Intelligent Transportation Systems Deployment Tracking Survey: 2023 Freeway Management Survey Findings

Final Report

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16. Abstract

This report summarizes the Freeway Management Survey findings of the 2023 Intelligent Transportation Systems (ITS) Deployment Tracking Survey. From 1999 to 2020, the ITS Joint Program Office (JPO) used the ITS Deployment Tracking Survey on an ongoing basis to collect information about ITS deployment in a subset of metropolitan areas across the United States by surveying state and local transportation agencies. With this most recent 2023 ITS Deployment Tracking Survey, a new survey methodology was implemented, which greatly expanded the geographic coverage of the ITS Deployment Tracking Survey to include smaller urban and rural areas in addition to large metropolitan areas.

The 2023 Freeway Management Survey was administered online from October 3, 2023 to January 19, 2024 to all State DOT districts and toll authorities that manage freeways. The survey achieved a response rate of 78 percent with 311 completed surveys. Where comparable data are available, trends are shown for the subset of freeway management agencies from large metropolitan areas.

The ITS JPO and other stakeholders may use the resulting data to inform strategic planning and investment decisions, identify opportunities to accelerate the deployment of ITS, establish baseline deployment for newer ITS technology deployments, document shifts in ITS deployment patterns and ITS market evolution, and identify opportunities for knowledge transfer and technical assistance.

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Acronyms

Acronym	Meaning
AV	automated vehicle
BIL	Bipartisan Infrastructure Law
CCTV	closed-circuit television
CV	connected vehicle
DMS	dynamic message signs
DOT	Department of Transportation
ESS	Environmental Sensor Stations
HMI	Human Machine Interface
ICM	integrated corridor management
IIJA	Infrastructure Investment and Jobs Act
ITS	Intelligent Transportation Systems
ITS JPO	Intelligent Transportation Systems Joint Program Office
MPO	metropolitan planning organization
OBU	onboard unit
RSU	roadside unit
RWIS	Road Weather Information Systems
SME	subject matter expert
TMDD	Traffic Management Data Dictionary
TSMO	Transportation Systems Management and Operations
USDOT	United States Department of Transportation
WZDx	Work Zone Data Exchange

Executive Summary

Introduction

This report summarizes the **Freeway Management Survey** findings of the 2023 Intelligent Transportation Systems (ITS) Deployment Tracking Survey. The United States Department of Transportation's (USDOT) Intelligent Transportation Systems Joint Program Office (ITS JPO) administers these surveys to track ITS deployment. The mission of the ITS JPO is to lead collaborative and innovative research, development, and implementation of ITS to improve the safety and mobility of people and goods. The ITS JPO's ITS Deployment Evaluation Program administers the ITS Deployment Tracking Survey with assistance from USDOT's John A. Volpe National Transportation Systems Center (Volpe).

The ITS JPO has been administering the ITS Deployment Tracking Survey to a subset of large metropolitan areas in the United States since 1999. **With this most recent 2023 Deployment Tracking Survey, a new survey methodology was implemented, which greatly expanded the geographic coverage of the ITS Deployment Tracking Survey to include smaller urban [1] and rural areas in addition to large metropolitan areas.** The change in methodology reflects a need to (1) obtain a better understanding of ITS deployment nationwide and (2) obtain ITS deployment information from communities of all sizes, not just from large metropolitan areas.

The ITS JPO and other stakeholders may use the resulting data to inform strategic planning and investment decisions, identify opportunities to accelerate the deployment of ITS, establish baseline deployment for newer ITS technology deployments, document shifts in ITS deployment patterns and ITS market evolution, and identify opportunities for knowledge transfer and technical assistance.

Methodology: Freeway Management Survey

The 2023 Freeway Management Survey is a census of all State Department of Transportation (DOT) districts [2] and all toll authorities that manage freeways. With the change in survey methodology, the number of agencies receiving the freeway survey nearly tripled in 2023 compared to the 2020 survey.

A soft launch of the Freeway Management Survey occurred on October 3, 2023, with the full launch following on October 5, 2023. Survey invitations were sent to State DOT districts and toll authorities. The final number of eligible agencies included 400 State DOT districts and toll authorities.

[1] This term is used to refer to small metropolitan and micropolitan areas.

[2] A few State DOTs refer to their agencies as "regions" or "divisions" rather than districts. For ease of reporting and consistency, the term "district" is used throughout this report.

During survey administration, multiple reminder efforts were undertaken to encourage survey response, including several rounds of reminders by email and telephone. The survey closed on January 19, 2024, resulting in 311 completed Freeway Management Surveys and a response rate of 78 percent.

Of the 311 total completed Freeway Management Surveys, 98 State DOT districts and toll authorities had been part of the previous ITS Deployment Tracking Survey sample (i.e., in large metropolitan areas). In this report, these 98 State DOT districts and toll authorities are referred to as the "historically surveyed freeway management agencies." Trend analysis compares these agencies' responses in 2023 to responses from the previous 2020 and 2016 Deployment Tracking Surveys. Trend charts are shown for questions that are the same (or very similar) across the three survey years. Where trend data are available, these results are presented in Chapter 4.

Key Freeway Management Survey Findings

Use of ITS safety systems technologies, closed-circuit television (CCTV) for incident detection/verification, work zone ITS technologies, and ITS for road weather is widespread.

- Among all 2023 freeway management agency respondents, 76 percent deploy at least one ITS safety systems technology, and these agencies deploy an average of 2.8 safety systems technologies. The ITS safety systems technologies that are most widely deployed by freeway management agencies include:
  - *Queue warning systems* (40 percent)
  - *Wrong way driving detection systems* (33 percent)
  - O*ver-height warning systems* (24 percent)
  - V*ariable speed limits* (23 percent)
  - *Dynamic curve warning systems* (22 percent)

- Similarly, about three fourths of freeway management agencies deploy at least one work zone ITS technology (76 percent). Freeway management agencies who reported using at least one work zone ITS technology deploy an average of 4.9 work zone technologies. The most-deployed work zone ITS technologies reported in 2023 include:
  - *Portable dynamic message signs (DMS)* (70 percent), a new response category in 2023
  - *Portable dynamic speed feedback/speed radar trailers* (59 percent), a new response category in 2023
  - *Portable CCTV* (51 percent)
  - *Queue detection and alert systems* (41 percent)
  - *Travel time systems* (38 percent)
  - *Portable traffic monitoring devices* (35 percent)

- Notably, about one fifth of freeway management agencies reported *no ITS safety systems are deployed* (21 percent), and 23 percent reported *no work zone ITS.*

- A large majority of 2023 freeway management agency respondents use *CCTV* (85 percent) for incident detection/verification on freeways.

- Likewise, a high percentage of surveyed freeway management agencies uses *permanent (stationary)* (79 percent) ITS Road Weather Information Systems (RWIS)/Environmental Sensor Stations (ESS) to collect weather and road condition data, while just over one fourth use *mobile (vehicle mounted)* (28 percent) systems.

Roadside infrastructure and external data sources are both widely used on freeways, whereas adoption of vehicle probe technology is more limited.

- A large majority of responding freeway management agencies deploy at least one roadside ITS technology (87 percent), and these deployers are using an average of 2.3 roadside ITS technologies. The roadside ITS technologies that are most widely deployed by freeway management agencies include:
  - *Radar/microwave detection* (69 percent)
  - *Inductive loops* (57 percent)
  - *Video imaging detection* (44 percent)

- Nearly all responding freeway management agencies use at least one source of external data in support of freeway management (90 percent). The external data sources that are most used by freeway management agencies include:
  - *Publicly available mapping and traffic information apps* (70 percent)
  - *Notifications from the public via social media, email, text or phone* (61 percent)
  - *Purchased third-party commercial data* (60 percent)

- Vehicle probe readers are deployed by 44 percent of freeway management agency respondents. More than one fourth reported deploying *Bluetooth readers* (28 percent), while fewer deploy *license plate readers* (15 percent) or *toll tag readers* (14 percent).

Certain operational strategies used on freeways, such as ramp metering, integrated corridor management (ICM), and managed lanes have lower rates of adoption.

- About one fifth of responding freeway management agencies reported operating or deploying:
  - *Ramp metering* (19 percent)
  - *ICM* (19 percent)
  - *Managed lanes* (18 percent)

Multiple methods and ITS technologies are used to share real-time traveler information, with DMS, social media, and websites topping the list.

- Nearly all surveyed freeway management agencies disseminate real-time traveler information about freeways (97 percent), and these agencies are using an average of 4.9 different methods/technologies to do so. A majority of freeway management agencies use:
  - *DMS (permanent and/or portable)* (89 percent)
  - *Social media* (85 percent)
  - *Websites* (75 percent)
  - *511* (63 percent)
  - *Email or text/SMS alert*s (62 percent)

- A lower percentage of freeway management agencies uses the following technologies for real-time traveler information on freeways:
  - *Third-party mobile apps* (50 percent)
  - *Agency-branded mobile applications* (32 percent)
  - *Highway Advisory Radio (HAR)* (23 percent)

For freeway management agencies, fiber-optic cable and cellular LTE-4G are the leading telecommunications technologies enabling ITS.

- Of the surveyed wired technologies, a large majority of freeway management agencies reported using *fiber-optic cable* (79 percent) to enable their ITS. A lower percentage of agencies uses all other surveyed wired technologies, including:
  - *Twisted copper pair/twisted wired pair* (32 percent)
  - *Coaxial* (21 percent)
  - *Data cable over modem* (16 percent)
  - *Digital subscriber line* (16 percent)

- Of the surveyed wireless technologies, a large majority of freeway management agencies are using *cellular (LTE-4G)* (75 percent) to enable their ITS. The reported deployment of other wireless technologies was significantly lower, including:
  - *Microwave* (33 percent)
  - *5G New Radio and small cell infrastructure* (30 percent)
  - *Wi-Fi* (16 percent)
  - Eleven (11) percent or fewer freeway management agencies use any of the other surveyed wireless technologies to enable their ITS.

Emerging technologies, such as connected vehicle (CV) and automated vehicle (AV) technologies, have relatively low deployment levels; however, almost one third of freeway management agencies report plans to deploy CV technologies.

- Less than one fifth of responding freeway management agencies are *developing, testing, or deploying CV technology* (15 percent), and nearly twice as many reported *planning to deploy CV* (29 percent).

- With respect to AV testing, 4 percent of freeway management agencies reported *leading AV testing/deployment* in the last five years, while 15 percent reported *supporting the planning or execution of an AV test/deployment* during that same period.

Some freeway management agencies reported using the same ITS technologies to address multiple types of transportation challenges, and a different percentage of agencies use the technologies depending on the challenge.

- *Queue warning systems* are used by the highest percentage of freeway management agencies at work zones (41 percent) and for safety (40 percent). A lower percentage use them to manage adverse road weather impacts (17 percent).

- *Variable speed limits* are used by 23 percent of freeway management agencies for safety, by 21 percent of agencies at work zones, and by 19 percent to manage adverse road weather impacts.

- *DMS* deployment was reported by the highest percentage of freeway management agencies for real-time information dissemination (89 percent), while *DMS (portable and/or permanent)* is used by a similar percentage to manage adverse weather impacts (85 percent). Fewer freeway management agencies reported using *portable DMS* at work zones (70 percent).

For several ITS technologies, deployment tends to be higher among State DOT districts with at least one large urban area[3] compared to those without a large urban area.

- Significantly higher percentages of State DOT districts with a large urban area compared to those without a large urban area deploy *wrong way driving detection systems* (45 percent compared to 25 percent), *over-height warning systems* (34 percent compared to 17 percent), *dynamic curve warning systems* (29 percent compared to 18 percent), and *reference location signs* (15 percent compared to 6 percent).

- For incident detection or verification, *CCTV* is deployed by a significantly higher percentage of State DOT districts with a large urban area compared to those without a large urban area (94 percent compared to 79 percent).

- State DOT districts with a large urban area are significantly more likely than districts without a large urban area to be *currently developing, testing, or deploying connected vehicle (CV) technologies* (24 percent compared to 8 percent) and *planning for CV* (36 percent compared to 23 percent).

- *ICM deployment* is significantly higher in State DOT districts with a large urban area compared to districts without a large urban area (27 percent compared to 16 percent). A significantly higher percentage of State DOT districts with a large urban area also *plan to deploy ICM* compared to districts without a large urban area (39 percent compared to 19 percent).

Among historically surveyed freeway management agencies (i.e., agencies surveyed in previous ITS Deployment Tracking Surveys), ITS deployment continues to grow for a range of ITS technologies.

Among historically surveyed freeway management agencies, it is possible to assess trends in ITS deployment because these agencies were surveyed in previous ITS Deployment Tracking Surveys. The trend data show that for these historically surveyed State DOT districts and toll authorities in a subset of large metropolitan areas, there is statistically significant growth since 2020 in the deployment/use of a range of ITS technologies, including:

- **Work zone ITS technologies**: *variable speed limit signs* (from 16 percent in 2020 to 34 percent in 2023) and *dynamic lane merge systems* (from 10 percent in 2020 to 25 percent in 2023)

- **Incident detection and verification methods:** *CCTV* (from 90 percent in 2020 to 98 percent in 2023) and *external data* (from 40 percent in 2020 to 66 percent in 2023)

[3] For the purposes of subgroup analysis, a large urban area was defined as either a city with a population greater than 100,000 or a county with a population greater than 950,000.

- **External data sources:** *publicly available mapping and traffic information apps* (from 68 percent in 2020 to 83 percent in 2023) and *notifications from the public via social media, email, texts, and phone* (from 52 percent in 2020 to 68 percent in 2023)

- **Roadside ITS infrastructure:** *inductive loops* (from 42 percent in 2020 to 59 percent in 2023), *video imaging detection* (from 13 percent in 2020 to 40 percent in 2023), and *magnetometers* (from 9 percent in 2020 to 19 percent in 2023)

- **Vehicle probe readers:** *license plate readers* (from 4 percent in 2020 to 13 percent in 2023)

- **Telecommunication technologies:** *5G New Radio and small cell infrastructure* (from 19 percent in 2020 to 36 percent in 2023)

- **Traveler information:** *third-party mobile apps* (from 47 percent in 2020 to 63 percent in 2023)

The survey also found a significant decrease since 2020 in the use of a few ITS technologies among historically surveyed freeway management agencies, including decreases in the deployment/use of:

- *Reference location signs* (from 29 percent to 14 percent)
- *GPRS-2G or 3G* (from 27 percent to 9 percent)
- *Agency branded mobile applications* (from 54 percent to 38 percent)
- *HAR* (from 37 percent to 24 percent)

Conclusions

With the 2023 ITS Deployment Tracking Survey, the ITS JPO significantly expanded the geographic coverage of the Freeway Management Survey to include all State DOT districts and toll authorities that manage freeways, enabling the reporting of ITS deployment nationwide. **The survey finds that most surveyed freeway management agencies are deploying ITS.** A large majority of freeway management agencies have deployed at least one ITS safety systems technology, work zone ITS technology, roadside ITS infrastructure technology, or incident detection technology (i.e., CCTV).

In general, ITS deployment tends to be higher among State DOT districts that have at least one large urban area (either a city with 100,000 or more people or a county with 950,000 or more people) compared to State DOT districts without a large urban area.

Among historically surveyed freeway management agencies (i.e., agencies from a subset of large metropolitan areas), the trend data show increased deployment for a range of ITS between 2020 and 2023. With the next Deployment Tracking Survey, it will be possible to assess ITS trends for the entire sample.

Chapter 1. Introduction

Purpose of the Report

This report summarizes the **Freeway Management Survey** findings of the 2023 Intelligent Transportation Systems (ITS) Deployment Tracking Survey. The United States Department of Transportation's (USDOT) Intelligent Transportation Systems Joint Program Office (ITS JPO) administers these surveys to track ITS deployment. The mission of the ITS JPO is to lead collaborative and innovative research, development, and implementation of ITS to improve the safety and mobility of people and goods. The ITS JPO's ITS Deployment Evaluation Program administers the ITS Deployment Tracking Survey with assistance from USDOT's John A. Volpe National Transportation Systems Center (Volpe).

The ITS JPO has been administering the ITS Deployment Tracking Survey to a subset of large metropolitan areas in the United States since 1999. **With this most recent 2023 ITS Deployment Tracking Survey, a new survey methodology was implemented, which greatly expanded the geographic coverage of the ITS Deployment Tracking Survey to include smaller urban [4] and rural areas in addition to large metropolitan areas.** The change in methodology reflects a need to (1) obtain a better understanding of ITS deployment nationwide and (2) obtain ITS deployment information from communities of all sizes, not just from large metropolitan areas.

The ITS JPO and other stakeholders may use the resulting data to inform strategic planning and investment decisions, identify opportunities to accelerate the deployment of ITS, establish baseline deployment for newer ITS technology deployments, document shifts in ITS deployment patterns and ITS market evolution, and identify opportunities for knowledge transfer and technical assistance.

Background

Since 1999, the ITS JPO has used the ITS Deployment Tracking Survey to collect information about the extent of ITS deployment in a subset of large metropolitan areas across the United States. The surveys were, and continue to be, administered to State and local transportation agencies, including freeway, arterial, and transit management agencies. The ITS JPO initially developed the ITS Deployment Tracking Survey to track and manage progress made toward a ten-year ITS deployment goal announced by the U.S. Secretary of Transportation in 1996. [5] The Secretary's goal focused on tracking ITS deployment rates in large metropolitan areas. At the time, ITS was a relatively new set of technologies that tended to be deployed in large metropolitan areas to address congestion, safety, and other transportation issues experienced most acutely by the nation's largest cities. The surveys were conducted every 1-2 years during the initial ten-year goal measurement period.

[4] This term is used to refer to small metropolitan and micropolitan areas.

[5] U.S. Transportation Secretary Peña's goal stated that the 75 largest metropolitan areas should be outfitted with an integrated ITS infrastructure in the next ten years.

Following the ten-year goal period, which ended around 2007, the surveys were conducted less frequently, on a roughly 3-year cycle, and continued to monitor the deployment of ITS in a subset of large metropolitan areas across the country.

However, in the years following the goal period, it became clear that the ITS Deployment Tracking Survey no longer provided the most complete picture of the extent and nature of ITS deployment in the U.S. During this time, ITS technologies became more mainstream and, as such, were increasingly deployed outside of large metropolitan areas. The ITS JPO's Benefits, Costs, and Lessons Learned databases [6] showed an increasing number of examples of ITS deployments in smaller urban (i.e., small metropolitan and micropolitan) and rural areas.

The ITS JPO's 2019 **Small Urban and Rural Transit Provider Survey** further demonstrated the high rates of deployment of some ITS technologies among smaller urban and rural transit providers. [7] Based on these trends, the ITS JPO determined that an update to the survey methodology was necessary to address these important gaps in survey coverage to better reflect a full range of communities and situations where ITS technologies are deployed.

