



# Saving Lives with Connectivity:

A Plan to Accelerate V2X Deployment



U.S. Department of Transportation

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## Non-Binding Contents

Except for the statutes and regulations cited, the contents of this document do not have the force and effect of law and are not meant to bind the States or the public in any way. This document is intended only to provide information regarding existing requirements under the law or agency policies.

## Introduction

The U.S. Department of Transportation (DOT) is committed to reducing deaths and serious injuries on our nation's roadways. As it implements the National Roadway Safety Strategy, the DOT is actively pursuing a comprehensive approach to reduce the number of roadway fatalities to the only acceptable number: zero. This National V2X Deployment Plan provides a vision of how deploying improved wireless connectivity enables a safer, secure, and more efficient transportation system while maintaining privacy and consumer protection.

**The only acceptable number of roadway deaths is zero.**

A powerful tool for achieving this ambitious, long-term goal is vehicle-to-everything (V2X) technology, which enables vehicles to communicate with each other, with other road users such as pedestrians, cyclists, individuals with disabilities, and other vulnerable road users, and with roadside infrastructure, through wirelessly exchanged messages. The "X" in V2X stands collectively for other road users and the roadside infrastructure. When equipped, the messages may contain key information about the location and actions of vehicles and other road users, traffic conditions – including the state of equipped traffic signals and prevailing roadway conditions – such as weather, pavement conditions, work zones, and other disruptions.

V2X provides connectivity through both direct and network communication. Under direct V2X, vehicles exchange frequent, structured messages through in-vehicle or aftermarket devices that continuously exchange relative speed, position, and other relevant data. This form of communications ensures 360-degree awareness, even in situations with poor or obstructed visibility, such as around corners or in dense fog. Alternatively, network V2X leverages conventional mobile networks to allow vehicles to send and receive messages. Direct V2X communication is suited for safety applications requiring low latency, while network V2X communication is more suited to carry information over longer distances, such as real-time information about traffic and road conditions.

V2X communications can give road users vastly improved information about potential risks in traffic situations. V2X has the potential to improve safety of vulnerable road users as infrastructure capabilities increase. Sharing key information between the various parties in the transportation network allows responses that may improve safety, prevent crashes, optimize system performance, enhance traveler mobility and accessibility, improve the efficiency of goods movement, mitigate negative environmental impacts, and address disparities in transportation equity.

**V2X can save lives by enabling wireless communications among vehicles, roadside infrastructure, and mobile devices.**

Deployments utilizing V2X technologies have already demonstrated safety benefits on a smaller scale throughout the nation. However, to realize the full potential of V2X technology, it is important to expand deployment consistently so that vehicles and infrastructure can communicate safely, securely, and without harmful interference across a variety of devices and platforms. To achieve this type of 'interoperable connectivity,' a diverse range of mobile, in-vehicle, and roadside technologies must be able to communicate everywhere, efficiently, and securely, in a way that protects personal information.

V2X communication supports the Safe System approach adopted by the DOT through the NRSS. The Safe System approach is a comprehensive approach that provides a guiding framework to make roads, streets, sidewalks, and other elements of the holistic system safer for all users.

The NRSS works by building and reinforcing multiple layers of protection to both prevent crashes from happening in the first place and to minimize harm caused to those involved when crashes do occur (Figure 1).

Under the NRSS, the DOT committed to advancing the use and deployment of V2X and other technologies to advance safer roadways. V2X technologies complement other safety countermeasures.

Technology advancements in vehicles and infrastructure have enabled incremental improvements in roadway safety. For example, the National Highway Traffic Safety Administration (NHTSA) estimates that 8,650 people died in the U.S. in traffic crashes in the first three months of 2024, a decrease of about 3.2% from 8,935 estimated fatalities during the same period in 2023. Despite eight consecutive quarters of decreasing fatalities since 2022, the goal continues to be zero deaths. A worrisome trend is a dramatic increase in pedestrian and bicycle fatalities. Pedestrian deaths in urban areas grew by 81 percent from 2013 to 2022. A broader, transformational approach, defined by the Safe System Approach in the NRSS, includes leveraging advanced technologies that can prevent or mitigate crashes. Opportunities exist to ensure connected V2X technologies are integrated into the transportation system. Not only can V2X technology save lives, but it can also enhance mobility, bolster efficiency, improve equity, and reduce negative environmental impacts. Accelerating V2X deployment based on secure by design principles is a crucial step to save lives while also protecting the confidentiality and integrity of V2X data and the availability of V2X communications.



**Figure 1. Principles of a Safe System Approach**

Source: DOT

## Plan Overview

This document presents a plan to accelerate the deployment of V2X. The Plan sets the DOT's vision, aspirational goals, and milestones, and issues a call to action for stakeholders, including *government at all levels*, public agencies, and the private sector. The aspirational goals and targets do not imply a legislative/regulatory mandate or dedicated federal funding. Instead, the Plan provides a path that demonstrates Federal leadership and will allow government and industry to work together towards the same goals.

The Plan describes how deployments can start now and defines the specific actions needed across stakeholder groups. It also identifies support available from the DOT and other sources. This Plan provides stakeholders with vital information to accelerate investment, research, and deployment in V2X technologies and helps stakeholders plan near-term and mid-term priorities. This Plan helps agencies develop the required technical expertise and institutional capacity for future deployment needs by providing a list of resources and technical assistance. The Plan seeks to reduce uncertainty among all stakeholders working towards the vision of a nationwide, secure, interoperable V2X ecosystem. Reduction in stakeholder uncertainty includes the DOT advocating for wireless spectrum allocated specifically for V2X safety applications by the Federal Communications Commission (FCC).

**V2X connectivity is a crucial, lifesaving tool in the safety toolbox ready to deploy now.**

In response to stakeholder inputs, the DOT will provide additional technical materials. The DOT will also provide ongoing technical assistance through peer-to-peer exchanges and online resources such as the Smart Community Resource Center. These (and other) DOT resources provide support and technical assistance to public and private sector V2X community members developing V2X deployment scenarios and associated roadmaps for products and services.

