | | Signal Optimization And Signal Priority / Freight Optimization Apps | | | | |
| **FOUNDATIONAL ENABLING ELEMENTS** | Interoperability | SCMS Policies, Complete Certification Tests, ◄ 5G New Radio-V2X Testing, Update and New V2X Deployment Resource Development, Tech Assistance, Training, and Lessons Learned/Best Practices, Benefits Assessment / Investment Decision Data and Information, Stakeholder and Public Outreach on Benefits of V2X | Complete Foundational Standards | | | 5G-V2X Transition ▶ |
| **NETWORKED APPS: SAFETY/ MOBILITY/ ENVIRONMENT/ EQUITY** | Analysis on Outside-the-30-MHz-Spectrum Uses / Demonstrating/Enabling Cloud and Network-Based V2X Applications | | | | | |

Figure 1.  Strategy road map for interoperable connectivity from  the U.S. DOT perspective.

# Breakout Session 1

## Background

At the workshop, four in-person groups and six virtual sessions met that all had a combination of state and local deployers, federal employees, OEM and vehicle manufacturer representatives, and other stakeholders. While the participants in these 10 groups all had independent conversations, there were many common themes and discussions. Session 1 asked each group to review and comment on the proposed U.S. DOT Goals. The proposed goals are captured in the sidebar, and the general feedback from participants is presented below:

> ### Proposed Goals for Session 1
>
> 1. By the end of 2023, stimulate and guide widespread V2X communications for transcontinental interoperable connectivity across urban, rural, and multi-state facilities and increased collaboration across agencies, borders, and jurisdictions by completing:
>    — A bold national V2X deployment plan.
>    — V2X deployment strategies.
>    — A list of V2X funding sources.
> 2. By 2025, facilitate market development and deployment by establishing certainty around interoperable connectivity, spectrum, and technology.
> 3. By 2025, be transitioning all/ most Dedicated Short Range Communications (DSRC) into LTE-V2X in existing deployments; adding LTE-V2X fresh-start sites; and begin connecting sites into national interoperable connectivity.
> 4. By 2028, have operational interoperable connectivity systems at a certain percentage of the nation's intersections and across major portions of our national road system to fully use the 20 MHz of spectrum.

## Goal Comments

Feedback made by the groups to the goals include:

- Widespread adoption of V2X communications will take time. However, many of the groups thought the proposed dates were too conservative. The time frames should be aggressive but realistic (e.g., the 2025 goals could be moved forward).
- More granularity is needed in the 2023 vision and goals. Consider making the deadline for guidance to be in fiscal year 2023, August preferred.
- In the first goal, consider changing "transcontinental" to "national" and "increased" to increase", and adding in a "phased deployment strategy." Define what "stimulate" means.
- In the first goal, consider adding in additional targets (sub-bullets) like "harmonization with existing communications networks"; "fully supported plan (FCC, U.S. DOT, NHTSA)"; leverage definitive incentives; and focus on targeted locations like intersections, work zones, and first responder fleets.
- In the second goal, add "standards and security" to the end.
- Consider rewording the second goal as there are already proven interoperable connectivity technologies.