The ITS JPO's ITS Deployment Evaluation Program began initial investigations into the development of a new survey approach and methodology following the 2016 ITS Deployment Tracking Survey. At that time, the ITS Deployment Evaluation Program began exploring potential sampling approaches with input from stakeholders, subject matter experts (SMEs), and survey statisticians. In 2022, a **Pilot Survey** of State Departments of Transportation (DOT) and smaller urban and rural local arterial management agencies was conducted to test the new sampling approach. The **Pilot Survey** showed that smaller urban and rural local arterial management agencies were willing and able to participate in the ITS Deployment Tracking Survey.

The ITS JPO decided to execute its new survey methodology starting with the 2023 ITS Deployment Tracking Survey, thereby expanding its geographic coverage to include smaller urban and rural areas in addition to large metropolitan areas. The methodology for each survey type (Freeway Management, Arterial Management, Transit Management) is highlighted below:

- **Freeway Management Survey**
  - Surveys all State DOT districts and toll authorities that manage freeways. [8]
- **Arterial Management Survey (two distinct populations)**
  - **Arterial State DOT Survey**: surveys all State DOT districts that manage arterials.
  - **Arterial Local Survey:** surveys a random sample of places and counties of varying population sizes (i.e., local agencies across metropolitan, micropolitan and rural areas) that manage arterial roads.

[6] For more information about the ITS Benefits, Costs, and Lessons Learned Databases, see: https://www.itskrs.its.dot.gov/.

[7] See: https://www.itskrs.its.dot.gov/deployment/othersurveys_surta_2019.

[8] Detailed information about the Freeway Survey methodology can be found in Chapter 2. For detailed information about the survey methodology for the Arterial State DOT, Arterial Local, and Transit Surveys, please see each of the respective reports (see: https://www.itskrs.its.dot.gov/deployment/2023DTS).

- **Transit Management Survey**
  - Surveys a random sample of transit agencies across large urban, small urban and rural areas from the National Transit Database. [9]

In addition to providing more comprehensive data about the extent of ITS deployment nationwide, the new ITS Deployment Tracking Survey methodology positions the ITS JPO to also baseline and, over time, track the growing pipeline of ITS projects that are currently being (and will be) deployed as a result of the Infrastructure Investment and Jobs Act (IIJA), also known as the Bipartisan Infrastructure Law (BIL). [10] Grant programs established under the BIL provide numerous funding opportunities for a wide variety of projects in communities of all sizes and location types. Several of the BIL grant programs offer opportunities to fund ITS deployments to help communities solve transportation challenges.

[9] The NTD is a legislative requirement (see Title 49 U.S.C. 5335(a)). This statute requires that recipients or beneficiaries of grants from the Federal Transit Administration (FTA) under the Urbanized Area Formula Program (§5307) or Other than Urbanized Area (Rural) Formula Program (§5311) submit data to the NTD. See: https://www.transit.dot.gov/ntd.

[10] See: https://www.transportation.gov/bipartisan-infrastructure-law.

Chapter 2. Methodology

This chapter describes the process for implementing the new ITS Deployment Tracking Survey methodology for the Freeway Management Survey.

Sample Development

The Freeway Management Survey uses a census sampling approach, surveying all State DOT districts and toll authorities that manage freeways (i.e., controlled access roadways [11]). Historically, from 1999 to 2020, the Deployment Tracking Survey surveyed State DOT districts and toll authorities in a subset of large metropolitan areas. With the expansion in 2023 from this sample to a full census of freeway management agencies, the ITS JPO nearly tripled the number of agencies receiving the Freeway Management Survey from about 140 to more than 400 State DOT districts and toll authorities.

Contact Development

Following the enumeration of all State DOT districts and toll authorities, the survey team identified a survey contact for each agency. This process involved online research to find an appropriate point of contact, such as a district engineer or ITS engineer, as well as the collection of other relevant information (e.g., whether the agency appeared to manage ITS).

Using the contact information available (either a specific contact or general agency phone number or email), the survey team reached out to every agency via email to describe the survey's purpose and agency eligibility criteria (i.e., agency must manage freeways to be within the survey population) and to confirm the contact's suitability to respond to the survey. Those that did not respond to the initial email received up to four phone calls coupled with follow-up emails to identify a suitable point of contact.

Table 1 shows the results of the contact confirmation process for the 417 originally identified freeway management agencies. The survey team sent a survey to every eligible agency with contact information, including confirmed and unconfirmed contacts. Agencies with unknown contact information could not be sent a survey. [12] Agencies could indicate "do not contact" to the survey team during contact confirmation, but no freeway management agencies made this request. Ineligible agencies (i.e., agencies that do not manage freeways and are therefore outside of the survey population) were removed from the sample.

[11] Freeways are controlled access roads, such as interstates and other freeways and expressways (i.e., functional classifications 1 and 2 per the Federal Highway Administration's Highway Functional Classification). https://www.fhwa.dot.gov/planning/processes/statewide/related/highway_functional_classifications/section00.cfm.

[12] For the purposes of calculating response rates, however, these respondents were still deemed eligible and included in the sample, as the survey team did not have enough information to classify them as ineligible.

In total, the eligible sample for the Freeway Management Survey following contact confirmation was 410, but since the contact information for one agency was unknown, the freeway survey was sent to 409 freeway management agencies (first two rows shown in Table 1).

Table 1. Summary of Freeway Management Agency Contact Confirmation

Sample Disposition (original sample=417)	Count
Points of Contact Confirmed	377
Unconfirmed, but Contact Information on File	32
Unknown Contact Information	1
Do Not Contact	0
Ineligible	7

Source: USDOT

Data Collection and Processing

Survey Questionnaire

Key topics covered by the 2023 Freeway Management Survey include safety related ITS technologies, incident detection and verification, real-time data collection, telecommunications, connected vehicles, automated vehicles, traffic management, traveler information, Regional (or State) ITS Architecture, agency coordination, ITS cybersecurity, and future deployment planning.

The 2023 Freeway Management Survey is a modified version of the 2020 survey. One key change between 2020 and 2023 is that the questions about ITS coverage (e.g., number of freeway miles covered by X technology) were either transformed into an adoption question (i.e., whether the agency has adopted X technology) or were eliminated (if an adoption question already existed) due to their high respondent burden and data reliability issues. Another key change from the 2020 survey to the 2023 survey was the addition of several new questions on connected vehicles and automated vehicles, as these emerging technologies had not been asked in an ITS JPO survey effort since 2019. [13]

Other substantive changes to the questionnaire were largely driven by the input of SMEs. In addition, minor modifications were made to some questions to improve clarity. New response options were also added to some questions, based on either common respondent input to open-ended responses ("Other") in the 2020 survey, or the need to include ITS technologies thought to be relevant to smaller urban or rural areas (e.g., wildlife crossing warning systems). Another noteworthy change is the increased use of definitions (via "hover boxes") for ITS technologies and other terms to assist respondents in filling out the survey. The full questionnaire with new questions identified is shown in Appendix C.

[13] See: https://www.itskrs.its.dot.gov/deployment/othersurveys_surta_2019.

Respondent Dashboard

An online personalized dashboard (see Figure 1) was developed to administer the ITS Deployment Tracking Survey to each respondent. The online dashboard provided details on the survey effort, including information about the survey sponsor, frequently asked questions, and the survey contractor's privacy policy. The online dashboard also allowed respondents to download a PDF version of the survey questionnaire(s) and included unique links to access their survey(s). Some individual respondents were assigned two or more surveys, as they represented multiple State DOT districts and/or more than one type of survey (e.g., freeway and arterial). If respondents exited the survey prior to completion, responses to any completed questions were saved and were accessible by respondents if they returned to the survey.

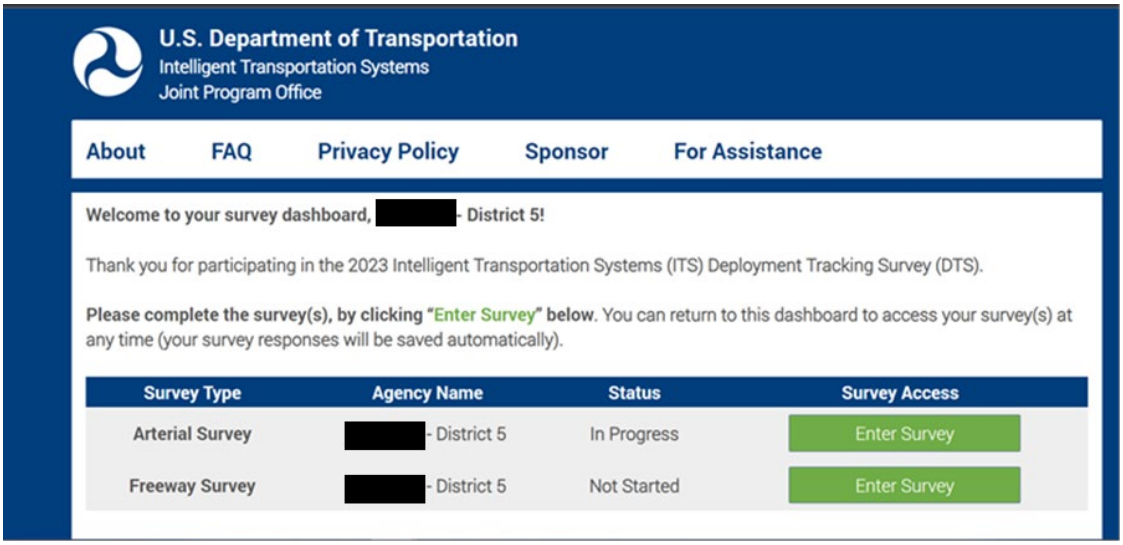


Figure 1. Example Personalized Survey Dashboard

Survey Administration

To test the functionality of the survey process, including the online survey instruments and dashboard, the survey invitation was sent to a small subset of freeway, arterial, and transit agencies (i.e., soft launch) on October 3, 2023, prior to the full launch of the Deployment Tracking Survey. The full launch occurred on October 5, 2023. In total, the Freeway Survey was sent to 409 agencies. While the survey was in the field, it was further determined that nine agencies were ineligible, either because there were no freeways in their districts, or they did not manage freeways. At the conclusion of survey administration, the final eligible sample included 400 freeway management agencies.

Multiple reminder efforts were undertaken to encourage survey response. Two rounds of reminder emails were sent in October 2023. Following these reminders, those who had not yet completed their assigned survey(s) were contacted by phone up to three more times in November and December of 2023. Telephone reminders also included a voicemail left for contacts who could not be reached by phone. Telephone reminders were also followed by an email to contacts. Additional telephone calls with email reminders were sent in mid-December targeting under-represented geographic areas. In early January 2024, emails were also sent to respondents whose surveys were "in progress," encouraging respondents to complete their survey.

The survey was closed on January 19, 2024. Of the 400 eligible freeway management agencies, there were 311 completed Freeway Management Surveys for a **response rate of 78 percent**.

Data Cleaning and Weighting

The survey data went through an extensive review and cleaning process, and open-ended responses were reviewed and coded into existing response categories as needed. The survey team consulted with USDOT SMEs to ensure that write-in responses were accurately recoded if appropriate.

The Freeway Management Survey did not require any data weighting; design weights were not applicable because the survey was a census, and non-response weighting was not needed due to high response rates (i.e., there was no significant non-response bias).

Chapter 3. Freeway Management Survey Findings

This chapter provides the results of the 2023 Freeway Management Survey, which was distributed to State DOT districts and toll authorities that manage freeways.

Overview of Responding Agencies

The responding agencies comprise State DOT districts (88 percent) and toll authorities (12 percent). This sample distribution resembles the overall population of freeway management agencies. Since State DOT districts cut across statistical areas (i.e., they typically include metropolitan, micropolitan, and rural areas), it is not possible to categorize State DOT districts by statistical area. However, the survey team could separate out the State DOT districts into two distinct groups: State DOT districts with at least one large urban area (defined as places [14] with populations greater than 100,000 or counties with populations greater than 950,000) and those without a large urban area, as shown in Table 2.

More than one third (38 percent) of responding State DOT districts have at least one large urban area, and 50 percent do not. The remaining 12 percent of respondents represent toll authorities.

Table 2. Breakdown of Respondent Groups

Group	Percent	N
State DOT districts with a large urban area	38%	119
State DOT districts without a large urban area	50%	154
Toll authorities	12%	38

Source: USDOT

Reporting Notes

This chapter is organized by ITS technologies and topics. In each section, findings are presented for all 2023 Freeway Management Survey respondents (i.e., a total of 311 respondents), where applicable. In some cases, percentages presented are based on a subset of respondents who received the question due to skip logic [15] in the survey. The 2023 survey question number and number of respondents for each question are referenced at the bottom of each figure (e.g., n=311). In some cases, respondents chose not

[14] For the purposes of reporting, "place" is used to describe all incorporated areas, such as cities, towns, villages, townships, and boroughs.

[15] Skip logic is survey programming that automatically skips respondents past one or more questions based on their response to a previous question. For example, if an agency did not indicate purchasing external data, they would skip out of the question that asks about how they use purchased external data.

to respond to a question. These non-responses are referred to as "missing" responses and are identified either in the figure or at the bottom of the figure.

Subgroup findings are presented where applicable. These analyses highlight significant differences, including differences based on:

- **Agency type**: State DOT districts compared to toll authorities
- **Population groups**: State DOT districts with at least one large urban area compared to State DOT districts without any large urban area

In comparing differences across subgroups, significance testing was performed at a significance level of 0.05, with a 95 percent confidence interval.

Safety-Related ITS Technologies

Safety-related ITS technologies include:

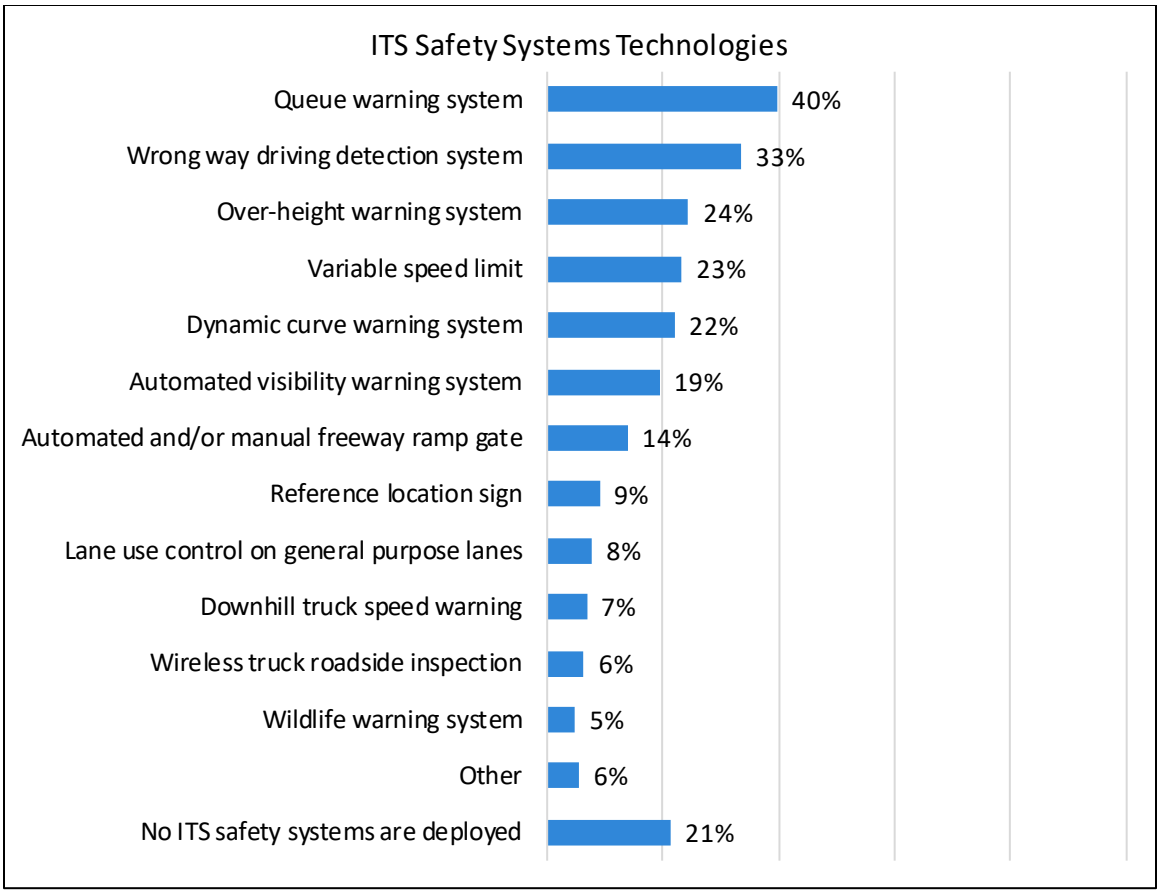
- ITS Safety systems technologies
- Work zone ITS technologies
- ITS for road weather management
- Automated enforcement technologies
- Incident detection and verification methods

ITS Safety Systems Technologies

Among all 2023 freeway management agency respondents, 76 percent reported deploying at least one ITS safety systems technology. Freeway management agencies deploying ITS safety systems used an average of 2.8 technologies.

Figure 2 shows *queue warning systems* (40 percent) are the most deployed ITS safety systems by freeway management agencies. *Wrong way driving detection systems* (33 percent) are deployed by one third of freeway management agencies, while nearly one fourth deploy *over-height warning systems (e.g., bridge, tunnel, gantries)* (24 percent), *variable speed limits* (23 percent), and *dynamic curve warning systems* (22 percent).

ITS safety systems deployed by nearly one fifth of surveyed freeway management agencies include *automated visibility warning systems* (19 percent), a new response category in 2023, and *automated and/or manual freeway ramp gates* (14 percent). Fewer than 10 percent of freeway management agencies deploy *reference location signs*, *lane use control on general purpose lanes*, *downhill truck speed warnings*, *wireless truck roadside inspections*, and *wildlife warning systems*, also a new response category in 2023. About one fifth of responding freeway management agencies reported *no ITS safety systems are deployed* (21 percent).



2023 Q13; (n=311; 3% missing) *Source: USDOT*

Figure 2. ITS Safety Systems Technologies

Table 3 shows that significantly higher percentages of State DOT districts with a large urban area compared to those without a large urban area deploy *wrong way driving detection systems* (45 percent compared to 25 percent), *over-height warning systems* (34 percent compared to 17 percent), *dynamic curve warning systems* (29 percent compared to 18 percent), and *reference location signs* (15 percent compared to 6 percent).

By contrast, State DOT districts without a large urban area were significantly more likely to report *no ITS safety systems are deployed* compared to those with a large urban area (24 percent compared to 14 percent).