## Notable DOT Actions for Accelerating V2X Deployment

The Plan builds from legacy and current DOT activities. Notable DOT actions initiated since August 2022, when the intelligent transportation systems (ITS) community emphasized a desire for federal leadership in interoperable connectivity at the First V2X Summit, are shown in [Table 1](#).

**Table 1. Notable DOT Actions Initiated Since August 2022**

### Demonstrating Federal Leadership

- Held an inaugural summit in August 2022 to identify a path forward for V2X deployment. At the summit, stakeholders identified key issues and challenges impacting V2X deployment. Feedback from the summit underscored a desire within the ITS community for strong federal leadership toward interoperable connectivity. The DOT convened a second summit in April 2023 to report on progress and gather input for the development of a National V2X Deployment Plan.
- Released the Draft National V2X Plan in October 2023 and received over 700 comments during the comment period. Finalized this National V2X Deployment Plan in response to stakeholder feedback and the need for strong federal coordination to show its commitment to using V2X to save lives and accelerate technology innovation and deployment to advance Departmental goals.

## Resolving Regulatory Uncertainty

- Supported the National Telecommunications and Information Administration (NTIA) and FCC to expedite the granting of waivers of certain FCC rules to permit the immediate deployment of V2X technology, by allowing V2X technology to be used in the upper 30-megahertz portion (5.895-5.925 GHz) of the 5.850-5.925 GHz (5.9 GHz) band, prior to adoption of the final C-V2X-based rules. The FCC granted 14 waiver requests in April 2023, 17 waiver requests in August 2023, 8 waiver requests in November 2023, and 11 waiver requests in April 2024 to organizations, including State departments of transportation. As of April 2024, a total of 50 waivers has been granted.
- Continues to conduct spectrum testing to provide data to the FCC and NTIA to support the release of the FCC's Second Report and Order on cellular V2X (C-V2X) technology.
- Issued in November 2023 a formal withdrawal notice of a previous proposal to mandate Dedicated Short Range Communications (DSRC)-V2V communications technology in all new light vehicles, because DSRC will no longer be allowed in the 5.9 GHz band after a to-be-determined transition period.

## Providing Technical Assistance and Resources to V2X Deployers

- Providing professional capacity building through the [Connected Vehicle Deployer Resources](#). Resources include the [Connected and Automated Vehicle Education \(CAVe\)-in-a-box](#) kit.
- Operating the Technical Assistance and Equipment Loan program, which gives deployers the opportunity to borrow V2X equipment for testing to ensure it will work with their existing infrastructure. Deployers can email [CAVSupportServices@dot.gov](mailto:CAVSupportServices@dot.gov).
- Providing technical assistance to agencies for [requesting waivers](#). In July 2023, the DOT provided support to multiple State and local agencies regarding filing a request for an FCC waiver.
- Creating a page on interoperable connectivity on the [Smart Community Resource Center](#) website that provides resources for V2X planners and deployers.
- Developing a fact sheet documenting federal funding opportunities available for V2X planning and deployment under the Bipartisan Infrastructure Law.
- Initiating the development of a V2X Deployer Resources document (expected 2024) to create actionable templates assisting State and local agencies in delivering standards driven V2X deployments.

## Convening Stakeholders and Sharing Best Practices

- Established in November 2023 a V2X peer group of 27 States and local agencies to share lessons learned and insights.
- Participating in national coalition meetings focused on V2X deployment with other stakeholders, including the American Association of State Highway and Transportation Officials, ITS America, the Institute of Transportation Engineers, and 5G Automotive Association.
- Hosted summits, workshops, and online webinars in the development of this Plan.

## Identifying Tested Day-One V2X Applications

- Gathering information on proven V2X applications for sharing with the V2X community through the Smart Community Resource Center.

## Investing Federal Funds in V2X

- Invested \$61.5 million in V2X technology research and deployment through the FHWA Turner Fairbank Highway Research Program over the last five years, with \$12.5 million in follow-on research projects budgeted for FY24.
- Identified and promoted funding opportunities made available through the Bipartisan Infrastructure Law, including awards to seven Strengthening Mobility and Revolutionizing Transportation (SMART) and four Advanced Transportation Technology and Innovation (ATTAIN) grants that include V2X elements. Approximately \$200 million in active, grant funded projects are underway now, including earlier Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD) grants.
- Initiated the Intersection Safety Challenge in April 2023 that incentivizes the innovative application of new and emerging technologies (such as V2X, artificial intelligence, advanced sensing) to identify and mitigate unsafe conditions involving vehicles and vulnerable road users at intersections.

# The National V2X Deployment Plan

## Vision

Enable a safe, efficient, equitable, and sustainable transportation system through the national, widespread deployment of secure, interoperable V2X technologies.

## Mission

Accelerate the deployment of secure, interoperable V2X connectivity using the dedicated 5.895-5.925 GHz spectrum and other available spectrum through collaboration and coordination across federal government, the public sector, and private industry.

## Goals and Targets

The DOT has established short-term, medium-term, and long-term roadmap of actions and steps that together are likely to lead to the achievement of the Plan's vision. No single goal or target is considered essential to achieving the vision of the plan. These are meant to illustrate a roadmap to achieve the vision. These aspirational goals and targets were informed by stakeholder inputs and engagements, DOT research and development activities, as well as industry trends and developments.

The DOT has defined three timeframes:

- Short-Term (2024 - 2028): Leading Deployers in Operation.
- Medium-Term (2029 - 2031): V2X Deployer Community Growth.
- Long-Term (2032 - 2036): Nationwide Secure, Interoperable V2X Deployed and Operational.

[Figure 2](#) summarizes key elements of the National V2X Deployment Plan Roadmap.

Tables 2, 3, and 4 present the short-term, medium-term, and long-term goals, and corresponding targets, and responsible lead stakeholder group by strategic areas of Infrastructure Deployments, Vehicles, Spectrum, Interoperability, and Benefits and Technical Assistance.

Establishing goals for various timeframes will assist stakeholders in focusing on actions that can be taken now with the current state of knowledge and technology. Long-term outcomes can be influenced by external factors and continued technological and institutional developments. Due to inherent uncertainties, there is a need to regularly monitor and adjust these goals and targets.