- The third goal (2025 transition goal) will be difficult to achieve without the FCC Second Report and Order. This goal sparked debate with some attendees arguing that making legacy DSRC part of this plan would be preferred so that states don't have to figure out and pay for the transition. Other attendees noted that states are already deciding to either transition from DSRC (by 2024) or turn them off. With rip-and-replace sites, the communications functionality will still exist but resources should be allocated judiciously.
- In the third goal, consider adding 5G New Radio in addition to LTE. Some attendees also felt that DSRC should be included in the plan.
- In the third goal, consider replacing "LTE V2X" with "Cellular V2X / 5G V2X." Some attendees noted that the LTE-V2X is already too late (older technology).
- The last goal should be 30 MHz rather than 20 MHz to ensure consistency with what the FCC has dedicated. Some attendees felt that there should be an effort to get the full 75 MHz back since some studies indicate that all 75 MHz are needed for national interoperable connectivity. Others in the group were not sure this is feasible in the near term.
- The goals need to identify areas of focus and be consistent with its terminology and definitions of terms such as V2X, C-V2X, widespread, and interoperability. However, the goals also need to be flexible enough for future technologies and spectrum to be included. Some attendees noted that interoperable connectivity should be written to be the connectivity of radio messages, and service/application level– for Roadside Units (RSU)/On-Board Units (OBU)/ Attenuators.
- Short-term and long-term goals that have specific targets are needed (i.e., "Begin connecting sites into national interoperable connectivity" is vague). These specific targets should be measurable (i.e., the goals should state the number of intersections with interoperable connectivity devices that should be deployed by a specific year).
- The goals should focus on safety benefits but the mobility, environmental, equity, and resilience benefits should also be included.
- The goals could include creating standards that are scalable and interoperable with other technologies.
- The goals should include using the interoperable V2X, using the 4G/5G, and a willingness to interface with the 5.9 GHz.
- The Plan should include goals and steps that all stakeholders need to take to achieve national interoperable connectivity. These stakeholders should guide what realistic needs and quantities are. They should also make commitments that are guided by new rulemaking.
- A goal around communication and outreach strategies (i.e. a public awareness campaign) should be included.
- A goal for developing "marketing materials" that show the benefits (safety, mobility, environmental, and equity benefits) of interoperable connectivity deployments would help sell the idea of interoperable connectivity deployments to local leadership.
- Within the Plan, the goals should create a roadmap that details specific goals for all stakeholders (including IOOs, OEMs, and device manufacturers) and prioritizes use cases, quantities, dates, and funding sources.
- The goal language should include specific Key Performance Indicators.
- The goals should include a vehicle component, rather than solely infrastructure. Goals should also be set for other agencies. These goals could be steps and actions each stakeholder needs to take to achieve national interoperable connectivity.

- Consider adding a goal of higher adoption on the part of manufacturers to commit to adding radios to vehicles.
- Some felt that the goal should be to transition all vehicles, not just "most," to ensure interoperability and growth.
- An explicit goal for cybersecurity is needed since there is still uncertainty around communications, the ability to trust messages, and how to handle bad actors within the system. Consider creating a goal to form a national Root Authority for Cybersecurity Security Credential Management Systems (SCMS).
- Setting New Car Assessment Program (NCAP) standards should be a goal since it is important for accelerating interoperable connectivity deployments. NCAP is implied in the second goal but should be explicitly stated.
- The goals should focus on quality of information, understanding the industry shifts, and ensuring dedicated funding.
- The goals should address near-term deployment of vehicle-to-vehicle (V2V) apps that are not covered by Advanced Driver Assistance Systems, such as Intersection Movement Assist, Do Not Pass Warning, and Emergency Electronic Brake Lights. The Plan should also include an incentive for OEMs to cover the cost of OBU/accessories, announcement by two or three major OEMs to deploy in 2025, and a longer-term roadmap for five years to deploy vehicle-to-infrastructure apps.

## Other Comments

While not specifically related to a goal, the groups noted that:

- The Vision and Mission Statement should include a reference to safety, environment, equity, resilience, and sustainability benefits. This helps to align the Vision and Mission with national values and principles.
- A clear strategy is needed for deploying interoperable connectivity devices. Consider creating and deploying a minimum viable product between 2025 and 2028 that might not be fully developed but can broadcast and receive functioning Signal Phase and Timing (SPaT), MAP (intersection geometry), and Basic Safety Message (BSM) messages. The incubation period for a technology to fully mature is generally five years; deployments will likely have to happen before the technology is fully mature.
- The industry needs to translate existing research into messaging that the technology and applications are at a high maturity and ready for deployment. However, some participants felt that the proposed goals are not looking into the future because they require 15-year-old technology that won't be manufactured in the future.
- Participants expressed the need for a clarified message that the various communications technologies are complementary and 5.9 GHz is not suitable for all applications.
- Participants discussed the need to ensure the survivability of the 30 megahertz still dedicated to ITS.
- The Plan should be forward-thinking and consider future technologies such as automated vehicles that will require cooperative maneuvers and no-light-of-sight sensing. Consider adding "future ready" into the Vision Statement or goals.
- There is some concern about the business case and funding for these devices. During the last summit, automakers noted that they need a business case to prioritize V2X deployments.
- A sustainable (long-term) financial model needs to be developed for these devices. To help with funding, a list of funding sources (including the Department of Homeland Security, the National Science Foundation, and the Department of Energy) would be helpful. In addition, the language and selection criteria in Notices of Funding Opportunity can also be carefully selected to help prioritize interoperable connectivity deployment projects. However, some attendees thought funding should be withheld until states produce their own interoperable connectivity plan. Some attendees noted that setting a goal of 2050 to have a dedicated funding source, with a 90/10 federal/state match, would help accelerate interoperable connectivity deployments.