Table 3. ITS Safety Systems Technologies: Significant Differences Between District Population Groups

Technology	State DOT Districts with a Large Urban Area (n=119)	State DOT Districts without a Large Urban Area (n=154)
Wrong way driving detection system	45%	25%
Over-height warning system	34%	17%
Dynamic curve warning system	29%	18%
Reference location sign	15%	6%
No ITS safety systems are deployed	14%	24%

Source: USDOT

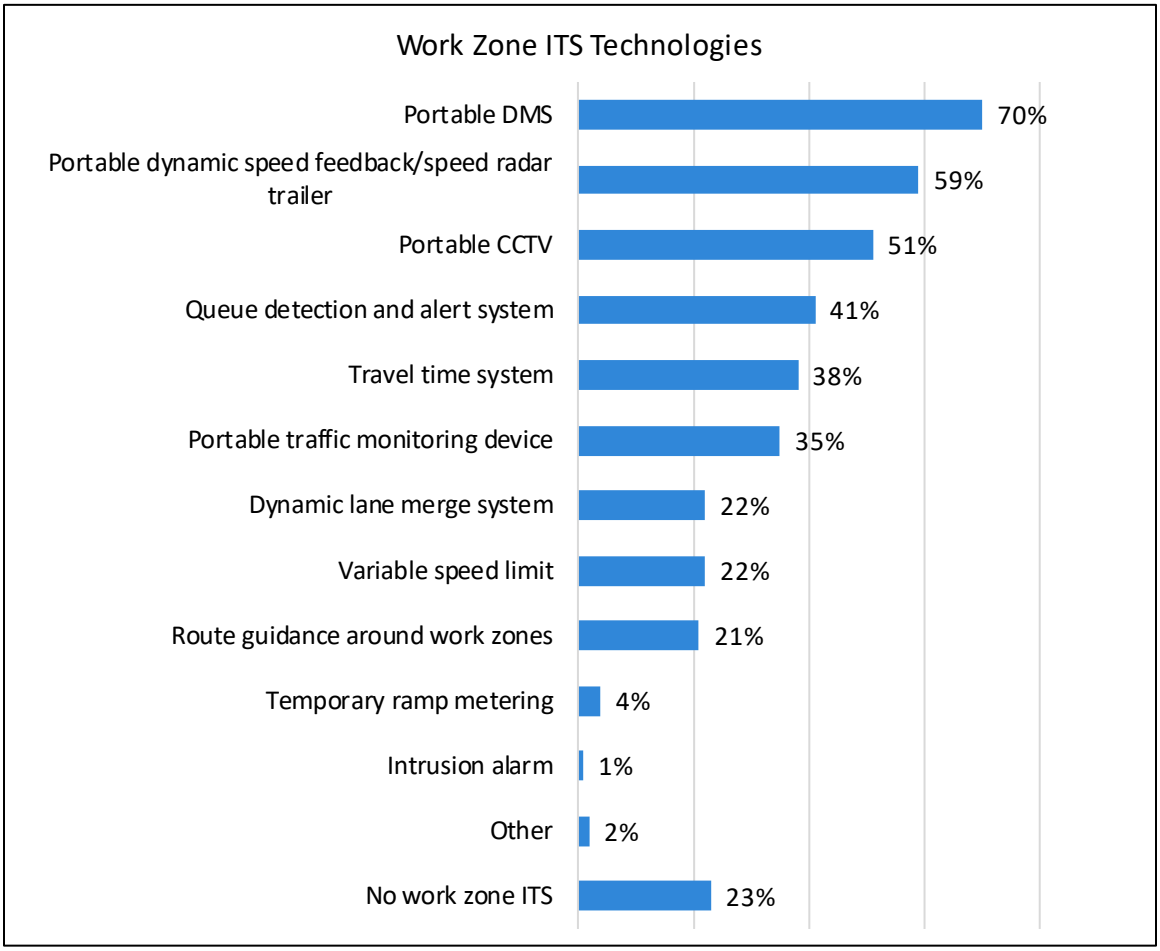
Work Zone ITS Technologies

Among all 2023 freeway management agency respondents, 76 percent reported deploying at least one work zone ITS technology. In a follow up question, respondents were asked to report on the specific work zone ITS technologies they use. Freeway management agency respondents who reported using any work zone ITS deploy an average of 4.9 technologies.

There were two new response categories in 2023—*portable dynamic message signs (DMS)* and *portable dynamic speed feedback/speed radar trailers*—which had been common write-in responses to the *Other* response option in the 2020 Deployment Tracking Survey. Figure 3 shows that these technologies are the most deployed work zone ITS technologies in 2023. Almost three fourths of freeway management agencies deploy *portable DMS* (70 percent), while 59 percent deploy *portable dynamic speed feedback/speed radar trailers*.

About half of freeway management agencies deploy *portable closed-circuit television (CCTV)* (51 percent), while fewer deploy *queue detection and alert systems* (41 percent), *travel time systems* (38 percent), and *portable traffic monitoring devices* (35 percent).

Dynamic lane merge systems (22 percent), *variable speed limits* (22 percent), and *route guidance around work zones* (21 percent) are each deployed by about one fifth of freeway management agencies. *Temporary ramp metering* and *intrusion alarms* are each deployed by fewer than 5 percent of freeway management agencies. About one fourth of freeway management agencies reported *no work zone ITS* (23 percent).



2023 Q17, Q18; (n=311; 1% missing) *Source: USDOT*

Figure 3. Work Zone ITS Technologies

As shown in Table 4, State DOT districts are significantly more likely to deploy various work zone ITS technologies compared to toll authorities, including *portable DMS* (73 percent compared to 45 percent), *portable dynamic speed feedback/speed radar trailers* (64 percent compared to 21 percent), *portable CCTV* (55 percent compared to 21 percent), *queue detection and alert systems* (45 percent compared to 13 percent), *travel time systems* (42 percent compared to 11 percent), *portable traffic monitoring devices* (40 percent compared to 5 percent), and *route guidance around work zones* (23 percent compared to 3 percent).

Toll authorities are significantly more likely than State DOT districts to report *no work zone ITS* (53 percent compared to 19 percent).

Table 4. Work Zone Technologies: Significant Differences Between Agency Types

Technology	State DOT Districts (n=273)	Toll Authorities (n=38)
Portable DMS	73%	45%
Portable dynamic speed feedback/speed radar trailer	64%	21%
Portable CCTV	55%	21%
Queue detection and alert system	45%	13%
Travel time system	42%	11%
Portable traffic monitoring device	40%	5%
Route guidance around work zones	23%	3%
No work zone ITS	19%	53%

Source: USDOT

ITS for Road Weather Management

The survey included a question on the different types (permanent, mobile, or transportable) of Road Weather Information Systems (RWIS)/Environmental Sensor Stations (ESS) deployed by freeway management agencies. Among all freeway management agency respondents, 80 percent reported using one or more types of RWIS/ESS.

Figure 4 shows a large majority of freeway management agencies use *permanent (stationary)* systems (79 percent), and more than one fourth use *mobile (vehicle mounted)* systems (28 percent). Use of *transportable (temporary use)* systems was reported by only 1 percent of freeway management agencies. Nearly one fifth of surveyed freeway management agencies reported *no ITS (RWIS/ESS) are deployed to collect weather and road condition data* (19 percent).

State DOT districts are significantly more likely to deploy ITS technologies for road weather management than toll authorities (82 percent compared to 63 percent).

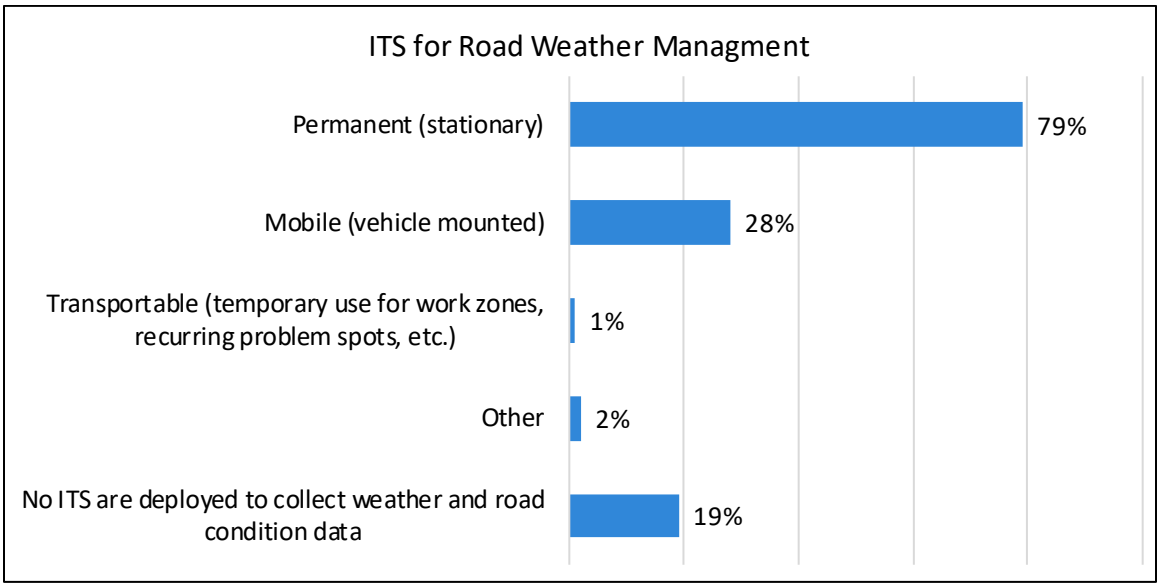


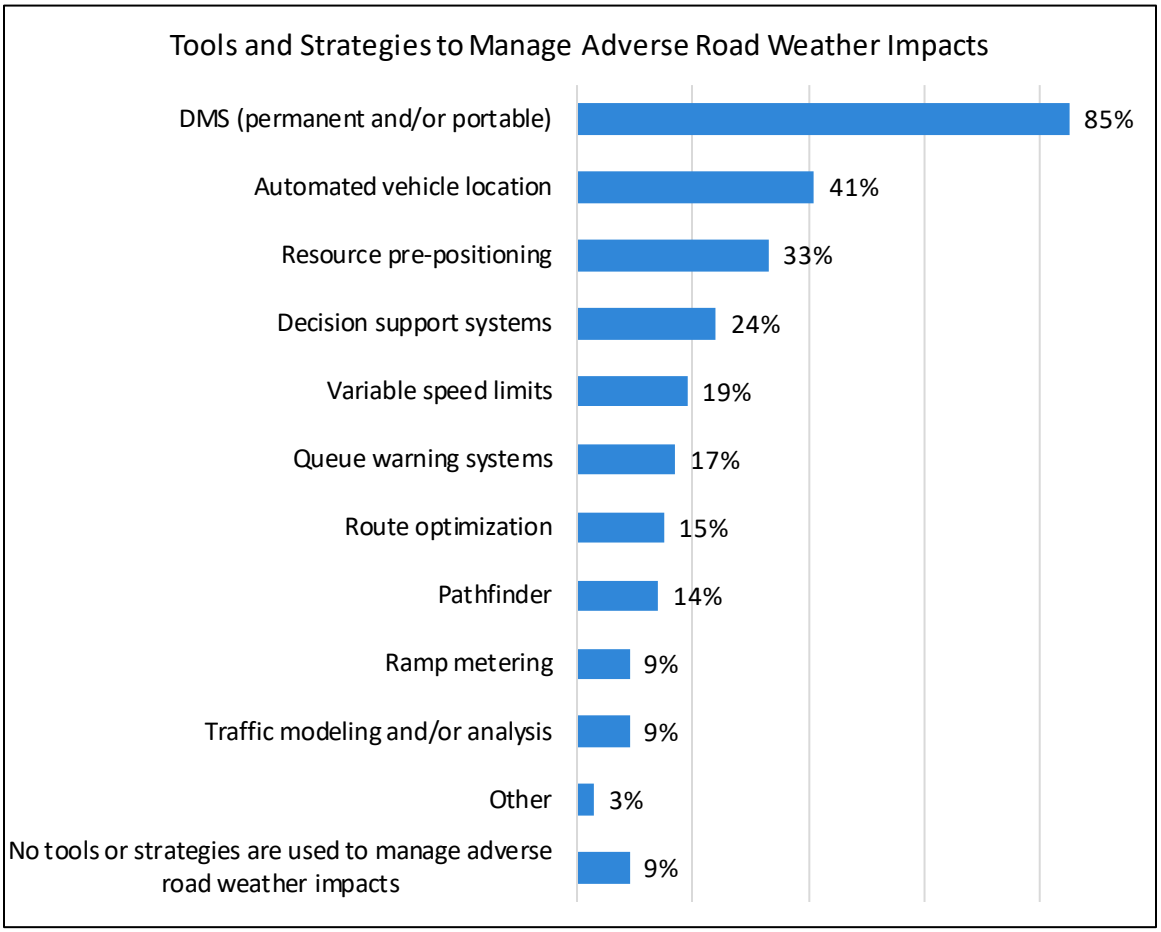
Figure 4. ITS for Road Weather Management

For the first time in 2023, the ITS Deployment Tracking Survey included a question asking all surveyed freeway management agencies which tools and strategies their agencies use to manage adverse road weather impacts.

Nearly all freeway management agencies reported using at least one tool or strategy to manage adverse road weather impacts (90 percent), and among the freeway management agencies using tools or strategies, they reported using an average of 3.0 tools or strategies (out of 11 response categories).

Figure 5 shows that most freeway management agency respondents use *DMS (permanent and/or portable)* (85 percent) to manage adverse road weather impacts. Less than half of freeway management agencies use *automated vehicle location* (41 percent), *resource pre-positioning* (33 percent) and *decision support systems* (24 percent).

Less than one fifth use *variable speed limits* (19 percent), *queue warning systems* (17 percent), *route optimization* (15 percent), and *Pathfinder*[16] (14 percent). *Ramp metering* and *traffic modeling and/or analysis* were each reported by fewer than 10 percent of freeway management agencies to manage adverse weather impacts. Nine (9) percent of freeway management agencies reported *no tools or strategies are used to manage adverse road weather impacts*.



2023 Q15; (n=311; 0.3% missing) *Source: USDOT*

Figure 5. Tools and Strategies to Manage Adverse Road Weather Impacts

[16] Pathfinder is a collaborative strategy for proactive transportation system management ahead of and during adverse weather events and encourages State DOTs, National Weather Service, and weather service contractors to share and translate weather forecasts and road conditions into consistent transportation impact messages for the public. For more information, see: https://ops.fhwa.dot.gov/publications/fhwahop18034/index.htm.

The only tool or strategy used by a significantly higher percentage State DOT districts with a large urban area than districts without a large urban area is *ramp metering* (18 percent compared to 5 percent).

Table 5 shows that State DOT districts were significantly more likely than toll authorities to report managing adverse road weather impacts with various tools and strategies, including *automated vehicle location* (44 percent compared to 18 percent), *Pathfinder* (16 percent compared to 3 percent), and *ramp metering* (11 percent compared to 0 percent).

Toll authorities, compared to State DOT districts, were significantly more likely to report *no tools or strategies are used to manage adverse road weather impacts* (21 percent compared to 8 percent).

Table 5. Tools and Strategies to Manage Adverse Road Weather Impacts: Significant Differences Between Agency Types

Technology	State DOT Districts (n=273)	Toll Authorities (n=38)
Automated vehicle location	44%	18%
Pathfinder	16%	3%
Ramp metering	11%	0%
No tools or strategies are used to manage adverse road weather impacts	8%	21%

Source: USDOT

Automated Enforcement

In 2023, 17 percent of all surveyed freeway management agencies reported deploying at least one automated enforcement technology.

Figure 6 shows that among the 54 freeway management agencies deploying automated enforcement technologies, about three fourths use *radar* (78 percent), *cameras* (76 percent), and *license plate recognition* (70 percent). *Toll tag readers* are used by 17 percent of freeway management agencies deploying automated enforcement.

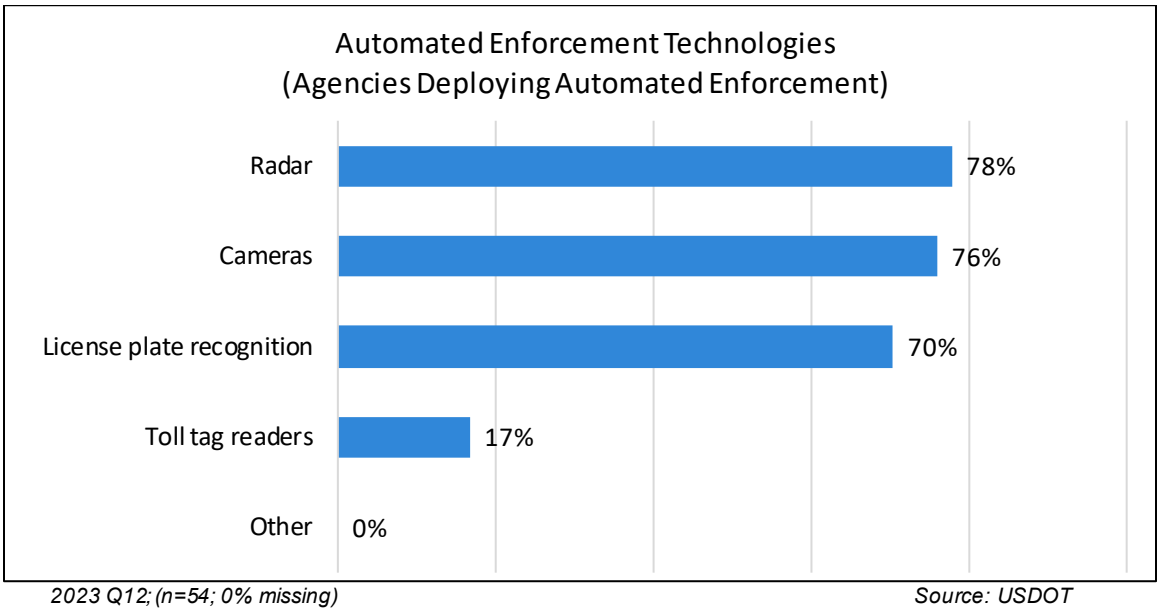
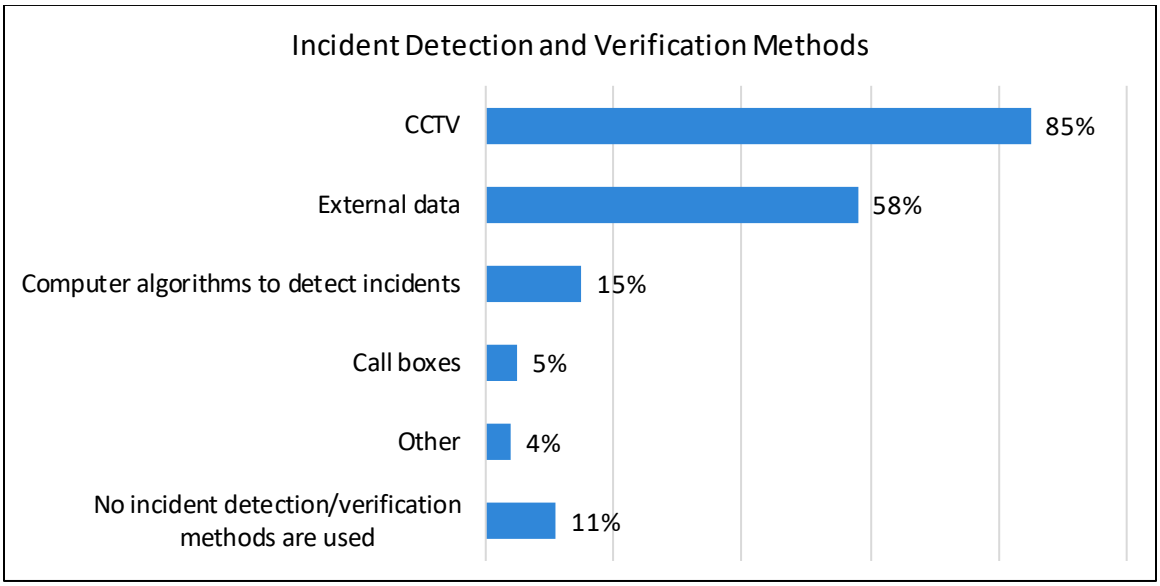


Figure 6. Automated Enforcement Technologies (Agencies Deploying Automated Enforcement)

Incident Detection and Verification

A large majority of freeway management agency respondents use at least one incident detection or verification method (88 percent).