The DOT has established milestones and targets in each of the goal areas as a call-to-action among all V2X stakeholders working towards the vision of this Plan. The DOT recognizes that realizing these milestones and targets will require commitment and investment from across the V2X community, not just from the DOT. In conjunction with the V2X community, the DOT intends to establish a more refined target criteria, baseline conditions, and a tracking capability for these milestones and targets, documented and shared through the Smart Community Resource Center.

## Secure Deployment: Cybersecurity and Privacy Principles

Successful V2X deployment requires cyber resilience so its communication services remain available and all users have confidence in the integrity of V2X data as well as trust in the confidentiality of data exchanged via V2X communications. This requires applying principles of secure by design — considering cyber and privacy risks at the outset and integrating cybersecurity principles when V2X is developed and deployed. Secure and resilient V2X depends on investment in cybersecurity and adopting a comprehensive approach to manage and reduce cyber risk.

Cybersecurity is critical to ensure V2X technologies — and the information they provide — can be used and are trusted through standard procedures to validate that information is correct. Secure V2X deployment includes ensuring Personally Identifiable Information (PII) is protected while also allowing parties to secure the data needed to advance a safe and efficient transportation system. Privacy of individuals must be considered and the collection and use of PII and potential PII must align to the purpose of the program. Participants must be informed of privacy practices and provided with understandable notice and provided options for consent. PII collected should be the minimum necessary for the purpose for which it is collected, maintained for the shortest time practical, and not used for any other reason than for which it was initially collected.

The DOT is cognizant that realizing secure V2X deployment requires implementing cybersecurity and privacy principles in a clear and practical way. The ITS Cybersecurity Research Program [website](#) documents DOT and modal agencies' resources. The DOT commits to developing and maintaining cybersecurity resources for the V2X community, as well as a detailed and testable definition of secure V2X deployment in support of this Plan.

## Interoperable Deployment

Crucial to the V2X vision is the notion of interoperability — that is, that a diverse range of mobile, in-vehicle, and roadside devices can communicate ubiquitously, efficiently, and securely in a privacy-protected manner using multiple wireless communications technologies, wireless messages, open data formats, and standards. Interoperability allows people and goods to move seamlessly across borders, jurisdictional boundaries, and systems. V2X connectivity is envisioned as a cooperative system where technology operates as a single system despite various stakeholders, owners, operators, and equipment. Achieving interoperability requires close coordination across government and industry.

The DOT's standards and architecture includes the [National ITS Reference Architecture](#), a resource that provides a framework for safe, secure, and effective interoperable systems. The National ITS Reference Architecture continues to be updated over time as technologies evolve and are deployed. The DOT is cognizant that testing and demonstration of interoperability must be concretely and precisely defined. The DOT commits to developing a detailed and testable definition of V2X interoperability in support of this Plan. The DOT also commits to defining and demonstrating successful V2X interoperability testing procedures.



## Benefits and Challenges

The National V2X Deployment Plan was created based on certain assumptions that could impact deployment. V2X is fundamentally cooperative technology where the large-scale benefits are a magnitude greater as a whole than in an individual system, which creates both opportunities and challenges. These high-level assumptions are highlighted below.

### Benefits

Evidence of the benefits of V2X technologies has been widely documented. A compilation of benefits can be found in the [ITS Deployment Evaluation](#) website. Examples include:

**V2X technology has the potential to improve safety and accessibility of all road users, including vulnerable road users and those with disabilities.**

- In 2017, NHTSA [estimated](#) that the implementation of two V2V safety applications using DSRC technology, Intersection Movement Assist (IMA) and Left Turn Assist (LTA), could prevent 439,000 to 615,000 crashes, 13 to 18 percent of the total reported crashes, and save 987 to 1366 lives annually when fully implemented. The estimated savings from these reduced crashes was \$55 to 74 billion annually when fully implemented.
- The [Tampa Hillsborough Expressway Authority \(THEA\) Connected Vehicle Pilot](#) estimated that 21 potential pedestrian crashes were prevented with V2X and Pedestrian Collision Warning application.
- A [study in Europe](#) found that with V2X, traffic management and signal control can reduce CO2 emissions by up to 16 percent. For an individual vehicle, [an eco-driving application](#) using V2X can provide an emissions reduction of almost 10 percent.

The Safety Pilot Model Deployment, the [Connected Vehicle Pilots](#), and other precursor V2X deployments have demonstrated the feasibility and some benefits of V2X communication using DSRC. Based on these results, large-scale deployments with C-V2X and other communications technologies have the potential to provide a variety of benefits at a national level.

### Spectrum Use Challenges

Wireless spectrum is limited and in great demand. Low-latency, safety-related applications will utilize the 30-megahertz portion (5.895-5.925 GHz) in the 5.9 GHz band reserved by FCC rule, while other applications will need to use other communication approaches, including solutions utilizing other spectrum. Various cellular communication-based approaches have been deployed; however, these may not be fully interoperable across multiple supplier ecosystems.

## Private Industry Participation Challenges

To deploy connectivity to save lives requires coordination both with vehicles and infrastructure. Original equipment manufacturers (OEMs) will decide the extent to which V2X devices — such as onboard units — are installed in new vehicles. OEMs may not all have uniform views on the business case to invest in V2X technologies, but they may collaborate with other members of the private sector, and public agencies deploying V2X infrastructure. Meanwhile, device manufacturers will likely seek to ensure that roadside units and onboard units are developed appropriately with standards to ensure interoperability and have them tested and certified so that deployers (OEMs and IOOs) have certainty about going forward successfully.

## Public Agency Capacity and Funding Challenges

Public agencies vary in their readiness to deploy V2X technology. Some agencies lack expertise, institutional capacity, or funding; and/or are using legacy systems. These differences need to be considered to support a collaborative and coordinated approach. Federal funds and assistance are available to support eligible deployments, considering both capital and operational costs, but ultimately it is up to States, tribal governments, and local governments that own and operate roadway systems to plan, design, construct, operate, and maintain V2X deployments.