- Other federal agencies are needed for a national interoperable connectivity deployment, including the FCC and NHTSA. Some attendees noted that having a 2023 goal where the FCC approves all waivers is important but acknowledged that this falls outside of the U.S. DOT's control. This goal should also include having the FCC complete its production and publishing of technical operating rules. The NHTSA should incorporate V2X into NCAP as soon as possible.
- NHTSA must be engaged and supportive. Full U.S. DOT support at the Secretary level is needed.
- The goals should also consider how different network communications applications (i.e., 5.9 GHz and cellular) can complement each other since each has unique benefits and drawbacks.
- Some discussions focused on how national interoperable connectivity will look in 2028. Some attendees see coordination and action more at the local levels by 2028, but not the national level.
- Developing "how-to" materials for state and local agencies would be helpful, especially for smaller agencies that have different levels of capacity and resources to transition. These materials should step through topics like where to go to learn about interoperable connectivity, whom to go to when purchasing a device and how to purchase them, ways to train their workforce, and how to certify after-market OBUs. Efforts can also be made by academia to train the next generation of transportation professionals. A reference architecture would also be helpful, like the National ITS Architecture.
- Deploying interoperable connective devices at intersections might not be as simple as some attendees say. Very few intersections in the U.S. are connected to a single system; most intersections would require significant updates for interoperable connectivity devices. However, intersection deployments offer the best opportunity for evaluating accuracy data and understanding how impactful the technology is for all vehicles like non-emergency medical vehicles and ride-hailing vehicles.
- The goals should set a foundation for the deployment of future safety applications. VRUs should be part of the safety conversation.
- Any measured costs and benefits should be publicly shared to create buy-in from the public and encourage interoperable connectivity deployment. Public buy-in is key because the public still questions or doesn't know about the technology, and they will generate demand for the technology. Qualitative observations are also important to capture as deployments become operational.
- The advantages of interoperable connectivity deployments in urban areas are easier to see, which is why an effort to demonstrate the benefits in rural areas is needed.
- There is a lack of confidence and certainty around the technology because spectrum comes before connectivity. Certainty includes both that the technology will be allowed on the roads in the future (i.e. will the spectrum exist in the future?), and that the technology (including the use cases) will work as intended. Action items that will show this certainty include:
  — Deployment of interoperable connectivity devices
  — Demonstration of mature technology interoperability
  — All required Federal Agencies (like NHTSA and the FCC) joining the interoperable connectivity discussion
  — Issuance of the technical rules in the Final Report and Order by the FCC
  — Identifying a standard set of messages (like MAP and SPaT) for specific use cases
  — Agreeing on and implementing security standards

- It was noted that instead of NCAP, there is precedence with the emerging electronic braking: an initiative and a memorandum of understanding (MOU) in conjunction with NHTSA (but mostly with automakers of their own accord) to deploy the technology. This effort allowed commercial markets to move forward without regulatory scrutiny. If there were an MOU to deploy with the U.S. DOT, including NHTSA, that would be a reaffirming message to stakeholders that automakers are committed to this safety technology. This could be an alternative option to NCAP.
- OEMs would like to know when their customers will see the benefit of interoperable connectivity.
- The standard messages (like BSMs) should be reevaluated. The BSM was designed 15 years ago and it lacks the necessary information to save lives.
- A spectrum roadmap for low latency communications with technology, dates, and migrations (e.g. DSRC to C-V2X to 5G) would be helpful. Some attendees noted that 5G is not compatible with the technology the FCC is currently granting new waivers to and that LTE (3GPP Rel 14/15) cannot be used in the same spectrum with 5G (3GPP Rel 16/17). A second 20 MHz channel should be set up.
- A list of prioritized use cases should also be developed. The number of use cases for each category (such as safety, operations, and efficiency), how each use case can be adopted, and how the benefits can be quantified should be measured.
- The Plan needs to consider the entire transportation ecosystem with established connectivity (OBUs and other devices like smartphones). Smartphone connectivity should be focused on applications to improve value.
- There are already-existing plans that would be useful references when writing the Plan, like the ITS America V2X Deployment Plan.
- The Plan should clearly define what is in the 30 MHz and what should be accomplished with other technologies.
- Interoperable connectivity deployments on public fleets will play an important role early on. Public investment, like transit, has reasons to deploy, like maximizing operations and safety. Private fleets generally make and spend money, so knowing the level of deployment is important to them.
- Clarity of market signal and willingness to move forward with technology is needed, either through regulatory or incentive mechanisms.