Figure 7 shows that a large majority of freeway management agencies reported using *CCTV* (85 percent), and over half use *external data (e.g., data provided by crowdsourcing, commercial providers, or citizen-reported)* (58 percent) for incident detection or verification. Substantially fewer agencies use *computer algorithms to detect incidents* (15 percent) and *call boxes* (5 percent). Eleven (11) percent of agencies reported *no incident detection/verification methods are used*.



2023 Q16; (n=311; 1% missing) *Source: USDOT*

Figure 7. Incident Detection and Verification Methods

As shown in Table 6, *CCTV* is deployed by a significantly higher percentage of State DOT districts with a large urban area compared to State DOT districts without a large urban area (94 percent compared to 79 percent). State DOT districts with a large urban area were significantly less likely than State DOT districts without a large urban area to report *no incident detection/verification methods are used* (4 percent compared to 16 percent).

Table 6. Incident Detection and Verification Methods: Significant Differences Between State DOT District Population Groups

Technology	State DOT Districts with a Large Urban Area (n=119)	State DOT Districts without a Large Urban Area (n=154)
CCTV	94%	79%
No incident detection/verification methods are used	4%	16%

Source: USDOT

Real-Time Data Collection

Real-time data collection includes:

- Roadside ITS infrastructure technologies
- Vehicle probe readers
- External data sources

Roadside ITS Infrastructure

A large majority of all freeway management agency respondents deploy at least one roadside ITS infrastructure technology (87 percent). Among these deploying freeway management agencies, an average of 2.3 different roadside ITS technologies are deployed.

As shown in Figure 8, about two thirds of responding freeway management agencies deploy *radar/microwave detection* (69 percent), over half deploy *inductive loops* (57 percent), and nearly half deploy *video imaging detection* (44 percent). *Infrared/thermal detection*, a new response category in 2023, and *magnetometers* are each deployed by fewer than 20 percent of agencies. Eleven (11) percent of freeway management agencies reported *no roadside infrastructure technologies are deployed*.

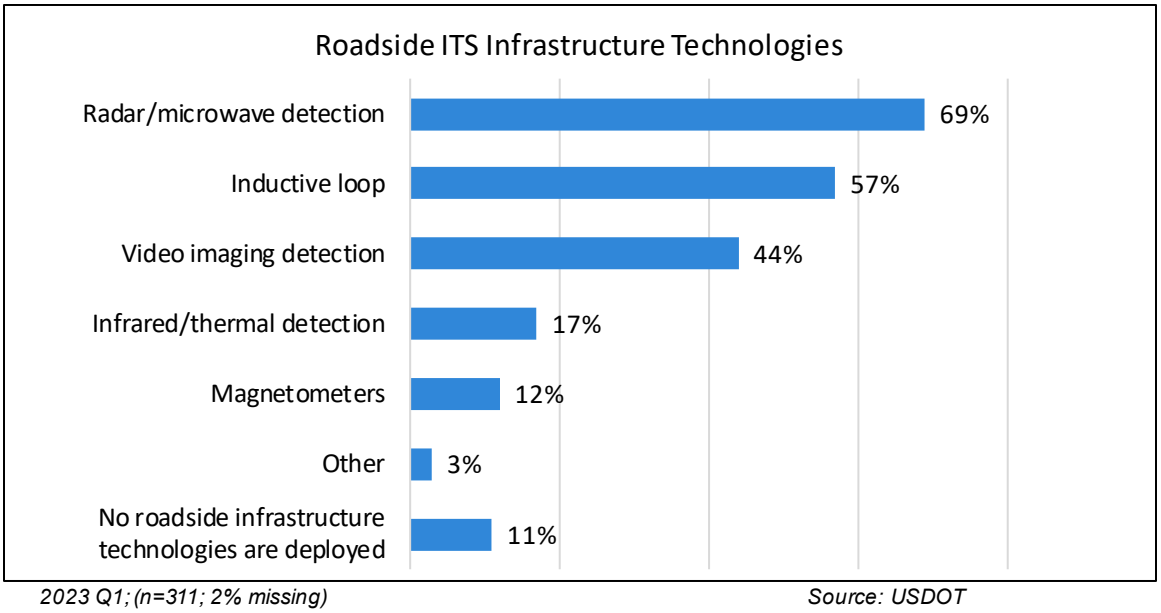


Figure 8. Roadside ITS Infrastructure Technologies

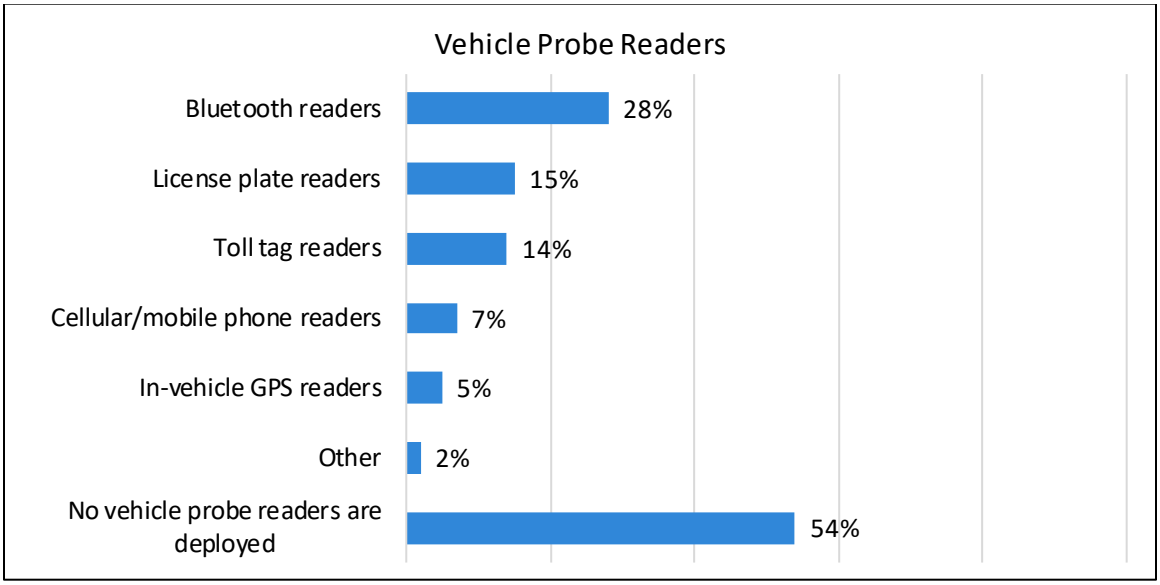
Radar/microwave detection is deployed by a significantly higher percentage of State DOT districts with a large urban area compared to State DOT districts without a large urban area (82 percent compared to 65 percent).

State DOT districts are significantly more likely than toll authorities to deploy *radar/microwave detection* (72 percent compared to 45 percent).

Vehicle Probe Readers

Vehicle probe readers are deployed by 44 percent of all freeway management agency respondents. Freeway management agencies deploying vehicle probe readers use an average of 1.6 different types of readers.

As shown in Figure 9, *Bluetooth readers* (28 percent) were the most reported vehicle probe readers followed by *license plate readers* (15 percent) and *toll tag readers* (14 percent). *Cellular/mobile phone readers* and *in-vehicle GPS readers* are each deployed by fewer than 10 percent of freeway management agencies. A majority of freeway management agencies reported *no vehicle probe readers are deployed* (54 percent).



2023 Q2; (n=311; 2% missing) *Source: USDOT*

Figure 9. Vehicle Probe Readers

As shown in Table 7, toll authorities are significantly more likely than State DOT districts to use *toll tag readers* (66 percent compared to 7 percent) and *license plate readers* (58 percent compared to 9 percent). By contrast, State DOT districts were significantly more likely than toll authorities to report *no vehicle probe readers are deployed* (59 percent compare to 16 percent). The greater use of vehicle probe technology among toll authorities is likely due, in part, to the use of vehicle probe readers in toll collection.

Table 7. Vehicle Probe Reader: Significant Differences Between Agency Types

Technology	State DOT Districts (n=273)	Toll Authorities (n=38)
Toll tag readers	7%	66%
License plate readers	9%	58%
No vehicle probe readers are deployed	59%	16%

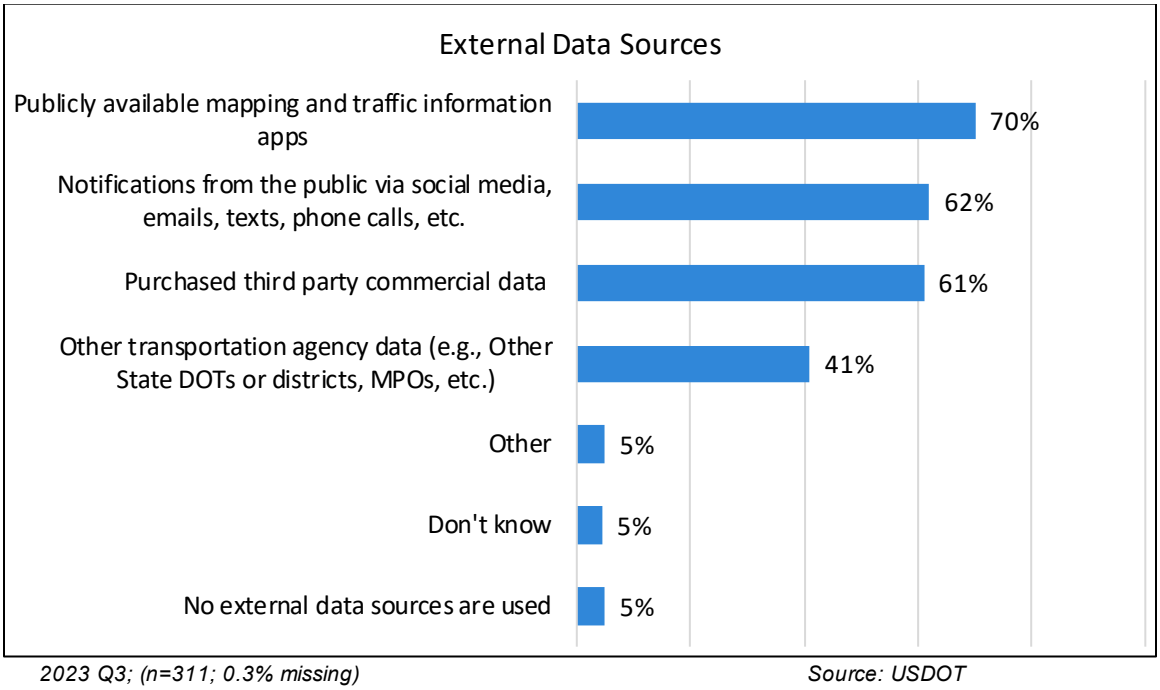
Source: USDOT

External Data Sources

Almost all freeway management agency respondents use at least one source of external data (90 percent) for freeway management.

As shown in Figure 10, a majority of freeway management agency respondents reported using *publicly available mapping and traffic information apps* (70 percent), *notifications from the public via social media, emails, texts, phone calls, etc.* (62 percent), and *purchased third-party commercial data* (61 percent).

Less than half of respondents reported using *other transportation agency data (e.g., other State DOTs or districts, MPOs, etc.)* [17] (41 percent), a new response category in 2023. Five (5) percent of freeway management agencies reported *no external data sources are used.*



2023 Q3; (n=311; 0.3% missing) *Source: USDOT*

Figure 10. External Data Sources

[17] Metropolitan planning organization (MPO).

Table 8 shows State DOT districts, compared to toll authorities, are significantly more likely to use *publicly available mapping and traffic information apps* (73 percent compared to 45 percent) and *purchased third-party commercial data* (65 percent compared to 32 percent). Toll authorities are significantly more likely than State DOT districts to use *other transportation agency data* (58 percent compared to 39 percent).

Table 8. External Data Sources: Significant Differences Between Agency Types

Source	State DOT Districts (n=273)	Toll Authorities (n=38)
Publicly available mapping and traffic information apps	73%	45%
Purchased third-party commercial data	65%	32%
Other transportation agency data	39%	58%

Source: USDOT

State DOT districts with a large urban area are significantly more likely than those without a large urban area to use *publicly available mapping and traffic information apps* (82 percent compared to 67 percent) and to have *purchased third-party commercial data* (79 percent compared to 54 percent), as shown in Table 9.

Table 9. External Data Sources: Significant Differences Between State DOT District Population Groups

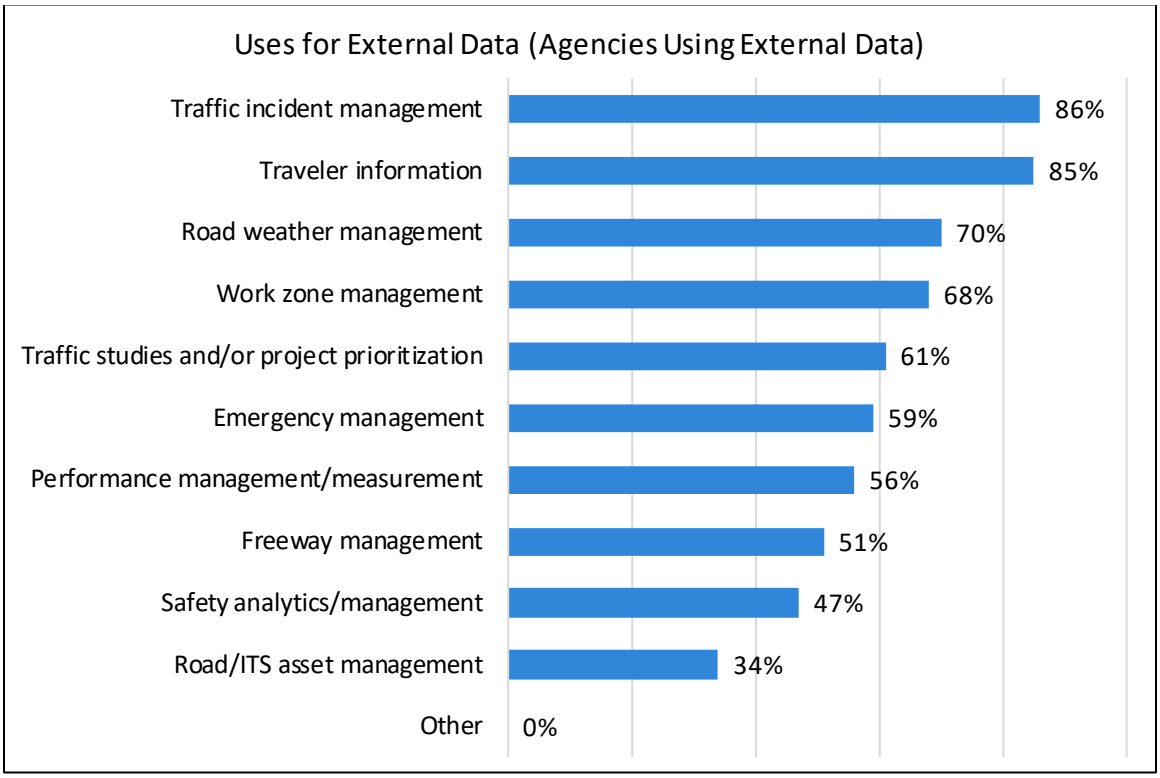
Source	State DOT Districts with a Large Urban Area (n=119)	State DOT Districts without a Large Urban Area (n=154)
Publicly available mapping and traffic information apps	82%	67%
Purchased third-party commercial data	79%	54%

Source: USDOT

The 2023 ITS Deployment Tracking Survey included a new question about how external data are being used, which was asked of freeway management agencies that reported using external data. Freeway management agencies using external data reported an average of 6.2 different uses for external data.

As shown in Figure 11, a large majority of the 280 freeway management agencies using external data use it for *traffic incident management* (86 percent) and *traveler information* (85 percent). Nearly three fourths reported using external data for *road weather management* (70 percent), and about two thirds reported using external data for *work zone management* (68 percent).

More than half of freeway management agencies reported using external data for *traffic studies and/or project prioritization* (61 percent), *emergency management* (59 percent), *performance management/measurement* (56 percent), and *freeway management* (51 percent). Nearly half of freeway management agencies reported using external data for *safety analytics/management* (47 percent), while *road/ITS asset management* (34 percent) was reported by nearly one third of freeway management agencies.



2023 Q4; (n=280; 0.4% missing) *Source: USDOT*

Figure 11. Uses for External Data (Agencies Using External Data)

As shown in Table 10, State DOT districts using external data are significantly more likely than toll authorities using external data to report using external data for *traveler information* (87 percent compared to 72 percent) and *performance measurement/management* (60 percent compared to 31 percent).

Table 10. Uses for External Data (Agencies Using External Data): Significant Differences Between Agency Types

Use	State DOT Districts (n=248)	Toll Authorities (n=32)
Traveler information	87%	72%
Performance measurement/ management	60%	31%

Source: USDOT

As shown in Table 11, State DOT districts with a large urban area using external data are significantly more likely than those without a large urban area to use external data for *freeway management* (60 percent compared to 44 percent) and *performance measurement/management* (67 percent compared to 53 percent).