## Documenting Benefits and Near-Term Successes

Secure, interoperable connectivity applications will continue to be developed with new use cases and innovations that build upon foundational technologies as well as deployment experience. In the near term, however, viable secure, interoperable connectivity deployments are needed to realize benefits and guide further development. The longer-term future possibilities are broader but will depend in part on achieving successes in the near term and the development of best practices, industry guidance, test procedures, and other components that support interoperability. The V2X benefits assessment will address impacts to all road users, including travelers with disabilities.

The DOT will focus future efforts on V2X applications with the highest near-term potential, cognizant of the challenges of extrapolating impacts to a broader range of operational and environmental constraints. The DOT will ensure near-term successes are packaged for maximum effectiveness in communication to both the V2X community and the general public.

## VISION

Enable a safe, efficient, equitable, and sustainable transportation system through the national, widespread deployment of secure, interoperable V2X technologies.

## MISSION

Accelerate deployment of secure, interoperable V2X connectivity using the dedicated 5.895-5.925 GHz spectrum and other available spectrum through collaboration and coordination across federal government, the public sector, and private industry.

### Short-Term Goals (2024–2028)

#### Infrastructure Deployments

- V2X deployed on 20% of National Highway System
- Top 75 metro areas have 25% of signalized intersections V2X enabled
- 12 interoperable, cybersecure deployments
- 20 grants in at least 10 states utilizing the 5.895-5.925 GHz band

#### Vehicles

- 2 Original Equipment Manufacturers (OEMs) commit to 5.895-5.925 GHz capable vehicles by 2028 model year

#### Spectrum and Interoperability

- 2 Security Credential Management System (SCMS) providers demonstrate interoperable security credentials management following secure by design principles
- 3 device suppliers and 2+ OEMs demonstrate interoperability
- FCC completes 2nd Report and Order on 5.9 GHz band

#### Benefits and Technical Assistance

- 3 benefit/cost case studies, including at least one focused on vulnerable road user safety
- 25 active Accelerating V2X Cohort members
- 10 regional secure, interoperable connectivity hands-on training events



### Medium-Term Goals (2029–2031)

#### Infrastructure Deployments

- V2X deployed on 50% of National Highway System
- Top 75 metro areas have 50% of signalized intersections V2X enabled
- 25 interoperable, cybersecure deployments
- V2X installed in 40% of the nation's intersections

#### Vehicles

- 5 vehicle models are 5.895-5.925 GHz capable
- 3 active deployments generate Infrastructure Owner-Operator (IOO) data used by 2 OEM production vehicles
- 4 suppliers, 3 OEMs demonstrate secure, interoperable connectivity

#### Spectrum and Interoperability

- 5 V2X use cases demonstrated in the 5.895-5.925 GHz band
- 5 V2X use cases demonstrated **beyond** the 5.895-5.925 GHz band (i.e., other communications technologies, including network-based communications technologies)
- 20 public agencies demonstrate interoperability
- 2 providers utilize interoperable SCMS credentials
- 10 certified devices on the market

#### Benefits and Technical Assistance

- 6 use cases (2 involving vulnerable road users) document V2X safety benefits/costs
- 50 active Accelerating V2X Cohort members author progress report

### Long-Term Goals (2032–2036)

#### Infrastructure Deployments

- V2X fully deployed on National Highway System
- Top 75 metro areas have 85% of signalized intersections V2X enabled, a majority of which feature vulnerable road user safety applications
- 50 interoperable, cybersecure deployments
- Secure, interoperable 5.895-5.925 GHz operations across 50 states
- V2X installed in 75% of the nation's intersections

#### Vehicles

- 6 OEMs have 5.895-5.925 GHz capable production vehicles for safety use cases
- 20 vehicle models are V2X capable

#### Spectrum and Interoperability

- 5 V2X use cases operational in the 5.895-5.925 GHz band in all 50 states
- 5 V2X use cases operational beyond the 5.895-5.925 GHz band in 5 states
- 20 certified devices dominate deployed V2X technology base

#### Benefits and Technical Assistance

- 10 deployments in operation for 5 years streaming benefits/cost data
- 75 active Accelerating V2X Cohort members sponsor pooled fund projects