# Breakout Session 2

## Background

Session 2 asked each group to design a roadmap. The groups were provided a matrix roadmap whose rows are categories of activities and columns are potential years when each activity milestone could happen. The groups were tasked with writing detailed milestones that need to happen in each activity area on sticky notes and then placing the sticky note on the timeline. The participants then voted on the activities they thought were most important.

When considering attendee feedback on the importance of each activity area presented in the provided roadmap, five out of fifteen activity areas received a majority of the votes. Those five, in order of votes received, were:

1. RSU Installations: Intersections, Highway Corridors, etc.
2. Public Fleet Deployments
3. Technology Stability: Standards and Certification Tests
4. OEM Equipped Passenger Vehicles and Safety Applications
5. Demonstrated interoperability:
    a. LTE V2X devices from different RSU/OBU manufacturers;
    b. Communications inside 30 MHz (of 5.9 GHz) to communications in other spectrum bands
    c. Security credential interoperability
    d. Application interoperability

*Appendix A* provides the attendee-identified milestone activities associated with these top five areas.

It should be noted that the virtual breakout groups had a more difficult time with this activity for a number of reasons. First, the whiteboard feature of the Zoom platform, which the facilitators had been instructed to use for compiling comments and adding milestones on the general roadmap, did not work. Second, many facilitators found that the groups in a virtual environment were less likely to co-develop a single roadmap rendition. The in-person participants had the advantage of gathering around a poster of the roadmap that they were asked to comment on, which made it much easier to stay focused on this task. Nevertheless, the combined roadmap table and corresponding narrative presented in this document reflects feedback from all participants, although the in-person groups perspectives may be overrepresented (see Appendices A and B).

## Roadmap Comments

The complete roadmap comments and their placement on the matrix are captured in the roadmap matrix [see Appendix B (separate file)]. A representative sample of comments made by the groups during the second session include (some comments may not be consistent with the combined roadmap matrix):

- By 2023, workforce development resources should be developed and can be integrated into Every Day Counts (EDC)-6 digital learning in the Traffic Incident Management practice. The EDC-6 overlaps with workforce development demonstrating that interoperable connectivity devices are another tool.
- By 2030, interoperable connectivity devices should be deployed on all signalized U.S. intersections. This is a bold but achievable goal. Demonstrating interoperability needs to happen soon.

- By 2023, there should be an application use framework that details LTE V2X vs Vehicle-to-Network (V2N) by message support, latency, etc. V2N is a form of C-V2X connectivity that enables vehicles to communicate with the Internet using cellular networks. Using V2N, vehicles would be able to communicate with each other and other objects such as streetlights, traffic signals, and pedestrians. LTE V2X specifically uses the 5.9 GHz band and is capable of low-latency safety-critical messaging.
  - By 2025, there should be scaled deployment of dual-use V2X/V2N, and support application framework suppliers in market and message interoperability performance should be improved.
  - Between 2025 to 2030, applications and communications should be fully interoperable.
- Security policies, operational functions, and certification were commonly noted as the most critical near-term items to accomplish. One group felt that deploying is more important than finalizing all the security items so that benefits can be shown immediately. Security is important because the messages being broadcasted and received need to be trustworthy:
  - In 2023, self-certification is acceptable, but there should be a more-robust certification in place by 2024.
  - By 2040, there should be a full third-party security audit certification.
  - Standards and security systems should be implemented simultaneously since there is an adoption period once standards are instituted.
- One group noted that V2X and standard enabling messages go hand-in-hand and need a common language. This is equally as important as the items in the Technology Stability: Standards and Certification Tests activity area.
- The RSU Installations: Intersections, Highway Corridors, etc. activity area has many dependencies on the other rows. It would be helpful to first set standards.
- Fleet deployment applications (including emergency vehicle preemption and transit signal priority) will also be key for achieving national interoperable connectivity. The goal and target should be to equip 6,000 vehicles by 2023 and 20,000 vehicles by 2025.
- By 2030, V2X should be integrated into NHTSA's NCAP. OEMs will install interoperable connectivity devices if it improves the vehicle's safety rating. One group noted that America is one of the few countries working on interoperable connectivity that does not have NCAP standards.
- Funding should be appropriated by 2023 (not spent). The $6.5 billion recommended in the ITS America National V2X Deployment Plan would be a good target. However, the funding will need to be fact-based and justified.
- Production-grade SPaT and MAP messages are needed at intersections by 2025. The ITS America National V2X Deployment Plan proposes a target of 20,000 intersections by 2025. 2025 was chosen as a target year because it takes approximately two years to go from nothing (2023) to deployment (2025). Eight years later, there should be deployments at 250,000 signalized intersections, which is 75% of the signalized intersections in America. The target should also include a certain percentage of vehicles on the road being equipped so that the infrastructure deployments are being used.
- The FCC Second Report and Order should be published by 2024 to show commitment to interoperable connectivity.
- International Municipal Signal Association certification is needed for the infrastructure devices and should be on the timeline. Deploying agencies need to consider their capabilities in maintaining RSUs and network communications. Traffic signal installers need to know how to turn on, configure, and maintain these devices. These classes and certifications can be created by the vendors.
- DSRC units should be turned on in 2023 to start saving lives. Many thought that the timeline was not aggressive enough. Others felt the timeline was too aggressive and not achievable, given all the issues impeding deployment right now.