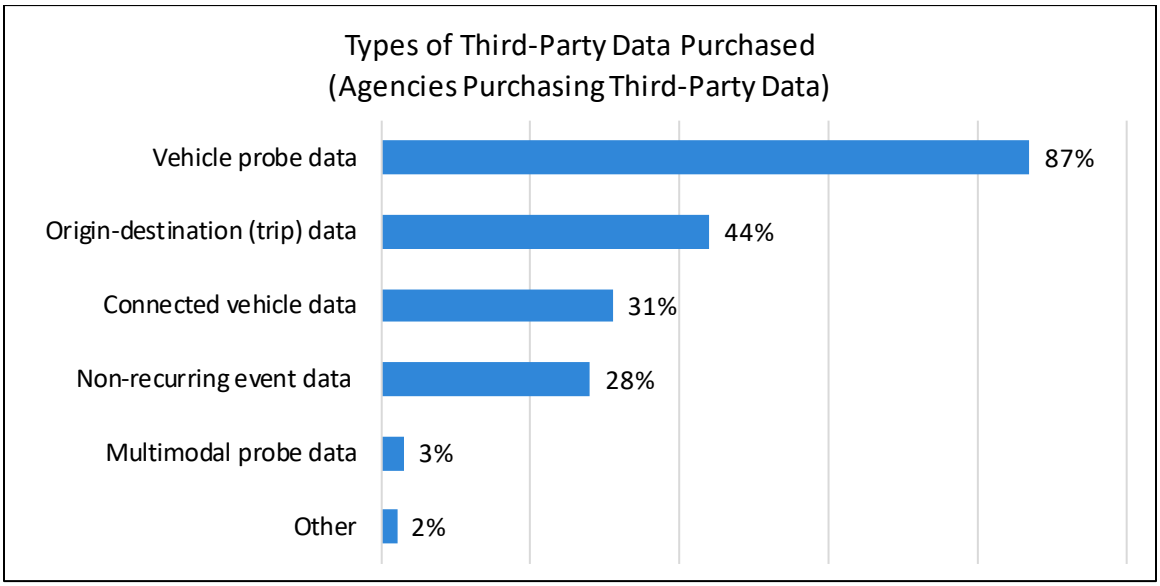
Table 11. Uses for External Data (Agencies Using External Data): Significant Differences Between State DOT District Population Groups

Use	State DOT Districts with a Large Urban Area (n=113)	State DOT Districts without a Large Urban Area (n=135)
Freeway management	60%	44%
Performance measurement/management	67%	53%

Source: USDOT

For the first time in 2023, freeway management agencies that reported *purchasing third-party commercial data* were also asked what types of freeway data the agency purchases. These agencies purchase an average of 2.0 types of third-party data.

As shown in Figure 12, a majority of the 189 freeway management agencies that purchase third-party data reported purchasing *vehicle probe data* (87 percent), while a lower percentage of these agencies purchases *origin-destination (trip) data* (44 percent), *connected vehicle data* (31 percent), *non-recurring event data* (28 percent), and *multimodal probe data* (3 percent).



2023 Q5; (n=189; 2% missing) *Source: USDOT*

Figure 12. Types of Third-Party Data Purchased (Agencies Purchasing Third-Party Data)

Telecommunications Technologies to Enable ITS

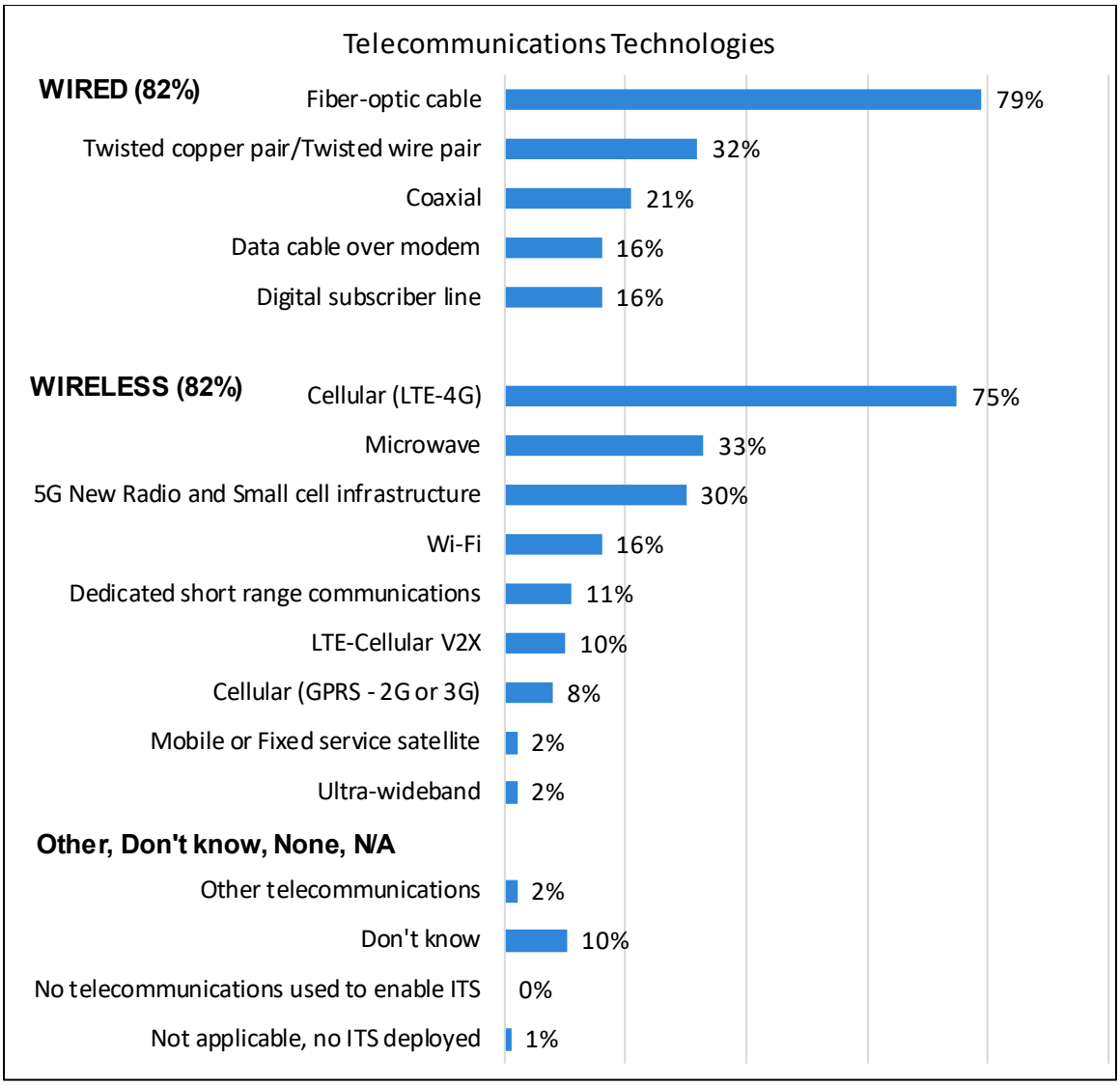
Telecommunications technologies enable communications between ITS devices, roadside devices, and/or a central processing location, typically for data collection and dissemination.

Among all 2023 freeway management agency respondents, 89 percent use at least one telecommunications technology (either wired or wireless) to enable ITS. Ten (10) percent of freeway management agencies responded *don't know;* no agencies reported *no telecommunications used to enable ITS on freeways,* and 1 percent reported *no ITS infrastructure or devices are deployed*.

As shown in Figure 13, 82 percent of freeway management agencies deploy at least one wired technology to enable ITS, and the same percentage of freeway management agencies deploys at least one wireless technology. On average, freeway management agencies report deploying a combination of 4.0 different wired and/or wireless telecommunications technologies to enable ITS.

Of the wired technologies, *fiber-optic cable* (79 percent) is the most used type of telecommunications technology by freeway management agencies. Substantially fewer freeway management agencies use *twisted copper pair/twisted wired pair* (32 percent) and *coaxial* (21 percent). *Data cable over modem* and *digital subscriber line* are each used by 16 percent of freeway management agencies.

Of the wireless technologies, *cellular (LTE-4G)* is used by a large majority of freeway management agencies (75 percent) to enable ITS with reported deployment levels significantly higher than any other wireless technologies. About one third of freeway management agencies reported using *microwave* (33 percent) and *5G New Radio and small cell infrastructure* (30 percent). Fewer agencies use *Wi-Fi* (16 percent), *dedicated short range communications* (11 percent), and *LTE-Cellular V2X* (10 percent). *Cellular (GPRS – 2G or 3G)*, *mobile or fixed service satellite*, and *ultra-wideband* are each deployed by fewer than 10 percent of freeway management agencies.



2023 Q35; (n=311; 0.3% missing) *Source: USDOT*

Figure 13. Telecommunications Technologies

As shown in Table 12, State DOT districts are significantly more likely than toll authorities to use *5G New Radio and small cell infrastructure* (33 percent compared to 8 percent), as well as *cellular (LTE-4G)*, which is used by 79 percent of State DOT districts compared to 47 percent of toll authorities.

Table 12. Telecommunications Technologies: Significant Differences Between Agency Types

Technology	State DOT Districts (n=273)	Toll Authorities (n=38)
5G New Radio and small cell infrastructure	33%	8%
Cellular (LTE-4G)	79%	47%

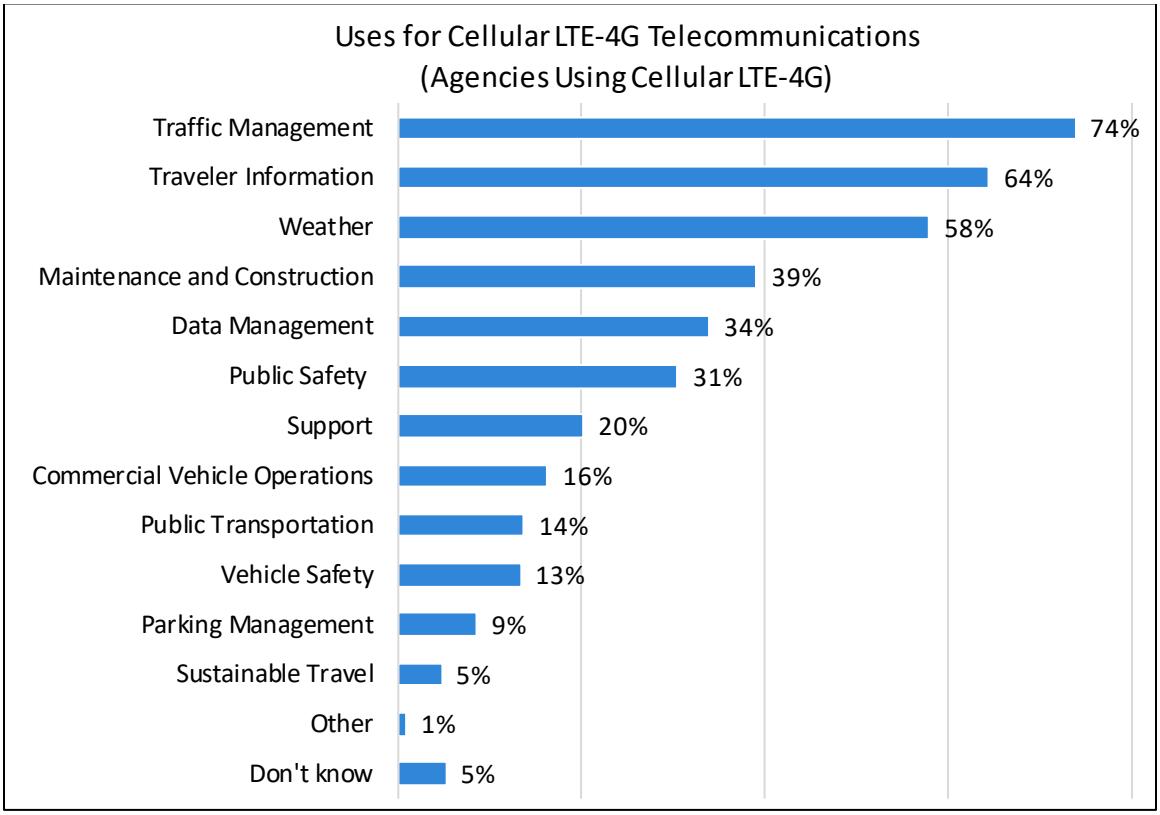
Source: USDOT

Among State DOT districts, *fiber-optic cable*, the most commonly used wired telecommunications technology to enable ITS, is deployed by a significantly higher percentage of State DOT districts with a large urban area compared to those without a large urban area (87 percent compared to 72 percent).

For the first time in 2023, survey respondents were asked how their agency uses telecommunications technologies to enable ITS. [18]

As shown in Figure 14, about three fourths of the 233 freeway management agency respondents using cellular (LTE-4G) use it for *traffic management* (74 percent), and a majority use it for *traveler information* (64 percent) and *weather* (58 percent). Thirty-nine (39) percent of freeway management agencies use cellular (LTE-4G) for *maintenance and construction*, while about one third use it for *data management* (34 percent) and *public safety* (31 percent).

One fifth use cellular (LTE-4G) for *support* (20 percent). Fewer than 20 percent of freeway management agencies use cellular (LTE-4G) for *commercial vehicle operations*, *public transportation, vehicle safety, parking management, sustainable travel,* and *other*. Five (5) percent reported *don't know.*



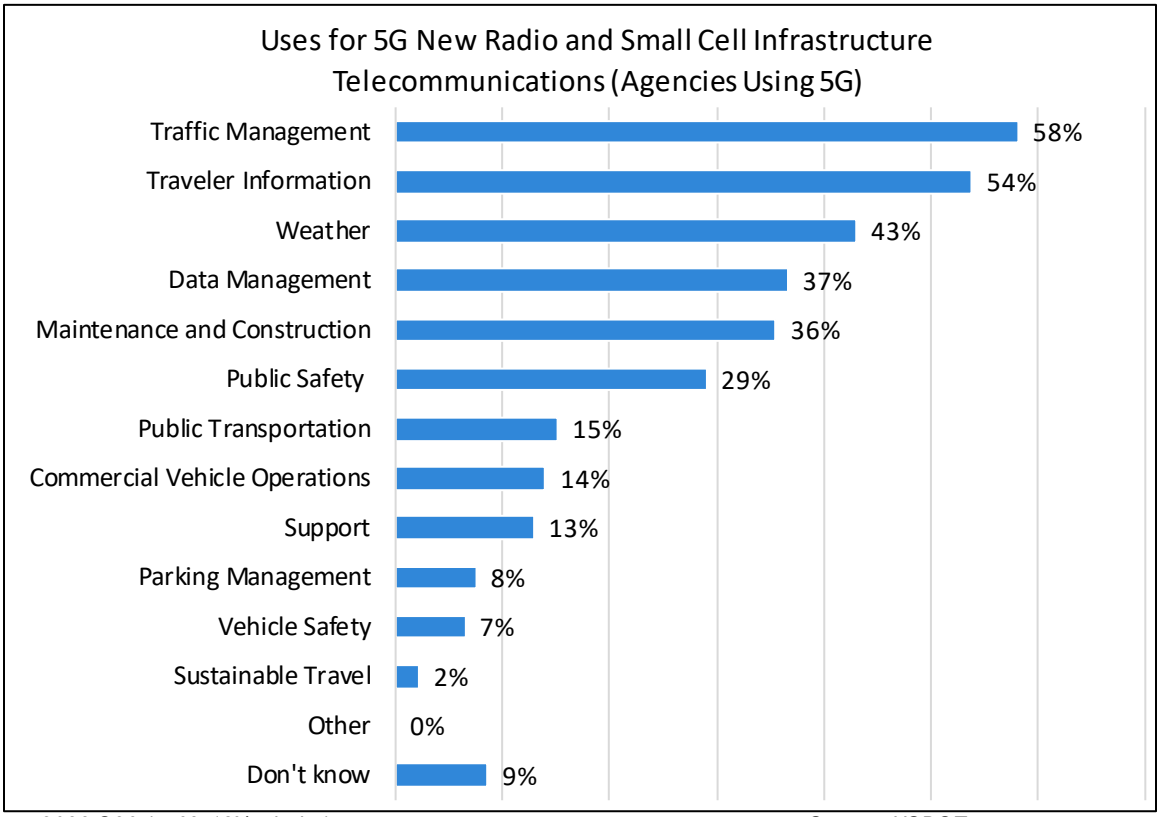
2023 Q36; (n=233; 7% missing) *Source: USDOT*

Figure 14. Uses for Cellular LTE-4G Telecommunications (Agencies Using Cellular LTE-4G)

[18] This follow-up question applied to a subset of telecommunications technologies. Excluded technologies were coaxial, fiber-optic cable, mobile or fixed service satellite, ultra-wideband, or microwave.

Figure 15 shows that over half of the 93 freeway management agencies using 5G New Radio and small cell infrastructure use it for *traffic management* (58 percent) and *traveler information* (54 percent). More than 40 percent of freeway management agencies use 5G New Radio and small cell infrastructure for *weather* (43 percent), and about one third use this telecommunications technology for *data management* (37 percent), *maintenance and construction* (36 percent), and *public safety* (29 percent).

Fewer than 20 percent of freeway management agencies use 5G New Radio and small cell infrastructure for *public transportation*, *commercial vehicle operations*, *support*, *parking management, vehicle safety,* and *sustainable travel*. Nine (9) percent reported *don't know.*



2023 Q36; (n=93; 18% missing) *Source: USDOT*

Figure 15. Uses for 5G New Radio and Small Cell Infrastructure Telecommunications (Agencies Using 5G)

Connected Vehicles

The questionnaire included a number of questions on the deployment of connected vehicle (CV) technologies. Due to the complex skip logic in this section of the survey, a summary of the questions is presented here.

All 311 freeway management agencies were asked first about whether they are currently developing, testing, or deploying CV technologies. Response options included *yes*; *no, but my agency is planning for CV*; *no plans for CV*; and *don't know*.