Source: DOT

Figure 2. Key Elements of the National V2X Deployment Plan Roadmap

**Table 2. National V2X Deployment Plan by Strategic Focus Area<sup>1</sup> (Short-Term, 2024-2028)**

Strategic Focus Area	Goals	Milestones / Targets	Stakeholders and DOT Roles
<b>Infrastructure Deployments</b>	<ul style="list-style-type: none"> <li>■ 20% of the National Highway System has V2X technology deployed for freeway-based applications</li> <li>■ Top 75 Metro areas<sup>2</sup> have 25% of their signalized intersections V2X-enabled</li> </ul>	<ul style="list-style-type: none"> <li>■ 12 corridor/regional deployments<sup>3</sup> with demonstrated secure, interoperable V2X technologies</li> <li>■ 20 grants awarded across at least 10 states that include the use of the 5.895-5.925 GHz band</li> </ul>	IOOs and their partners, primed by DOT seed funding/grants
<b>Vehicles</b>	<ul style="list-style-type: none"> <li>■ 5.895-5.925 GHz equipped vehicles from leading OEMs are either in production or with formalized commitment</li> </ul>	<ul style="list-style-type: none"> <li>■ 2 OEMs have 5.895-5.925 GHz capable vehicles in production (or commit to do so by 2028 model year)</li> <li>■ 10 public fleet operators outfit vehicles with aftermarket safety devices</li> </ul>	Private sector (OEMs, aftermarket safety device vendors) in coordination with public sector fleet operators
<b>Spectrum</b>	<ul style="list-style-type: none"> <li>■ 5.895-5.925 GHz spectrum finalized by the FCC with all rules/provisions in place, affirming a long-term spectrum commitment</li> </ul>	<ul style="list-style-type: none"> <li>■ 5.9 GHz band final rules (FCC 2nd R&amp;O) formally completed</li> <li>■ 2 V2X use cases demonstrated utilizing the 5.895-5.925 GHz band</li> <li>■ 2 V2X use cases demonstrated utilizing spectrum <b>beyond</b> the 5.895-5.925 GHz band (i.e., other communications technologies, including network-based communications technologies)</li> </ul>	DOT supports the release of the FCC’s Second Report and Order on C-V2X technology
<b>Interoperability</b>	<ul style="list-style-type: none"> <li>■ All standards required for interoperability in 5.895-5.925 GHz band published</li> <li>■ Initial standards and architecture extending interoperability beyond 5.895-5.925 GHz band established</li> </ul>	<ul style="list-style-type: none"> <li>■ 3 device suppliers and 2 OEMs demonstrate interoperability among products in an operational deployment</li> <li>■ 2 SCMS providers demonstrate interoperable security credentials management following secure by design principles</li> <li>■ 5 certified devices on the market</li> </ul>	Private sector, with DOT and IOO support
<b>Benefits and Technical Assistance</b>	<ul style="list-style-type: none"> <li>■ Provide technical assistance programs to help the V2X community design, build, operate, and maintain secure, interoperable V2X systems</li> <li>■ Secure by design principles codified in V2X-specific technical assistance</li> <li>■ Foundational educational materials, V2X benefit/cost case studies widely available</li> </ul>	<ul style="list-style-type: none"> <li>■ 3 benefit/cost case studies, including at least one focused on vulnerable road user safety and benefits to travelers with disabilities</li> <li>■ 25 active members in Accelerating V2X Cohort spanning 10 states</li> <li>■ 10 regional secure, interoperable connectivity hands-on training events</li> </ul>	DOT acts as clearinghouse, sponsors community-building activity

<sup>1</sup> This table represents our reporting of the results of the many stakeholder engagements that occurred leading up to and during the development of this Plan.

<sup>2</sup> A Metropolitan Statistical Area (MSA) consists of one or more counties that contain a city of 50,000 or more inhabitants, or contain a Census Bureau-defined urbanized area (UA) and have a total population of at least 100,000 (75,000 in New England) ([Ch13GARM.pdf \(census.gov\)](#)).

<sup>3</sup> Each regional/corridor deployment spans a minimum of 300 miles of roadway (combined highway and surface street) and/or 300 intersections/interchanges.

**Table 3. National V2X Deployment Plan by Strategic Focus Area (Medium-Term, 2029-2031)**

Strategic Focus Area	Goals	Milestones / Targets	Stakeholders and DOT Roles
<b>Infrastructure Deployments</b>	<ul style="list-style-type: none"> <li>■ 50% of the National Highway System has V2X technologies deployed for freeway-based applications</li> <li>■ Top 75 Metro areas have 50% of their signalized intersections V2X-enabled</li> </ul>	<ul style="list-style-type: none"> <li>■ 25 corridor/regional deployments with demonstrated secure interoperable V2X technologies</li> <li>■ 40% of the nation’s intersections have V2X technology installed across large, mid-size and rural communities</li> </ul>	IOOs and their partners, leveraging Bipartisan Infrastructure Law (BIL) resources
<b>Vehicles</b>	<ul style="list-style-type: none"> <li>■ Explore data-driven strategies that could effectively incentivize secure, interoperable systems and accelerated deployment</li> <li>■ OEM production vehicles utilize IOO data</li> <li>■ Secure, interoperable connectivity data exchanges support early use cases</li> </ul>	<ul style="list-style-type: none"> <li>■ 5 vehicle models are 5.895-5.925 GHz capable, including 2+ heavy/commercial vehicle models</li> <li>■ 3 active deployments generate IOO data used by 2 OEM production vehicles</li> <li>■ 4 suppliers, 3 OEMs demonstrate secure, interoperable connectivity</li> </ul>	Private sector, in coordination with DOT
<b>Spectrum</b>	<ul style="list-style-type: none"> <li>■ Use cases beyond 5.895-5.925 GHz spectrum are well-defined and shared widely</li> <li>■ Cybersecurity methodologies are interoperable both within and beyond the 5.895-5.925 GHz band</li> </ul>	<ul style="list-style-type: none"> <li>■ 5 V2X use cases demonstrated utilizing the 5.895-5.925 GHz band</li> <li>■ 5 V2X use cases demonstrated utilizing spectrum <b>beyond</b> the 5.895-5.925 GHz band (i.e., other communications technologies, including network-based communications technologies)</li> <li>■ End-to-end SCMS capability demonstrated within and beyond the 5.895-5.925 GHz band</li> </ul>	Private sector, with DOT and IOO support
<b>Interoperability</b>	<ul style="list-style-type: none"> <li>■ Reference implementation for secure, interoperable connectivity developed and delivered</li> <li>■ Reliable, scalable device certification processes utilized by multiple vendors.</li> </ul>	<ul style="list-style-type: none"> <li>■ 20 public agencies demonstrate secure, interoperable connectivity</li> <li>■ SCMS credentials are in secure, active interoperable use from 2 providers</li> <li>■ 10 certified devices on the market</li> </ul>	Private sector, with DOT and IOO support
<b>Benefits and Technical Assistance</b>	<ul style="list-style-type: none"> <li>■ Report published documenting the cost-benefit of investing in V2X technology, including operational and maintenance costs</li> <li>■ ITS community delivers a plan update on its progress towards national deployment</li> </ul>	<ul style="list-style-type: none"> <li>■ 6 use cases (2 involving vulnerable road users) document V2X safety benefits/costs</li> <li>■ 50 active members of DOT Accelerating V2X Cohort author progress report, spanning 25 states</li> </ul>	DOT acts as clearinghouse, facilitates community