- One OEM representative noted that short-term applications are expected to be infrastructure based, like traffic signals. For V2V applications to be effective, there needs to be a proliferation of technology within vehicles. The customer-perceived value, or value proposition, should come from the infrastructure-related applications.
- The discussion also touched on the need for nationwide deployment, with OEM participants discussing the need for two or three mega-region deployments that show safety benefits on a wide scale.

## Other Comments

- During deployment, stakeholder coordination is the most important task. All parties have a specific role and need to be talking to each other. For example, agencies procure and deploy the RSUs. The providers engage with the road operators as well as with road system partners.
- Use cases throughout each of the milestones should be developed and focus on storytelling. The ease of deployment and benefits should be considered. Cases of successful deployments should also be highlighted and shared through a medium like a showcase site. This site can be broken into urban and rural areas. However, messaging and application deployment need to align.
- Consider marketing this material at other transportation-related conferences like the Consumer Electronics Show (CES) and school bus shows.
- Multiple groups discussed the challenges of deploying new technologies. To help express confidence in the new technology to agencies and their leadership, stability first needs to be proven. Then, standards and specifications should be created and shared. There needs to be consistencies and capacity in how application interoperability is populated (like the capacity to maintain base data like up-to-date signal timing). The agency should consider whether it is in the position to install and maintain RSUs, or if they are better positioned to utilize network communications because these new technologies will require maintenance and hardware upgrades. The agencies need to balance costs with maintenance for these technologies; be sure the technology is scalable (can gracefully handle an increase in users) into the future; and consider certification, training, and capacity to sustain a qualified workforce to maintain the systems.
- The public also needs to be educated. National awareness of electric and autonomous vehicles is significant. How can we weave connectivity into that story? However, some attendees felt that marketing materials were not the most critical action item/milestone at this time and that deployment should be the first step.
- One group noted that there should be a plan to incorporate low- and high-latency applications. There are virtual RSUs in the works, such as using cell towers or other communications infrastructure, not just RSU installation. These solutions could expand the functionality. However, these virtual RSUs can have a higher latency than physical RSUs so safety applications would not be ideal for virtual RSUs.
- One group discussed the need for a common language for enabling messages, and the importance of partnering with road operators and road system partners to develop and foster innovative deployments.
- One group highlighted the need for high confidence in detecting bike and pedestrian movements and suggested that more working groups should be established to address this issue.
- One group did not put milestones in the VRU row because it's challenging to measure VRU improvements. The group also noted that there was another row where pedestrian crash applications were listed; thus, most VRU comments went there. Most VRU challenges are solved by making the drivers aware of VRUs. However, VRUs are an important component of interoperable connectivity.