The subset of freeway management agencies that reported they are not currently developing, testing, or deploying CV but are planning for CV deployment in the future were asked two follow-up questions:

- Whether their plans for CV are documented *(yes, no, don't know)*
- When they plan to begin developing, testing, or deploying CV (*within the next 3 years*, *in 3 to 6 years*, or *in 7 or more years*)

The subset of freeway management agencies that reported they are currently developing, testing, or deploying CV technologies were asked two follow-up questions:

- Whether they are deploying roadside units (RSUs) on freeways *(yes, no, don't know)*
- Whether they are developing, testing or deploying CV applications on freeways *(yes, no, don't know)*

If a freeway management agency reported deploying RSUs on freeways, it was asked two additional follow-up questions:

- How many RSUs are being tested or deployed on freeways
- Which standard data structures are being transmitted for the CV system by those RSUs

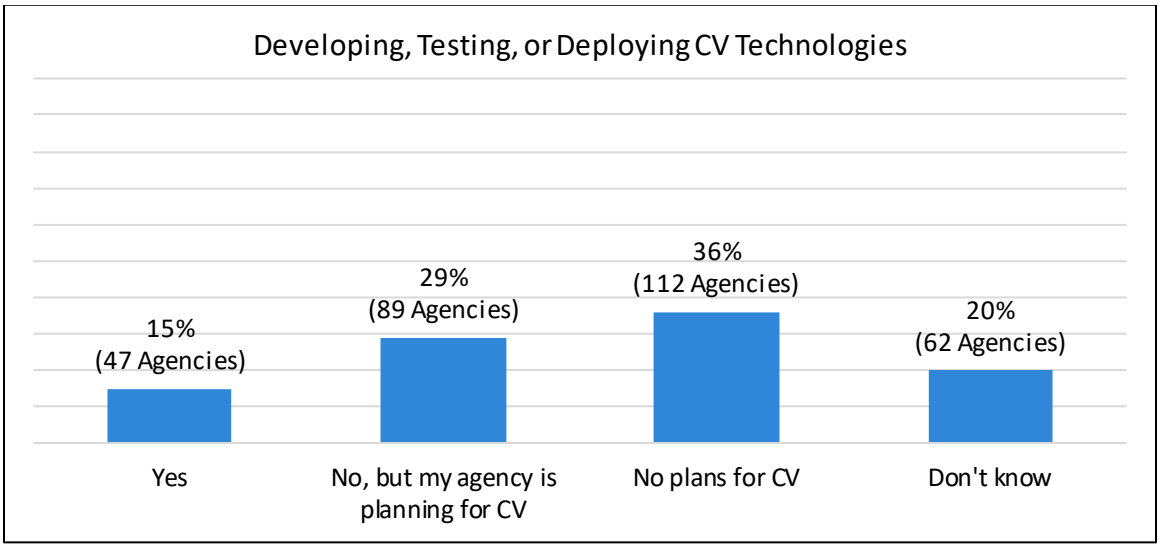
If a freeway management agency indicated it was developing, testing, or deploying CV applications for use on freeways, it was asked a single follow-up question:

- Which specific CV applications is the agency developing, testing or deploying on freeways

The findings for all these questions are presented in this section.

Developing, Testing, Or Deploying CV Technologies

Figure 16 shows that of all 311 freeway management agency respondents, 15 percent are *currently developing, testing, or deploying connected vehicle (CV) technologies*, while 29 percent are *planning for CV*. About one third of agencies reported *no plans for CV* (36 percent). Twenty (20) percent of freeway management agencies reported *don't know*.



2023 Q21; (n=311; 0.3% (1 agency) missing) *Source: USDOT*

Figure 16. Developing, Testing, or Deploying CV Technologies

State DOT districts with a large urban area are significantly more likely than State DOT districts without a large urban area to be *currently developing, testing, or deploying CV technologies* (24 percent compared to 8 percent), and similarly more likely to be *planning for CV* (36 percent compared to 23 percent).

State DOT districts without a large urban area are significantly more likely than those with a large urban area to report *no plans for CV* (46 percent compared to 20 percent), as shown in Table 13.

Table 13. CV Technologies: Significant Differences Between State DOT District Population Groups

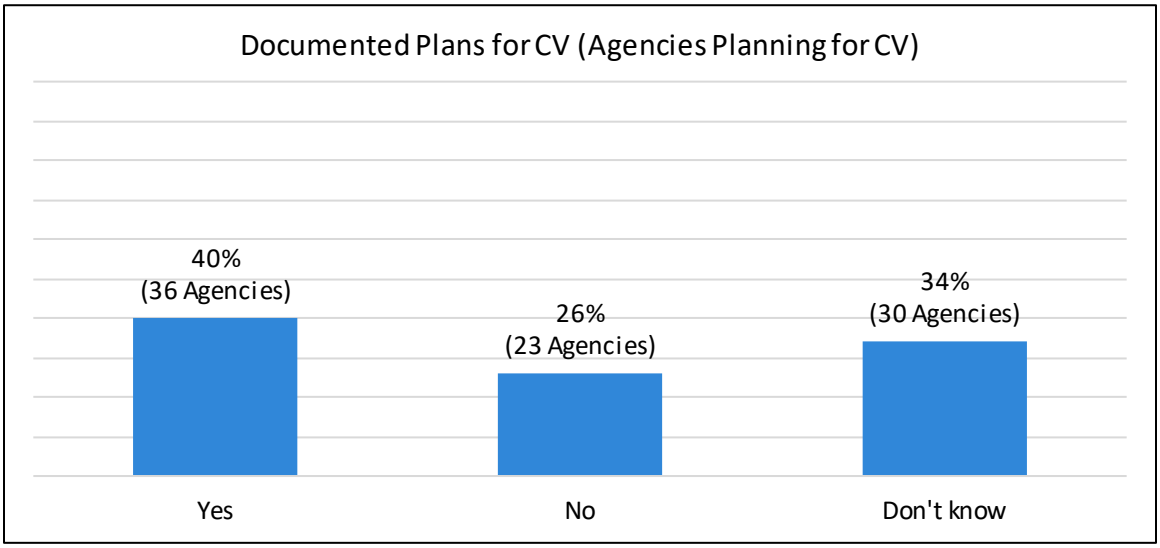
Response	State DOT Districts with a Large Urban Area (n=119)	State DOT Districts without a Large Urban Area (n=154)
Currently developing, testing, or deploying CV	24%	8%
Not currently developing, testing or deploying, but my agency is planning for CV	36%	23%
No plans for CV	20%	46%

Source: USDOT

Planning For CV (But Not Currently Developing, Testing, or Deploying)

The 89 freeway management agencies that are not currently developing, testing, or deploying CV but are planning for CV on freeways (referred to as "agencies planning for CV" in this section, and as shown previously in Figure 16) were asked if those plans are documented.

Of these 89 freeway management agencies planning for CV, 40 percent *have a documented plan*, as shown in Figure 17; 26 percent reported *no documented plans for CV*, and 34 percent reported *don't know*.



2023 Q22; (n=89; 0% missing) *Source: USDOT*

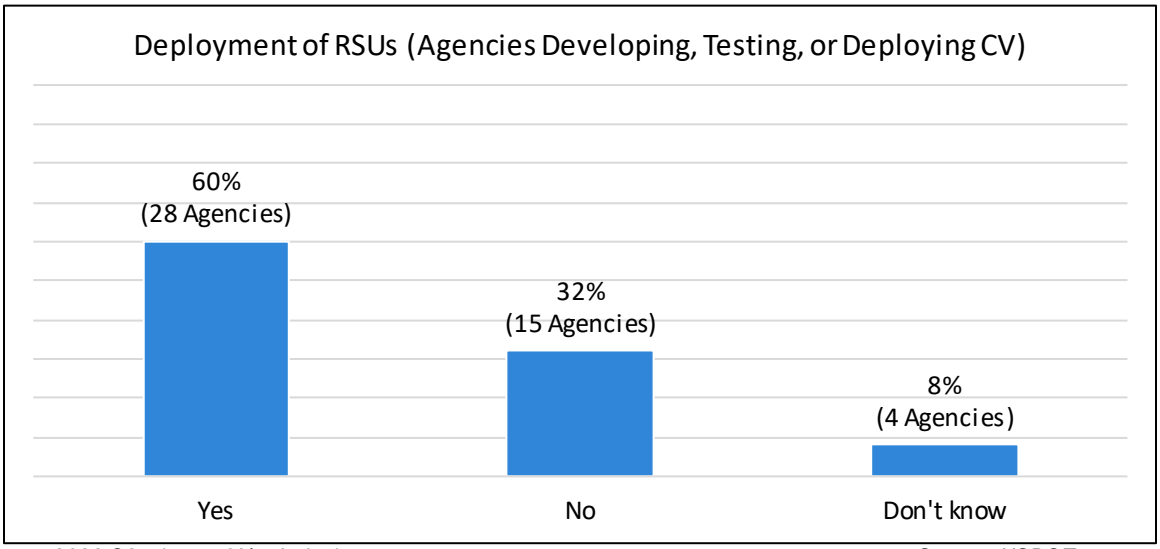
Figure 17. Documented Plans for CV (Agencies Planning for CV)

Additionally, among these 89 freeway management agencies planning for CV, 38 percent expect to begin developing, testing, or deploying *within the next 3 years,* 27 percent *in 3 to 6 years*, 2 percent *in 7 or more years*, and 33 percent reported *don't know.*

The 47 freeway management agencies that reported they are currently developing, testing, or deploying CV were asked separate questions about their deployment of roadside units (RSUs) and deployment of CV applications. The findings are presented in the following two sections of the report.

Deployment of RSUs Among Agencies Developing, Testing, or Deploying CV

The 47 freeway management agencies that are developing, testing, or deploying CV technologies (as shown previously in Figure 16) were asked if their agency deploys RSUs on freeways to support CV and/or AV testing/deploying. Figure 18 shows a majority *deploy RSUs* (60 percent), about one third *do not deploy RSUs* (32 percent), and 8 percent reported *don't know*.



2023 Q24; (n=47; 0% missing) *Source: USDOT*

Figure 18. Deployment of RSUs (Agencies Developing, Testing, or Deploying CV)

Since the number of freeway management agency respondents deploying RSUs is small (28 agencies), the findings for the RSU follow-up questions are presented by number of agencies instead of percentages.

Of the 28 freeway management agencies deploying RSUs on freeways:

- Fourteen (14) agencies deploy *1 to 10 RSUs*.
- Eight (8) agencies deploy *11 to 50 RSUs*.
- Six (6) agencies deploy *more than 50 RSUs*.

In addition, the 28 freeway management agencies deploying RSUs on freeways reported that their RSUs are transmitting the following standard data structures:

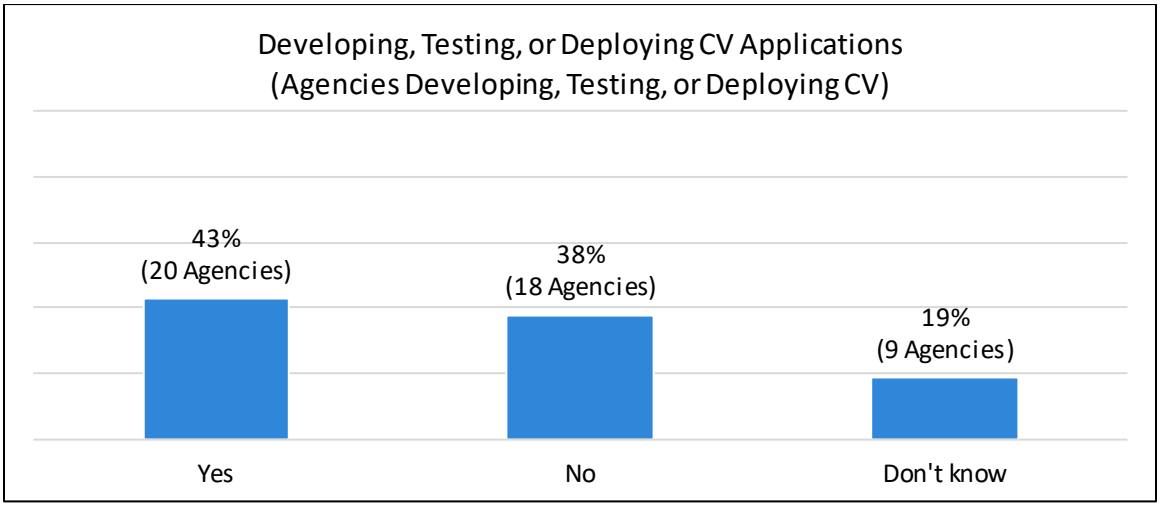
- *Basic safety messages* (19 agencies)
- *Traveler information messages* (14 agencies)
- *Roadside safety messages* (9 agencies)

Five (5) or fewer freeway management agencies are transmitting each of the following: *MAP data, signal phase and timing data*, and *sensor data sharing messages*.

Deployment of CV Applications Among Agencies Developing, Testing, or Deploying CV Technologies

The 47 freeway management agencies that are developing, testing, or deploying CV technologies (as shown previously in Figure 16) were asked if their agency is developing, testing or deploying any CV applications for use on freeways. [19]

As shown in Figure 19, 43 percent of freeway management agencies developing, testing, or deploying CV are *developing, testing, or deploying CV applications*, while 38 percent reported they are *not developing, testing, or deploying CV applications*, and 19 percent reported indicated *don't know*.



2023 Q27; (n=47; 0% missing) *Source: USDOT*

Figure 19. Developing, Testing or Deploying CV Applications (Agencies Developing, Testing, or Deploying CV)

The 20 freeway management agencies that are developing, testing, or deploying CV applications were asked to indicate the specific CV applications being developed, tested, or deployed. Since the number of freeway management agencies developing, testing, or deploying CV applications on freeways is small, numbers are presented instead of percentages.

[19] Respondents were asked, "Is your agency developing, testing, or deploying any connected vehicle applications for use on freeways (i.e., using an in-vehicle onboard unit (OBU), Human Machine Interface (HMI), handheld device, or similar)? *This may include applications that your agency is testing either on its own fleet or in partnership with automakers/original equipment manufacturers."*

The 20 freeway management agencies developing, testing, or deploying CV applications reported the following:

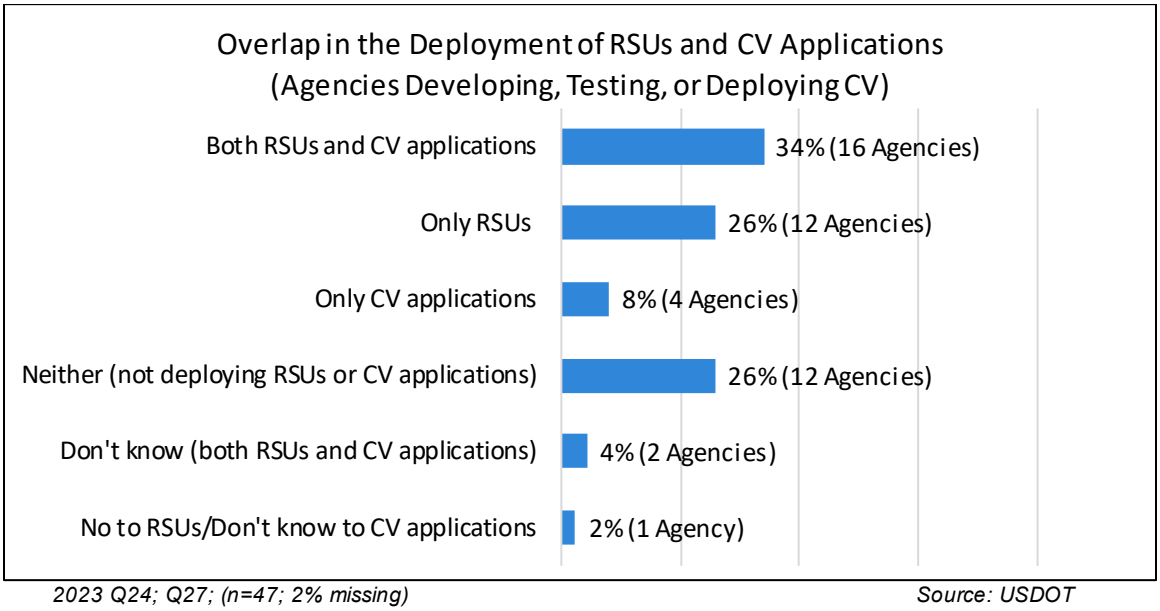
- *Agency data applications* (8 agencies)
- *Road weather warnings* (8 agencies)
- *Queue warnings* (7 agencies)
- *Curve speed warnings* (5 agencies)
- *Reduced speed/work zone warnings* (5 agencies)

Four (4) or fewer freeway management agencies are deploying *emergency electronic brake lights*, *forward collision warning*, *blind spot/lane change warning,* or *other CV applications*.

Overlap in the Deployment of RSUs and CV Applications Among Agencies Developing, Testing, or Deploying CV Technologies

Additional analysis was performed to understand the extent to which freeway management agencies are deploying RSUs and/or CV applications, as shown in Figure 20.

Of the 47 agencies developing, testing, or deploying CV on freeways (as previously shown in Figure 16), 34 percent reported deploying both RSUs and CV applications, about one fourth reported only RSUs (26 percent), and 8 percent reported deploying only CV applications. Twenty-five (25) percent of freeway management agencies developing, testing, or deploying CV reported deploying neither RSUs nor CV applications. Four (4) percent of agencies developing, testing, or deploying CV reported *don't know* when asked about both RSUs and CV applications. Two (2) percent of agencies developing, testing, or deploying CV reported *do not deploy RSUs* and *don't know* regarding CV applications.



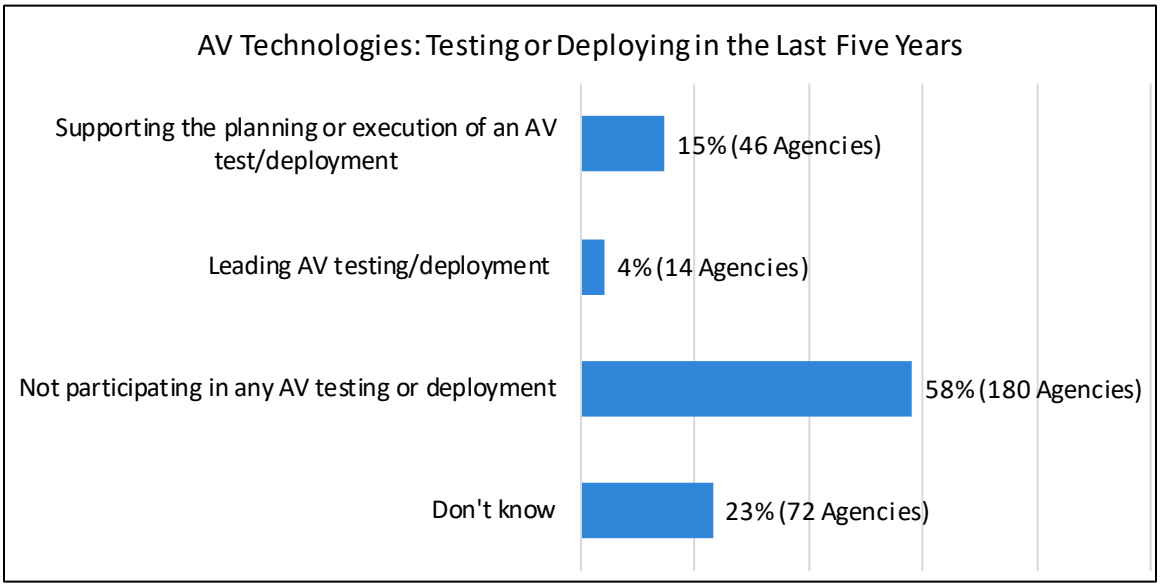
2023 Q24; Q27; (n=47; 2% missing) *Source: USDOT*

Figure 20. Overlap in the Deployment of RSUs and CV Applications (Agencies Developing, Testing, or Deploying CV)

Automated Vehicles

Figure 21 shows that of all 311 responding freeway management agencies, 4 percent reported *leading or has led automated vehicle (AV) testing/deployment* in the last five years, while 15 percent reported *supporting or has supported the planning or execution of an AV test/deployment* in the last five years. [20]

A majority of freeway management agencies are *not participating in any AV testing or deployment* (58 percent), and 23 percent reported *don't know*.