**Table 4. National V2X Deployment Plan by Strategic Focus Area (Long-Term, 2032-2036)**

Strategic Focus Area	Goals	Milestones / Targets	Stakeholders and DOT Roles
<b>Infrastructure Deployments</b>	<ul style="list-style-type: none"> <li>■ V2X secure, interoperable connectivity deployed widely, seen as a fundamental element of system operations, and functions within a mature ecosystem featuring all stakeholders</li> <li>■ The National Highway System is fully deployed for freeway-based applications</li> <li>■ Top 75 Metro areas have 85% of signalized intersections V2X-enabled, a majority of which feature vulnerable road user safety applications</li> </ul>	<ul style="list-style-type: none"> <li>■ 50 corridor/regional deployments with demonstrated secure interoperable V2X technologies</li> <li>■ Secure, interoperable 5.895-5.925 GHz operations demonstrated across 50 states</li> <li>■ 75% of the nation’s intersections have V2X technology installed across large, mid-size and rural communities</li> </ul>	IOOs and their partners, leveraging program funding
<b>Vehicles</b>	<ul style="list-style-type: none"> <li>■ Adoption of secure, interoperable connectivity by infrastructure owners/operators and OEMs is widespread</li> </ul>	<ul style="list-style-type: none"> <li>■ 6 OEMs have 5.895-5.925 GHz capable production vehicles employing safety-related use cases</li> <li>■ 20 vehicle models are 5.895-5.925 GHz capable, including 12+ heavy/ commercial vehicle models</li> </ul>	Private Sector (OEMs) and their partners
<b>Spectrum and Interoperability</b>	<ul style="list-style-type: none"> <li>■ Interoperability realized for use cases both within and beyond the 5.895-5.925 GHz spectrum</li> <li>■ Reference implementation for secure, interoperable connectivity enhanced and maintained</li> <li>■ Certified devices dominate dynamic V2X technology base</li> <li>■ Cybersecurity is interoperable both within and beyond the 5.895-5.925 GHz band and across applications</li> </ul>	<ul style="list-style-type: none"> <li>■ 5 V2X use cases operational in the 5.895-5.925 GHz band in all 50 states</li> <li>■ 5 V2X use cases operational in spectrum beyond the 5.895-5.925 GHz band in 5+ states</li> <li>■ 20 certified devices dominate deployed V2X technology base</li> <li>■ 10 deployments feature interoperable SCMS capability both within and beyond the 5.895-5.925 GHz band and across applications</li> </ul>	Industry acts as champion for the V2X community
<b>Benefits and Technical Assistance</b>	<ul style="list-style-type: none"> <li>■ National benefits and costs pipeline established drawing on data streaming from operational systems</li> </ul>	<ul style="list-style-type: none"> <li>■ 10 deployments in operations for 5+ years streaming benefits and cost data</li> <li>■ 75 active members of DOT Accelerating V2X Cohort sponsor ongoing pooled fund projects spanning 45 states</li> </ul>	DOT acts as clearinghouse for benefits, costs, and technical assistance, partners with pooled fund partners

## Key Focus Areas Enabling Secure, Interoperable V2X Deployment

Figure 3 illustrates key focus areas that enable successful interoperable and cybersecure V2X deployments.



### Systems Engineering Processes

Critical for risk management and ensuring the right system is being developed to meet transportation needs.



### Wireless Technologies

Need to utilize current licensed (5.895-5.925 GHz, cellular, satellite) and unlicensed (Wi-Fi) spectrum and stay abreast of future advancements.



### Standards & Architecture

Protocols for transmitting and processing messages need to be defined clearly and with documented specifications.



### Cybersecurity

A cybersecurity profile must be maintained that enables planned interoperable connectivity deployment.



### Trust & Credential Management

A Security Credential Management System is needed to authenticate and sign messages to establish trust.



### V2X Certification

Devices must be tested to ensure conformity to key industry standards, requirements, and functionality.



### Policies

Evolving policies include standards, communications, security, privacy, data governance, and accessibility/equity in deployment.



### Spectrum Governance

The licensed ITS band and additional spectrum options may be governed differently.



### Outcome / Benefit Framework

The network effect and the technology adoption life cycle are critical factors for advantageous benefit/cost ratios.

**Figure 3. Key Focus Areas Enabling Secure, Interoperable V2X Deployments**

Source: DOT

## V2X Community Stakeholders and Potential Actions

Stakeholder groups, including automotive OEMs and IOOs, came together to present a vision for V2X deployment, as shown in [a call to action prepared by ITS America](#) and released in April 2023. These collaborations are important to facilitate peer exchange and to present cross-industry perspectives to those who may not regularly interact with IOOs or OEMs. The collective voice of deployers plays an important role in conveying their willingness and desire to deploy. It also shows the growing market potential for industry to address and innovate.

Achieving the goals laid out in this Plan depends on collaboration with multiple stakeholders. No one group can achieve these goals on their own. This section identifies major stakeholder groups (see [Figure 4](#)) and roles to clarify expectations, encourage dialogue, and coordinate activities. This framework is not an exhaustive list but shows examples of key roles and responsibilities. Stakeholders are encouraged to openly share their perspectives, plans, and commitments. There is a need for collective action to deploy V2X connectivity.

[Table 5](#) shows potential actions for major stakeholder groups.