- Another group discussed VRUs in the V2X environment. This group noted that the safety of VRUs is typically improved by sending drivers in-vehicle messages, but some agencies are working on sending VRUs messages on their hand-held devices (like a cell phone) since there are very few vehicles on the road equipped to display an in-vehicle warning message in 2023. However, to accomplish this, VRU trajectory data needs to be accurately captured and analyzed, which is challenging, especially at unmarked crossings. Logistically, VRU detection should also come from a single vendor, ones willing to share, or a centralized cloud-based data exchange mechanism because siloed data would inhibit some safety applications.
- One group discussed deployments in larger cities. The group discussed security protocols stopping test applications on EMS vehicles but targeted 2025 to implement interoperable security qualification. Security is the first step towards interoperable connectivity. The cities are also deploying and testing along corridors first and then plan to move into urban areas. The discussion also touched on the technical aspects of RSU installation, including the human-machine interface displaying alerts, having an application programming interface that is geographically aware. They also discussed that OBU edge software is usually a third-party application so there is a gap with throwing the alert up because the fields don't always align.
- One group discussed the need to have 20 MHz applications in the 30 MHz band. There should also be an emphasis on first responder (fire, police, and EMS) applications. Fire response can access and tie into the geographic information system of the compromised building. Emergency management offices can benefit from V2V and V2X technologies. These could also be low-latency applications.
- NHTSA already has DSRC interoperable connectivity safety data from about six years ago that could be leveraged to show safety benefits. These quantified safety benefits could be updated and used to market the benefits of interoperable connectivity to NHTSA.
- One attendee notes that the waiver process does not line up with the project process. Ideally, we want to get to a place where we can just update the software to conform to FCC rules as they come out. As we deploy things, we want to be able to update them seamlessly as rules change.
- Multiple groups noted that funding is a challenge. The U.S. DOT should be funding all pieces of deployments, not just a report, which can take years to publish. The report should lead to deployments. The report should also be future-proof and not be obsolete in 10 years.
- Some groups felt that the timeline was not aggressive enough. OBUs should be working in months and message-sending applications should be deployed by the end of this year.
- One group discussed the chips, noting that they would like to learn more about the pairing of C-V2X chip IDs with LTE_ Telematic Control Unit (TCU) Integrated Circuit Card Identification Number and how it is being managed. The group would also like to incorporate goals around how the vehicle-side processors would complement OBUs. Most TCUs come equipped with supporting computing and application resources; there is a move with chipset vendors to build support for C-V2X into the 5G module.
- The ITS America National V2X Deployment Plan puts a heavier burden on deploying at a certain number of intersections in urban areas. However, these urban areas will see the benefits of interoperable connectivity. Deploying at intersections can be challenging, especially if there is no communication at the intersection. Participants felt that deployments should also occur along corridors and in rural areas to share the burden and benefits.
- Multiple stakeholders, both IOOs and OEMs, need to agree on standard definitions of messages for deployments. After the definitions are set, it will be possible to set out performance requirements for the technology. Procedures will also

need to be established to make sure messages are transmitted, performance requirements are met, and messages are being validated.

- Public fleets will play an important role in interoperable connectivity early on to demonstrate the functionality and benefits of interoperable connectivity deployments. Many public agencies are enthusiastic about transit signal priority and emergency vehicle priority. There will need to be buy-in from transit agencies and first responders. From an OEM perspective, there won't be deployments for a few years which is why deploying on public fleets was discussed several times.
- One group noted that private fleet deployment would probably be like a freight use case early on.
- The V2V applications need a noticeable market penetration of equipped vehicles which can take years. Consider looking at (and, for research, mimicking) the European Union which has messages like collective perception message for collective perception which can be used to increase the reach of the communication.
- OEM and Aftermarket Safety Device Equipped Passenger vehicles are needed as soon as possible. However, it was noted that the OEM's business plan was to monetize data and they won't want to share that information.
- One attendee noted that BSMs are not efficient and should be reworked.
- One group discussed interoperable connectivity deployment challenges, which included:
  — Demonstrating day 1 applications, benefits, and challenges early
  — Ensuring consistency of SPaT messages across devices and deployments
  — Using the same root certificate across municipalities and manufacturers
  — Ensuring new releases are scalable
  — Third part testing of data accuracy in messages
- One group discussed the need for nationwide deployment being spread out across the country or in a few (two to three) super regions. An OEM representative also mentioned that their vehicles are made to be sold across the country, not just in one region, even if it is a super region. While the vehicles cannot support the technology before turning on C-V2X, the vehicles can help the public become familiar with the technology outside of the 5.9 GHz. This group felt that having a top-down approach may slow down deployments and seeing results, and states would be less likely to follow at a more localized scale. Having smaller-scale deployments would be more beneficial for seeing results more quickly and help smooth adoption nationwide. The group also felt that the super region approach is similar to the CV test deployments in New York, Tampa, and Wyoming. A switch is needed from a research paradigm to a broad-scale deployment paradigm, which is what most deploying stakeholders, from OEMs to IOOs, want.
- V2V applications need more penetration of the technology to have sufficient interactions for benefits to be achieved, which might take many years.
- The participants also discussed the importance of a document defining basic safety requirements and standards, as well as operational specs that everyone can follow.
- Challenges such as demonstrating benefits and ensuring scale were discussed.
- One group's discussion focused on national interoperability and the need for a multi-stakeholder IOO OEM definition on messages for deployments.