2023 Q29; (n=311, 0.4% (1 agency) missing) *Source: USDOT*

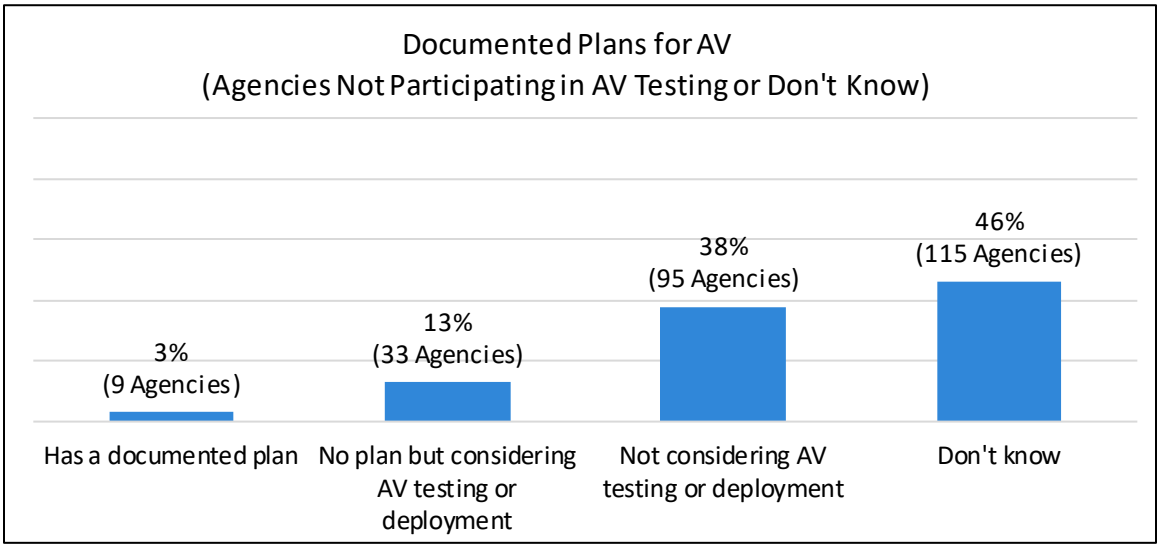
Figure 21. AV Technologies: Testing or Deploying in the Last Five Years

[20] Respondents were able to select both *leading* and *supporting,* if applicable. Therefore, the number of agencies do not add to the survey total (n=311). The net for these two responses is 19 percent (58 freeway management agencies either leading or supporting AV testing/deployment).

Freeway Management Agencies Not Participating in AV Testing/Deployment

The 252 freeway management agencies either not participating in AV testing/deployment or that reported don't know (as previously shown in Figure 21) were asked about their plans for AV.

Figure 22 shows that only 3 percent of these agencies *have a documented plan to participate in AV tests or deployments*, and 13 percent reported *no plan but considering AV testing or deployment.* Nearly one half of these freeway management agencies reported *don't know* (46 percent), and 38 percent reported their agency is *not considering AV testing or deployments*.



2023 Q30; (n=252; 0% missing) *Source: USDOT*

Figure 22. Documented Plans for AV (Agencies Not Participating in AV Testing or Don't Know)

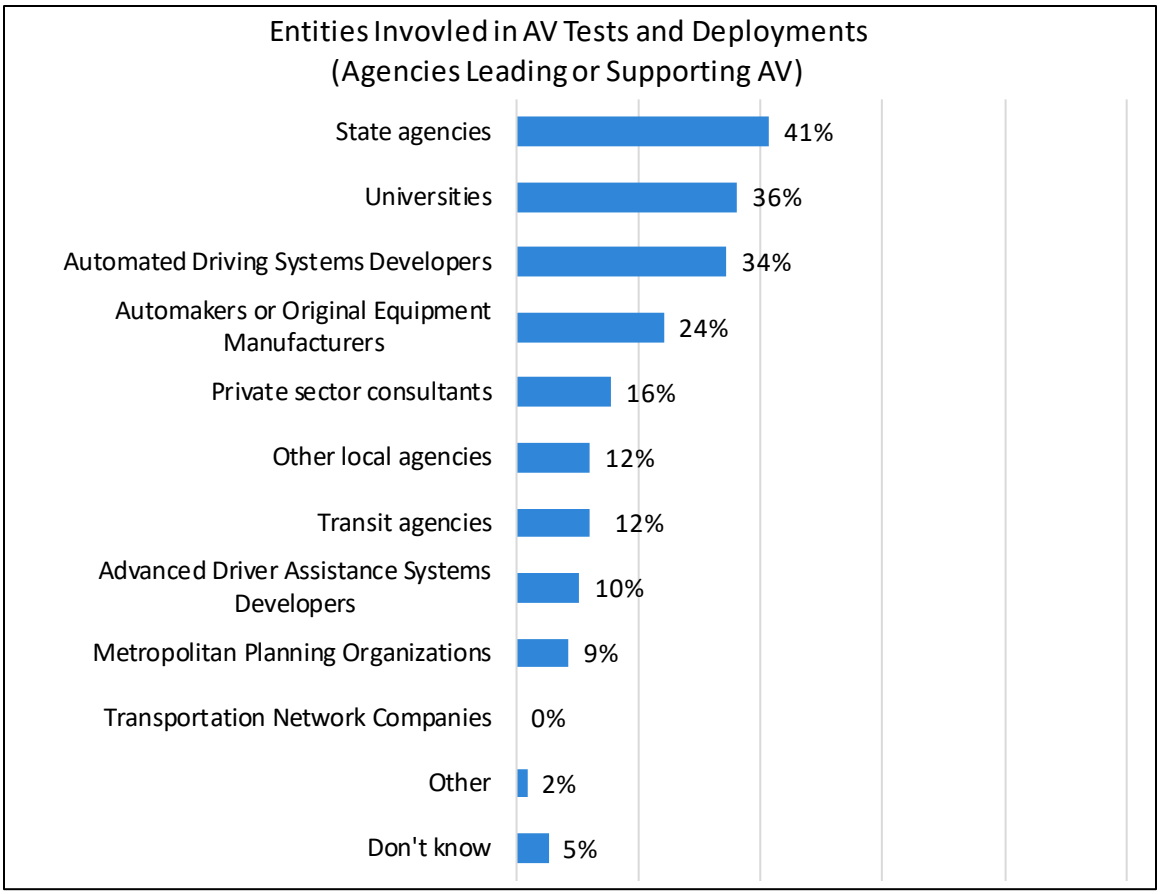
The 42 freeway management agencies with documented plans for AV or considering AV testing or deployment were asked about their timeline for deploying. Of these 42 freeway management agencies, 4 agencies expect to begin pursuit *within the next 3 years,* 13 agencies *in 3 to 6 years*, and 2 agencies *in 7 or more years*. Twenty-three (23) agencies reported *don't know.*

Freeway Management Agencies Leading or Supporting AV Testing/Deployment

The 58 freeway management agencies leading or supporting AV testing or deployment were asked with which entities they partnered.

Figure 23 shows 41 percent of these agencies partnered with *state agencies.* About one third partnered with *universities* (36 percent) and *Automated Driving Systems Developers* (34 percent), and about one fourth partnered with *Automakers or Original Equipment Manufacturers* (24 percent). Sixteen (16) percent of freeway management agencies reported partnering with *private sector consultants*, and 12 percent reported partnering with *other local agencies* and *transit agencies.*

Advanced Driver Assistance Systems Developers, and *Metropolitan Planning Organizations* were each reported to be partners by fewer than 10 percent of agencies. Five (5) percent of freeway management agencies leading or supporting AV testing or deployment reported *don't know.*



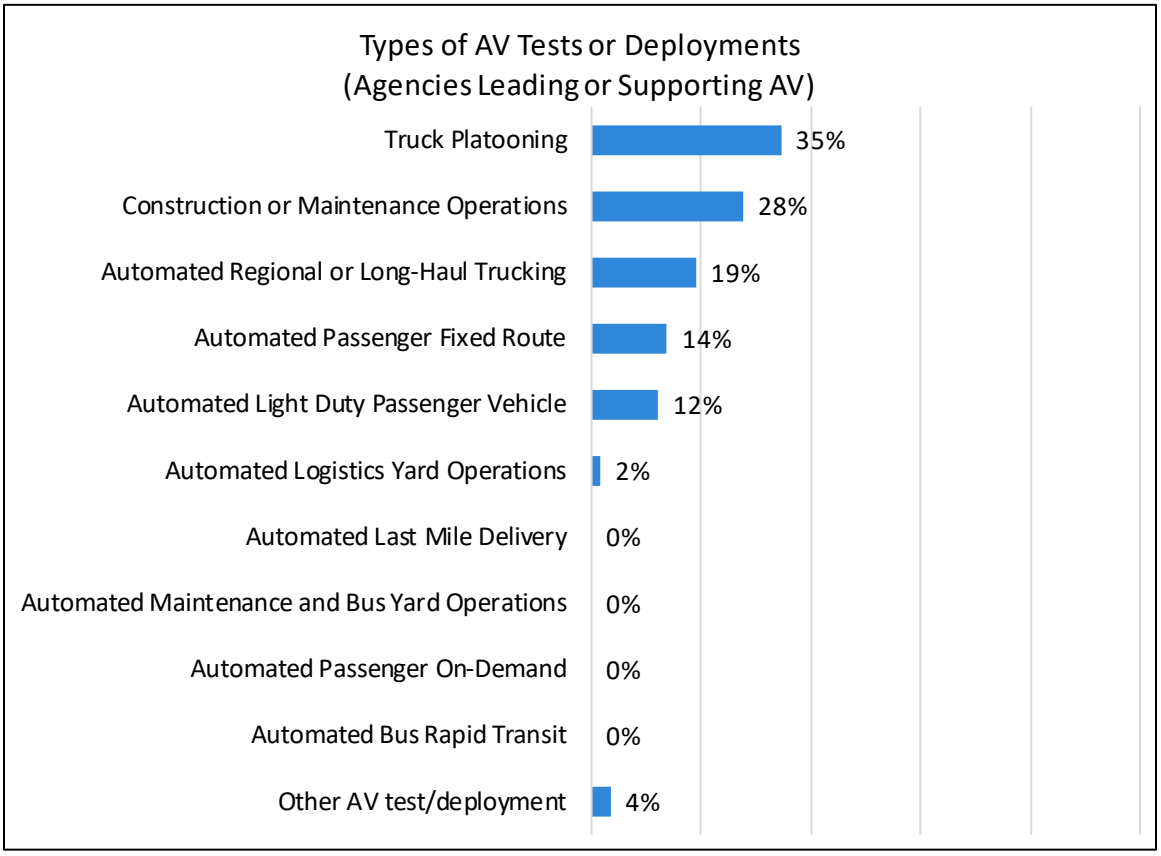
2023 Q32a, Q32b; (n=58; 5% missing) *Source: USDOT*

Figure 23. Entities Involved in AV Tests and Deployments (Agencies Leading or Supporting AV)

The 58 freeway management agencies leading or supporting AV in the last five years were asked about the types of tests or deployments they undertook.

Figure 24 shows that *truck platooning* (35 percent) is being tested or deployed by over one third of agencies leading or supporting AV, and *construction and maintenance operations* (28 percent) is being tested or deployed by over one fourth of these agencies.

Nineteen (19) percent of these agencies reported tests or deployments of *automated regional or long-haul trucking*, 14 percent reported *automated passenger vehicle routes*, 12 percent reported *automated passenger fixed route*, and 2 percent reported *automated logistics yard operations.*



2023 Q33; (n=58; 5% missing) *Source: USDOT*

Figure 24. Types of AV Tests or Deployments (Agencies Leading or Supporting AV)

Traffic Management

This section of the report presents findings on different traffic management technologies and strategies, including:

- Managed lanes
- Ramp metering
- Integrated corridor management (ICM)
- Transportation Systems Management and Operations (TSMO) Plan [21]

Managed Lanes

Managed lanes involve operating a set of freeway lanes that are separate from general purpose lanes. This can be accomplished using a variety of operational strategies including pricing, vehicle eligibility, and access control to achieve optimal traffic conditions. To successfully execute these types of operational strategies, ITS is often used.

As shown in Figure 25, nearly one fifth of freeway management agencies reported *their agency operates managed lanes* (18 percent), and 9 percent reported that *another entity manages lanes*. In total, 26 percent of agencies reported managed lanes (either managed by the responding agency or another entity) within their jurisdiction. About three fourths of freeway management agencies reported *no managed lanes operated on freeways in their jurisdiction* (73 percent).

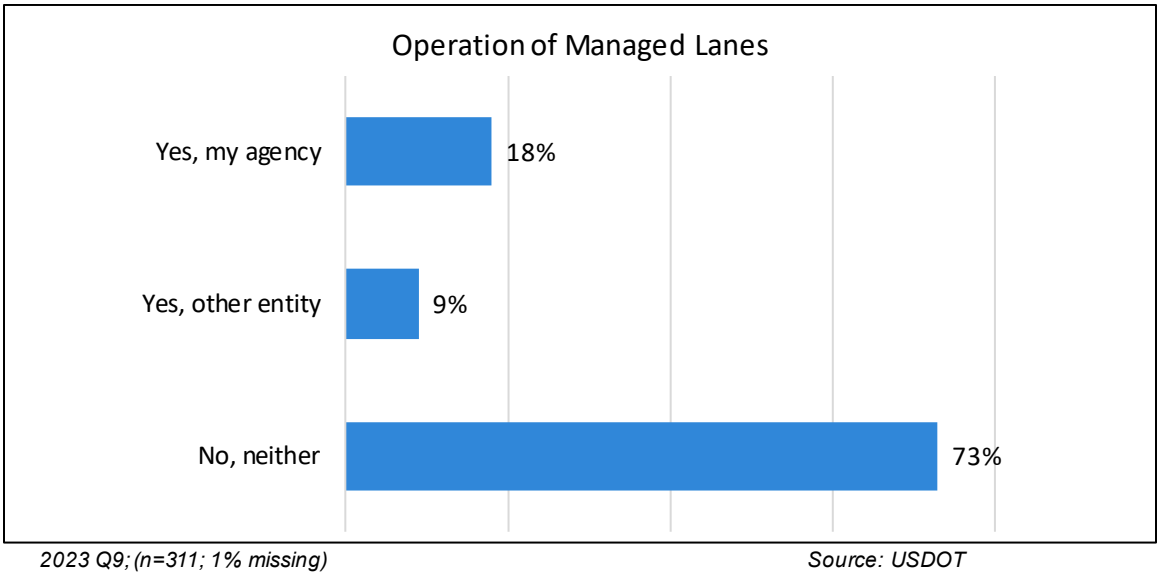


Figure 25. Operation of Managed Lanes

[21] TSMO is a set of strategies that focus on operational improvements with the goal of maximizing performance of the existing transportation system. TSMO looks at performance from a systems perspective, in which strategies are coordinated across multiple jurisdictions, agencies, and modes.

State DOT districts with a large urban area are significantly more likely to have managed lanes either managed by the State DOT district or another entity (37 percent) compared to State DOT districts without a large urban area (19 percent).

The 82 freeway management agency respondents with managed lanes within their jurisdiction (either managed by the responding agency or another entity) were asked about the managed lanes strategies used, which are shown in Figure 26.

Lane use control (46 percent) is used by nearly one half of these freeway management agencies. About one third use *hard shoulder running* (34 percent), *High Occupancy Vehicle* lanes (33 percent), and *High Occupancy Toll* lanes (33 percent). Less than one fourth use *variable speed limits* (24 percent), while less than one fifth of these freeway management agencies use *reversible flow* lanes (16 percent). *Transit only* and *truck only* managed lane strategies are each used by fewer than 10 percent of responding agencies.

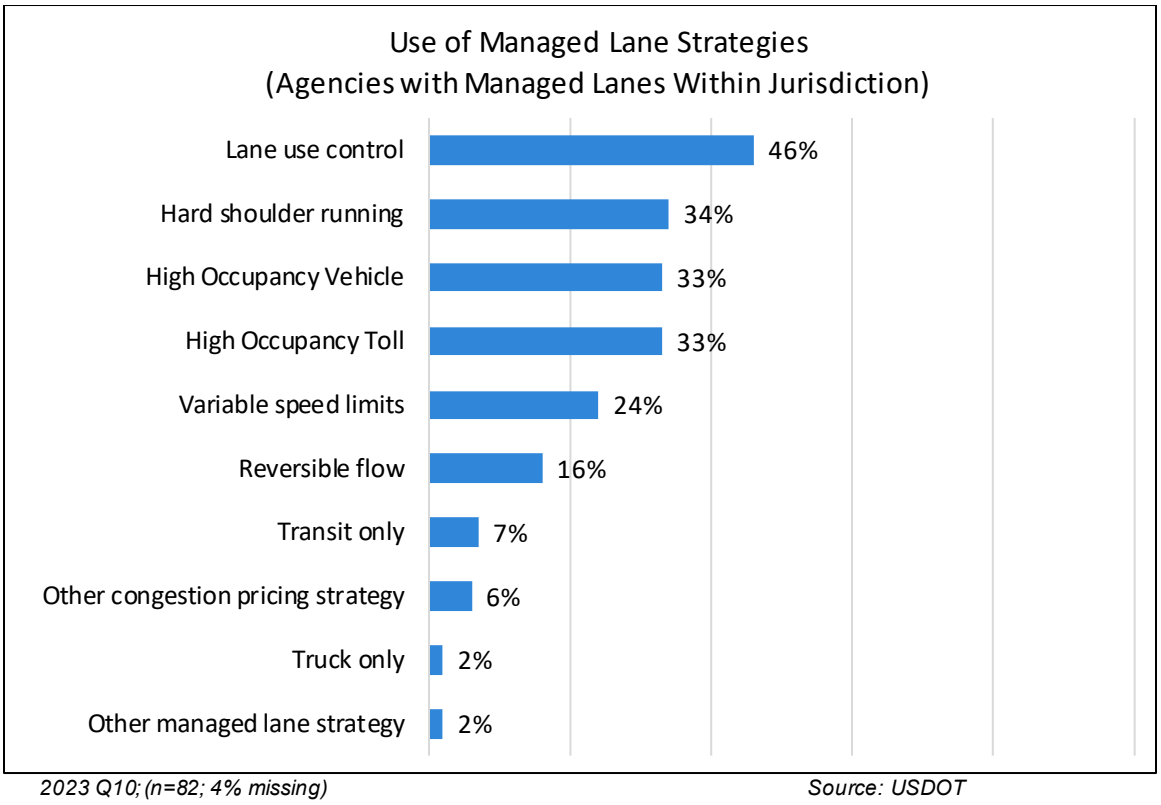
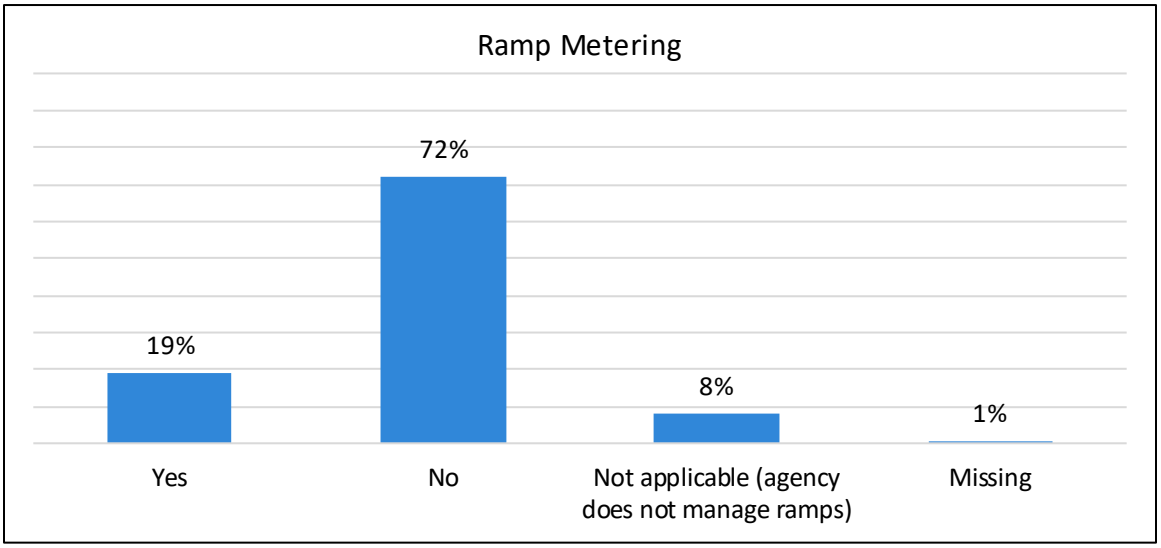


Figure 26. Use of Managed Lanes Strategies (Agencies with Managed Lanes Within Jurisdiction)

Ramp Metering

As shown in Figure 27, less than one fifth of all surveyed freeway management agencies *deploy ramp metering* (19 percent). About three fourths *do not deploy ramp metering* (72 percent), while 8 percent of responding freeway management agencies *do not manage ramps*.