**Figure 4. V2X Community Stakeholder Groups**



**Table 5. Potential Actions for Major Stakeholder Groups**

<p><b>DOT</b></p>	<p><b>NTIA</b></p>	<p><b>Transit Operators</b></p>
<p>Provide federal leadership by hosting events and documenting a national vision and action plan for deployment.</p>	<p>Coordinate and convey federal (DOT) transportation perspective and interests in spectrum decisions and rules to FCC.</p>	<p>Deploy and operate on-board and center-based V2X applications to enhance transit safety, efficiency, and performance.</p>
<p>Provide seed funding and investment to accelerate V2X deployments.</p>	<p><b>OEMs</b></p>	<p><b>Freight Operators</b></p>
<ul style="list-style-type: none"> <li>■ Launched a new financial assistance program focused on V2X investment in 2023.</li> <li>■ Promote use of discretionary grant programs like ATAIN, SMART, and SS4A grants to launch V2X deployments that address cyber risk per DOT discretionary grant Critical Infrastructure Security and Resilience (CISR) requirements.</li> </ul>	<p>Develop, test, and deploy secure interoperable V2X safety applications.</p>	<p>Deploy V2X applications that provide internal return-on-investment, including safety and efficiency applications and driver support.</p>
<p>Convene and facilitate stakeholders to share information / best practices.</p>	<ul style="list-style-type: none"> <li>■ Initiate deployment of C-V2X technology and safety applications in new vehicles of all types (including fleet vehicles).</li> <li>■ Deploy secure interoperable safety and non-safety applications utilizing 5.895-5.925 GHz and other spectrum approaches.</li> <li>■ Actively partner with IOOs to enable national rollout of secure interoperable applications in production vehicles.</li> <li>■ Support precompetitive Research and Development (R&amp;D) and standardization.</li> <li>■ Collaborate on message sets and standards for interoperability.</li> <li>■ Provide sustained input to FCC regarding impact of V2X technologies.</li> </ul>	<p><b>App Developers</b></p> <p>Design and develop applications that utilize connectivity.</p>
<ul style="list-style-type: none"> <li>■ Establish an Accelerating V2X Cohort and document benefits, costs, and lessons learned.</li> <li>■ Fund detailed technical assistance training at conferences, annual meetings, and regional events.</li> <li>■ Operate training and equipment loan programs.</li> <li>■ Fund the Connected and Automated Transportation Coalition program.</li> <li>■ Update websites and the Smart Community Resource Center.</li> <li>■ Foster emerging V2X technology addressing vulnerable road user safety and multi-modal use cases.</li> <li>■ Enable interoperability through coordination with stakeholder groups and standards-related activities.</li> <li>■ Organize and deliver a V2X community event in 2024, specifically providing a venue for states and private industry to register their commitments to actions aligned with the Plan.</li> </ul>	<p><b>Automotive Suppliers</b></p>	<p><b>Service Providers</b></p> <p>Develop and operate supporting services that enable secure interoperable connectivity applications.</p>
<p>Provide support for standards, architecture, and testing to accelerate interoperability.</p>	<p>Develop secure V2X-enabled vehicle components and applications for OEMs to include in production vehicles.</p>	<p><b>ITS Equipment/Software Vendors</b></p> <p>Develop infrastructure-based components and software to fulfill public agencies' secure interoperable connectivity needs.</p>
<ul style="list-style-type: none"> <li>■ Conduct additional spectrum testing to provide data to FCC/NTIA for consideration by FCC in their Second Report and Order on C-V2X.</li> <li>■ Explore data-driven strategies that could effectively incentivize secure interoperable systems and accelerated deployment.</li> <li>■ Assess rules and guidance to ensure alignment with the Plan.</li> </ul>	<p>Support precompetitive R&amp;D and standardization.</p>	<p><b>Design/Integration/Deployment Consultants</b></p> <p>Provide support for public agencies to design, procure, integrate, and deploy solutions for secure interoperable connectivity.</p>
<p><b>FCC</b></p>	<p>Collaborate on message sets and standards for interoperability.</p>	<p><b>Security Credential Providers</b></p> <p>Provide security credential-related services (i.e., SCMS, certificates) to enable trust among interoperable connectivity entities and applications.</p>
<p>Work with DOT and industry to determine rules for use of 30 megahertz spectrum allocation to ITS services in 5.895-5.925 GHz band.</p>	<p><b>States, Local Governments, Tribes, and Public Agencies</b></p>	<p><b>Test Certification Providers</b></p> <p>Provide testing and certification services to enable trust in secure interoperable connectivity component functionality, performance, and standards conformance.</p>
	<p>Update investment and transportation plans to include V2X technology.</p>	<p><b>Standards Development Organizations</b></p> <p>Develop standards to realize interoperability and support cooperative applications.</p>
	<p>Deploy and operate secure interoperable, cybersecure infrastructure-based V2X technologies and applications.</p>	<p><b>Trade and Industry Associations</b></p> <p>Provide industry stakeholder feedback to inform DOT and provide expertise.</p>
	<ul style="list-style-type: none"> <li>■ Leverage federal seed funding to inform and test interoperability.</li> <li>■ Collaborate on message sets and standards for interoperability.</li> <li>■ Work with local emergency services, transit, school bus, and other public sector vehicle fleets to enhance vehicle participation.</li> <li>■ Ensure interoperability is a routine element of state long-range and Metropolitan Planning Organization (MPO) plans.</li> <li>■ Participate in national events to remain up-to-date on V2X technology.</li> </ul>	<p><b>Communications Providers</b></p> <p>Build, operate, and maintain private communications networks to provide communications services to customers.</p>

## Future DOT Actions and Support

To successfully accelerate this technology deployment to save lives and advance national goals, the U.S. needs to develop the workforce and skills critical to growing these systems. Growing the knowledge and skills of professional staff within public agencies is critical. One way would be to assess internal organizational capacities, gaps, and needs to plan a deployment that is tailored to their community.

The DOT will coordinate resources from across operating agencies and offices (including the Federal Highway Administration [FHWA], the Intelligent Transportation Systems Joint Program Office [ITS JPO], Federal Transit Administration [FTA], Federal Motor Carrier Safety Administration [FMCSA], and NHTSA) to support the deployment of V2X technologies by public agencies and tribal governments. [Table 6](#) provides a non-exhaustive list of resources and technical assistance the DOT will offer to ensure the U.S. leverages connectivity to save lives.

**Table 6. Examples of DOT-Sponsored Activities from Research to Deployment**

Technical	Stakeholder Engagement	Professional Capacity Building
<ul style="list-style-type: none"> <li>■ Funding</li> <li>■ Mapping tool and technical support</li> <li>■ Architecture and standards development support</li> <li>■ Wireless interference testing</li> <li>■ Research on cybersecurity needs, connected vehicle analysis, modeling, simulations, and digital infrastructure</li> <li>■ Project evaluation tools (and decision support resources)</li> <li>■ V2X technical assistance and supporting documentation</li> </ul>	<ul style="list-style-type: none"> <li>■ Conduct summits and workshops to provide updates on the National V2X Deployment Plan and sharing information and best practices</li> <li>■ Document best practices</li> <li>■ Supporting pooled fund studies</li> <li>■ Coordination with DOT modal administrations and federal agencies</li> <li>■ Stakeholder engagement with industry associations</li> </ul>	<ul style="list-style-type: none"> <li>■ Training</li> <li>■ Help desk</li> <li>■ Equipment loan program</li> <li>■ Cohorts and peer exchange programs</li> <li>■ Smart Community Resource Center</li> </ul>

The DOT will develop V2X technical assistance and supporting documentation to provide deployers with a convenient and informative resource on the technical aspects of secure, interoperable connectivity. These materials will point to sources of more detailed technical information so that deployers can more easily find what they need to plan, develop, and operate secure, interoperable V2X deployments, as well as engage with the supporting technical working groups to share innovations and experiences. The technical assistance and supporting documentation will be kept up to date over time with regularly updated content on the Smart Community Resource Center.