# Analysis of Feedback

While most of the attendees could be categorized as favorable towards interoperable connectivity deployment, there were areas of disagreement and conflicting views in the feedback provided. Some participants felt that the timeline was not aggressive enough, while others raised concerns about waiver issues and thought the timeline might not be achievable. Additionally, there were differing opinions on the need for a mandate for manufacturers to deploy by a certain time and the importance of marketing materials. Finally, there were varying opinions on the best approach for nationwide deployment, with some advocating for a national scale and others suggesting a ground-up approach. Some emphasized the need for DSRC units and the roadmap timeline, while others emphasized the need for U.S. DOT funding and deployment.

Many attendees struggled with the timeline and were only able to identify immediate steps and gaps impeding progress. Participants stated that a certification process is the key to moving forward on any of the elements of the road map. This will help to increase technology stability.

## State and Local Agencies (IOOs)

Local agencies need the most help in the following areas:

- Funding streams for operations and maintenance scale
- Technical assistance and workforce development/technology stability: standards and certification
- RSU installations
- Development of a certification process to move forward on any of the elements of the roadmap
- Esurance of maintenance and operations on the back end, including certification, training, and capacity to sustain a qualified workforce to maintain the systems
- Prioritization of public fleet deployments to get more communities wanting and demanding it
- Demonstrating day 1 benefits and challenges early
- Consistency of SPaT messages across interoperability
- Third-party testing of data accuracy in messages

## Federal Government

According to the provided feedback, the federal government can take the following actions to help local agencies:

- Create funding streams to support pilot projects and move agencies beyond the pilot stage
- Provide technical assistance and workforce development to ensure technology stability, standards, and certification
- Provide U.S. DOT funding to develop standards for RSU installation
- Develop a national policy as a foundation before building out a roadmap.
- Focus on public/private use cases and market saturation of CVs and automated vehicles
- Prioritize public fleet deployments to get more communities wanting and demanding it
- Establish vehicle fleets to take advantage of V2X features
- Educate the public and schools about V2X technology
- Develop use cases and storytelling to demonstrate successful deployments
- Create C-V2X showcase sites to demonstrate use cases for rural areas

- Update the software to conform to FCC rules as they come out
- Harmonize the waiver process with the project development process
- Provide third-party testing of data accuracy in messages

Additionally, the federal government can prioritize the following activities to move forward on scaled deployment:

- Infrastructure installations
- Demonstration of interoperability
- Technology stability
- V2X applications
- Public fleet deployments
- V2X enabling messages
- VRU vehicle deployments

Finally, the federal government can anticipate other V2X applications and work with partners to create shared expectations and a common/standard language.

## OEM Participation

To encourage V2X deployment, OEMs can take the following steps:

- Support the technology in the vehicle even before turning on C-V2X by doing things that work outside of the 5.9 GHz spectrum that allows vehicles to start receiving messages. This will help the public become familiar with the technology.
- Encourage the Secretary to talk about CVs to raise awareness
- Include V2X integration into the NCAP by 2030 to motivate OEMs to deploy the technology
- Create C-V2X showcase sites to demonstrate use cases for rural areas and take the technology to school bus shows, sales events, and the CES
- Work from the ground up to enable results on the ground and smooth adoption nationwide
- Focus on a broad scale deployment paradigm instead of a research paradigm
- Develop use cases and focus on storytelling to demonstrate successful deployments
- Educate the public about V2X technology
- Weave connectivity into the national awareness on electricity and autonomy