The Accelerating V2X Cohort was chartered in 2023 and serves as a community of practice of active deployers working together to accelerate the adoption and deployment of secure, interoperable V2X technologies. As part of the cohort, members are encouraged to share their experiences, challenges, best practices and documentation for the purpose of addressing technical implementation questions among cohort members.

The DOT also encourages the broader deployment community to be aware of other activities that can inform deployment planning and implementation and consider upcoming and longer-term innovations. For example, the DOT sponsors V2X testing events in locations around the country that can be used by state and local transportation agencies to conceptualize, validate, and refine V2X technologies.

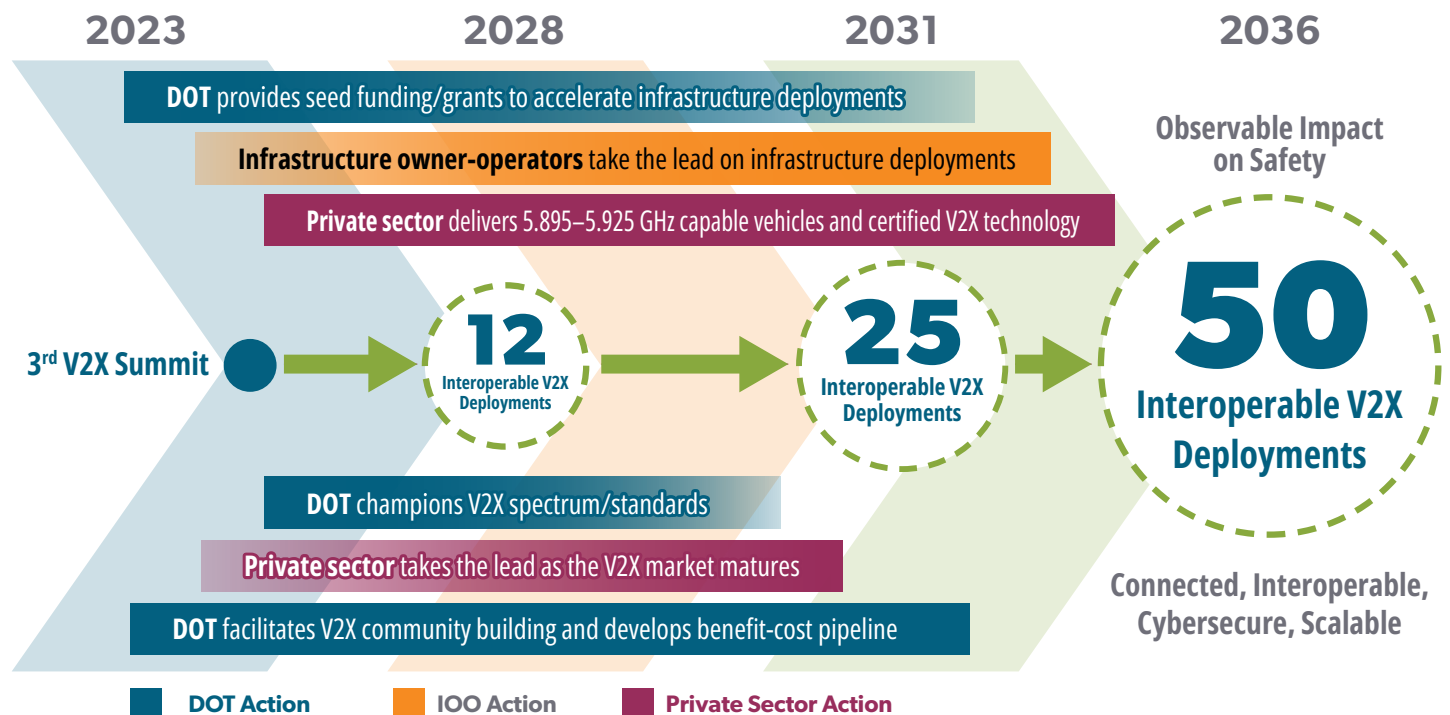
## Conclusion

This National V2X Deployment Plan outlines a vision and path to deployment of improved connectivity for a safer, more efficient transportation system. Past research and deployments show the promises of V2X technology. The need for action is urgent in order to realize these benefits today. V2X is fundamentally a cooperative technology where the large-scale benefits are a magnitude greater as a whole than in an individual system, and through this Deployment Plan, the Department is leading efforts to accelerate the use of V2X to benefit the nation and the traveling public. Achieving and sustaining interoperability is necessary to fully realize the benefits across a nation where vehicles and travelers span cities, states, counties, federal, and tribal lands. The DOT, public agencies, the private sector, and transportation operators must work together to shape the direction of the future. The DOT remains committed to supporting and advancing the deployment of V2X technologies that enable the vision of a future with zero deaths or serious injuries.

**V2X technology can improve safety on a national scale, and the time to invest is now.**

V2X connectivity is an important transformational technology that not only advances safety but also enhances mobility, bolsters efficiency, improves equity, and reduces negative environmental impacts. Accelerating V2X deployment now is a crucial step toward saving lives with connectivity (see [Figure 5](#)).

With this Plan, the DOT seeks a better transportation future.



**Figure 5. Strategic, Coordinated Actions of Key Stakeholders Create Momentum Towards Secure, Interoperable V2X Deployments**

Source:DOT