## Appendix A. Top Five Activity Areas and Milestones Determined by Attendee Feedback and Prioritization

| Timeline/ Activity Area | 2023 | 2025 | 2030 | 2040 |
|---|---|---|---|---|
| **RSU Installations:** **Intersections, Highway Corridors, etc.** *(Attendee Rank: #1/15)* | • Individual state deployment plans approved by end of year (EOY) <br>• National deployment plan approved by EOY <br>• Replace 10% of deployed RSUs <br>• Funded deployment <br>• Understand the need for standards and standardize RSUs by end of 2023 <br>• Improve MAP workflow | **2024:** <br>• Transition existing DSRC to LTE-V2X <br>• Test 3 or 4 RSUs with major OBUs for interoperability by USDOT <br>**2025:** <br>• 5% to 30% of intersections <br>• 75% connected and 10% non-connected at at-risk intersections <br>• Prioritize intersections with high rates of accidents <br>• Combine with electric implementation <br>• SPaT and MAP available on 5.9GHz at 20,000 intersections <br>• Identify corridors needed | **2028 / Year 5:** <br>• 100,000 signalized intersections (35% large, 25% midsized, 8% rural) <br>• 100% new build <br>**2030:** <br>• 25% to 90% of intersections <br>• US-wide infrastructure deployment (as opposed to local or state), highway corridors | **2033 / Year 10:** <br>• 250,000 intersections (85% large, 60% midsized, 20% rural) <br>**2040:** <br>• All remaining intersections and priority areas equipped |

| Timeline/ Activity Area | 2023 | 2025 | 2030 | 2040 |
|---|---|---|---|---|
| **Public Fleet Deployments**<br><br>*(Attendee Rank: #2/15)* | • LTE 25%<br>• 6,000 public fleet vehicles<br>• Multi-stakeholder (IOO & OEM) definition of what messages are needed for deployment<br>• Traffic signal preemption/priority for transit vehicles | • LTE 50%<br>• 20,000 public fleet vehicles<br>• National procurement of aftermarket OBUs for use in public fleets | **2027:**<br>• Expand public fleet deployment<br>**2028:**<br>• LTE 75%<br>• 30 MHZ 25%<br>• Aftermarket deployment in 20% of vehicles<br>**2030:**<br>• 30 MHz 50%<br>• Public education and explaining the benefits<br>• Mix of cloud and physical deployment | • 30 MHz 75% |
| **Technology Stability: Standards and Certification Tests**<br><br>*(Attendee Rank: #3/15)* | • Standards and performance tests (Awareness apps)<br>• Begin testing on CV2X 5.9GHz in urban scenarios<br>• Begin testing on how many connections can be maintained with 1 RSU in dense urban areas | **2024:**<br>• Harmonized available global standards for US<br>**2025:**<br>• Complete Society of Automotive Engineers (SAE) Connected Intersection Standards development | • Industry consensus on how lower layer protocol evolution will be achieved:<br>—4G indefinitely?<br>—4G -> 5G?<br>—4G -> 6G in 203X?<br>—Different approaches for different apps? | |

| Timeline/ Activity Area | 2023 | 2025 | 2030 | 2040 |
|---|---|---|---|---|
| **OEM Equipped Passenger Vehicles & Safety Applications**<br><br>*(Attendee Rank: #4/15)* | • Commitment to volume deployment<br>• Define a small set of critical use cases that will be developed with support from USDOT/OEMs<br>• Announce incentive for OEMs to deploy<br>• Follow up with OEMs to announce deployment by mid-2024 | • "Early adopter" OEM launch<br>• OEMs representing 25% of US market announce intent to start deployment by 2028<br>• Deployment based on previous commitments<br>• OEMs include OBUs off production line<br>• Limited field testing by USDOT with vehicles of major OEMs<br>• OEM production vehicles alert drivers based on intersection data | **2027:**<br>• Provide future mandate for CV2X in all vehicles<br>• Voluntary CV2X deployment<br>**2028:**<br>• OEMs representing 50% of US market start to deploy by 2028 or announce intent to start deployment by 2031<br>**2030:**<br>• "Wait and see" OEM launch<br>• 90% of all newly manufactured vehicles<br>• All vehicles come to market equipped and accept validated messages<br>• All vehicles on the road are connected | • "Only if mandated" OEM launch |
| **Demonstrated in-teroperability:**<br><br>**\* LTE-V2X to LTE V2X**<br>**\* Comms inside 30 MHz to comms in other spectrum**<br>**\* Security credential interoperability**<br>**\* Application in-teroperability**<br><br>*(Attendee Rank: #5/15)* | • Demonstrate a minimum of 3 device suppliers in market<br>• Message interoperability by EOY | • Demonstrate at least 10 device suppliers in market<br>• Message interoperability performance improved<br>• Evaluate increased spectra allocation<br>• Use-case/application interoperability testing<br>• Common interoperable set that can be used by all: SPaT, the Institute of Electrical and Electronics Engineers, SAE, SCMS, MAP | • Demonstrated interoperability 2026-2028 *given production timeline* | |

U.S. Department of Transportation