2023 Q6; (n=311) *Source: USDOT*

Figure 27. Ramp Metering

State DOT districts with a large urban area are significantly more likely to deploy ramp metering than State DOT districts without a large urban area (37 percent compared to 8 percent).

Figure 28 shows the capabilities of the 60 freeway management agency respondents that are deploying ramp metering. A majority of ramp metering deployers reported using *local adaptive/responsive ramp metering based on real time traffic conditions in local vicinity of the ramp* (60 percent).

Forty (40) percent of deployers use *fixed/pre-timed ramp metering (e.g., based on historical data)*, while 28 percent of deployers use *corridor or system-wide adaptive/responsive ramp metering based on real time traffic conditions along a facility, corridor, or system*.

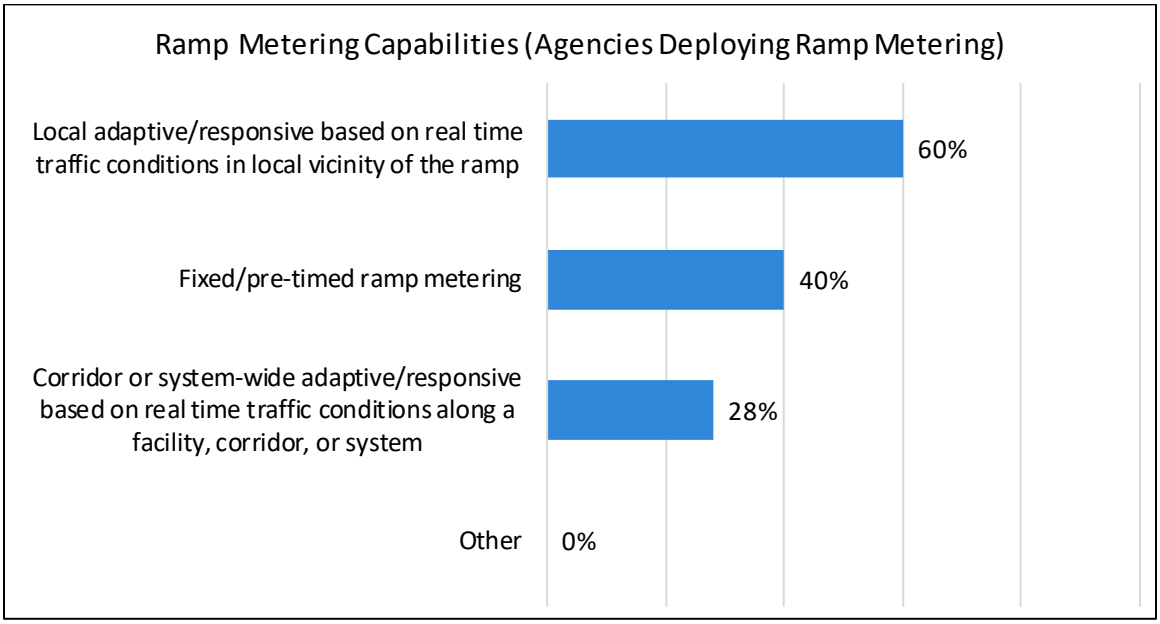


Figure 28. Ramp Metering Capabilities (Agencies Deploying Ramp Metering)

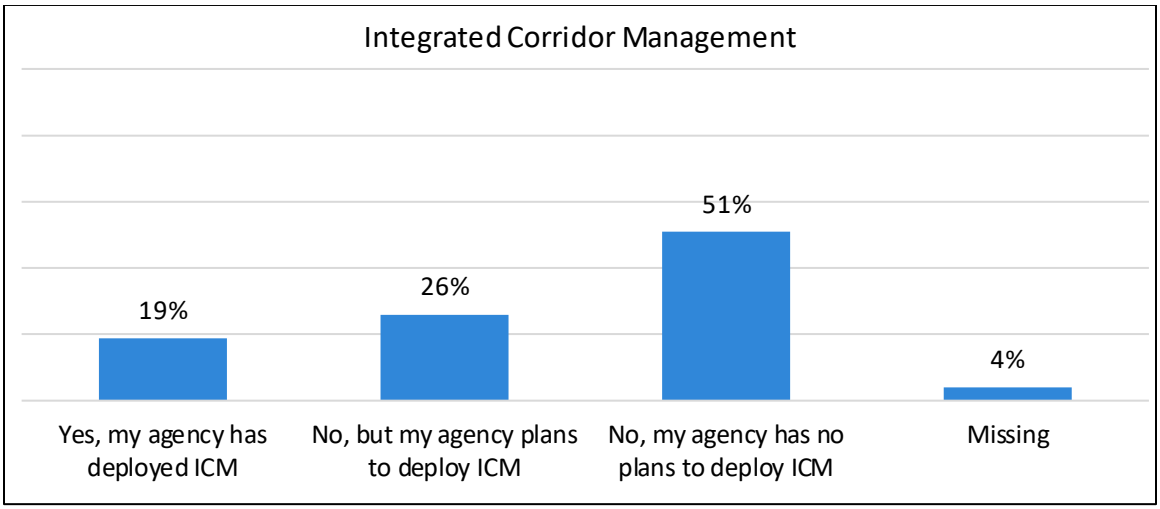
The 42 freeway management agency respondents using *local adaptive/responsive ramp metering* and/or *corridor or system-wide adaptive/responsive ramp metering* were asked about their adoption of advanced ramp metering technologies.

Of these deployers, 28 agencies reported *no advanced metering technologies are deployed*. Six (6) of these agencies use *dynamic bottleneck identification*, 3 agencies use *integration with adjacent arterial traffic signals,* and 2 agencies use *automated incident detection*.

Integrated Corridor Management

ICM is an approach to managing a transportation corridor as a multimodal system, integrating operations such as traffic incident management, work zone management, traffic signal timing, and real-time traveler information dissemination to maximize the capacity of all facilities and modes across the corridor. A corridor includes freeway, arterial, and public transit facilities with cross-facility connections.

Figure 29 shows that about one fifth of freeway management agency respondents *deploy ICM* (19 percent) while about one fourth *plan to deploy ICM* (26 percent). About half of freeway management agencies *have no plans to deploy ICM* (51 percent).



2023 Q50; (n=311) *Source: USDOT*

Figure 29. Integrated Corridor Management

As shown in Table 14, *ICM deployment* is significantly higher in State DOT districts with a large urban area compared to State DOT districts without a large urban area (27 percent compared to 16 percent), and a significantly higher percentage of State DOT districts with a large urban area *plan to deploy ICM* compared to State DOT districts without a large urban area (39 percent compared to 19 percent). By contrast, State DOT districts without a large urban area are significantly more likely than those with a large urban area to report *no plans to deploy ICM* (61 percent compared to 32 percent).

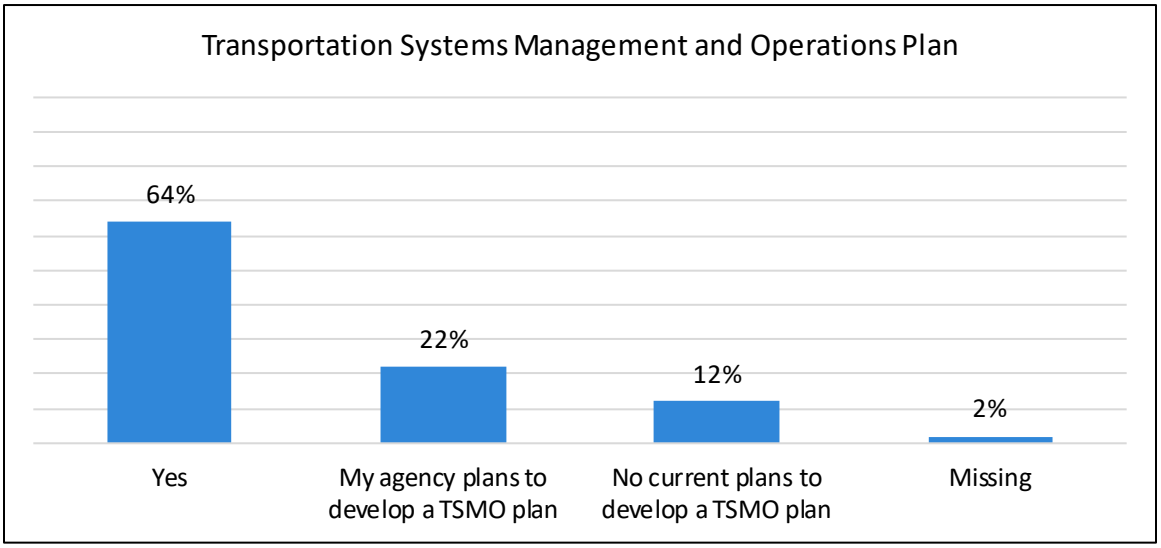
Table 14. Integrated Corridor Management: Significant Differences Between State DOT District Population Groups

Response	State DOT Districts with a Large Urban Area (n=119)	State DOT Districts without a Large Urban Area (n=154)
Yes, my agency has deployed ICM	27%	16%
No, but my agency plans to deploy ICM	39%	19%
No, my agency has no plans to deploy ICM	32%	61%

Source: USDOT

Transportation Systems Management and Operations Plans

Figure 30 shows about two thirds of responding freeway management agencies *have a TSMO Plan* (64 percent), and over one fifth of agencies *plan to develop a TSMO plan* (22 percent). Twelve (12) percent have *no current plans to develop a TSMO plan.*



2023 Q40; (n=311) *Source: USDOT*

Figure 30. Transportation Systems Management and Operations Plan

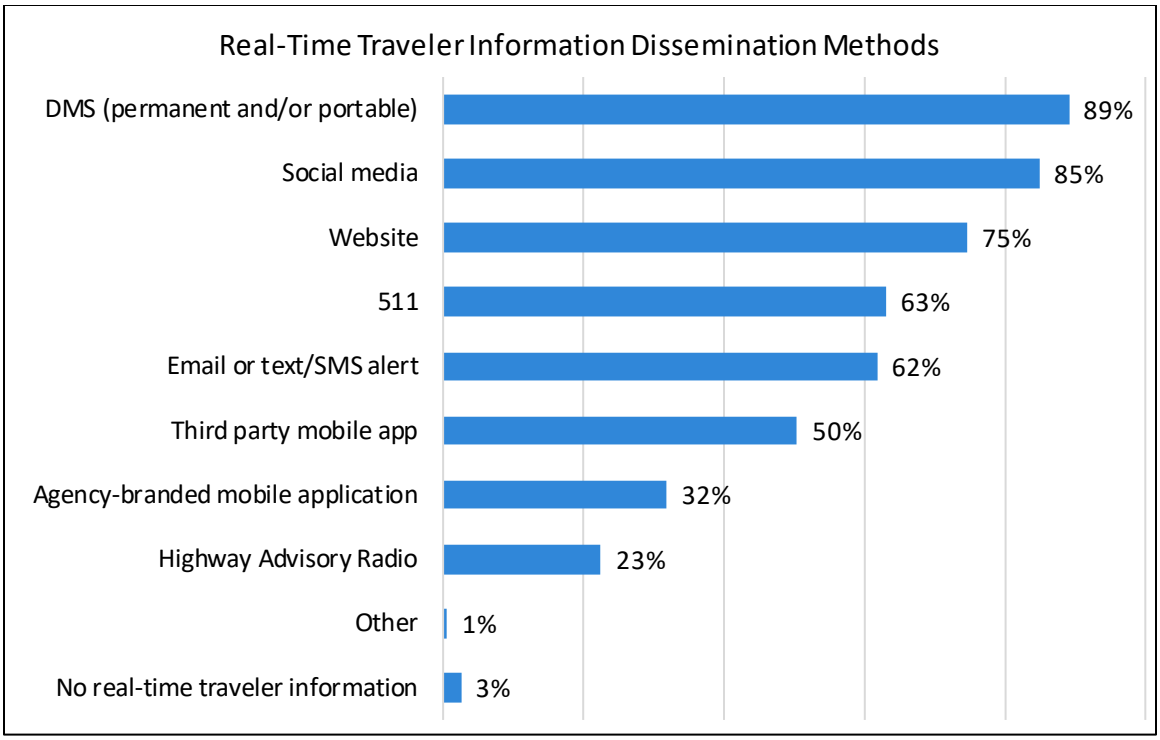
State DOT districts are significantly more likely than toll authorities to *have a TSMO plan* (67 percent compared to 37 percent).

Traveler Information

Nearly all surveyed freeway management agencies disseminate real-time traveler information about freeways using at least one method (97 percent), and these agencies reported using an average of 4.9 different methods.

Figure 31 shows *DMS (permanent and/or portable)* (89 percent) and *social media* (85 percent) are each used by a large majority of freeway management agencies to share real-time traveler information, and about three fourths use *websites* (75 percent). *511* (63 percent) and *email or text/SMS alert*s (62 percent) are each used by a smaller majority of agencies.

Half of freeway management agencies disseminate real-time traveler information via *third-party mobile apps* (50 percent). About one third of agencies use *agency-branded mobile applications* (32 percent), and fewer than one fourth use *Highway Advisory Radio (HAR)* (23 percent).



2023 Q19; (n=311; 0% missing) *Source: USDOT*

Figure 31. Real-Time Traveler Information Dissemination Methods

As shown in Table 15, three methods of real-time traveler information dissemination are used by significantly higher percentages of State DOT districts than toll authorities — *social media* (87 percent compared to 68 percent), *511* (66 percent compared to 40 percent), and *agency-branded mobile applications* (34 percent compared to 13 percent).

Table 15. Real-Time Traveler Information Dissemination Methods: Significant Differences Between Agency Types

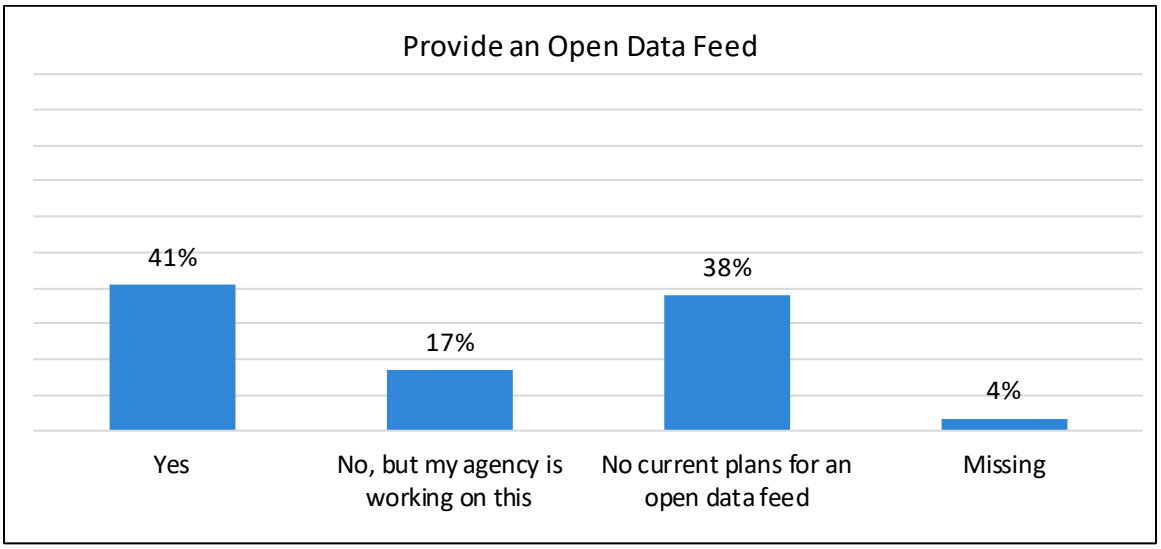
Response	State DOT Districts (n=273)	Toll Authorities (n=38)
Social media	87%	68%
511	66%	40%
Agency-branded mobile applications	34%	13%

Source: USDOT

Most real-time traveler information dissemination methods are used by nearly equal percentages of State DOT district population groups. However, State DOT districts with a large urban area are significantly more likely than State DOT districts without a large urban area to use *third-party mobile apps* (60 percent compared to 47 percent).

Open Data Feed

Figure 32 shows that 41 percent of freeway management agency respondents *provide an open data feed* that shares some type of real-time transportation-related data using data standards/specifications. Nearly one fifth of freeway management agencies reported *working on providing an open data feed* (17 percent) while 38 percent have *no current plans for an open data feed.*



2023 Q20; (n=311) *Source: USDOT*

Figure 32. Provide an Open Data Feed

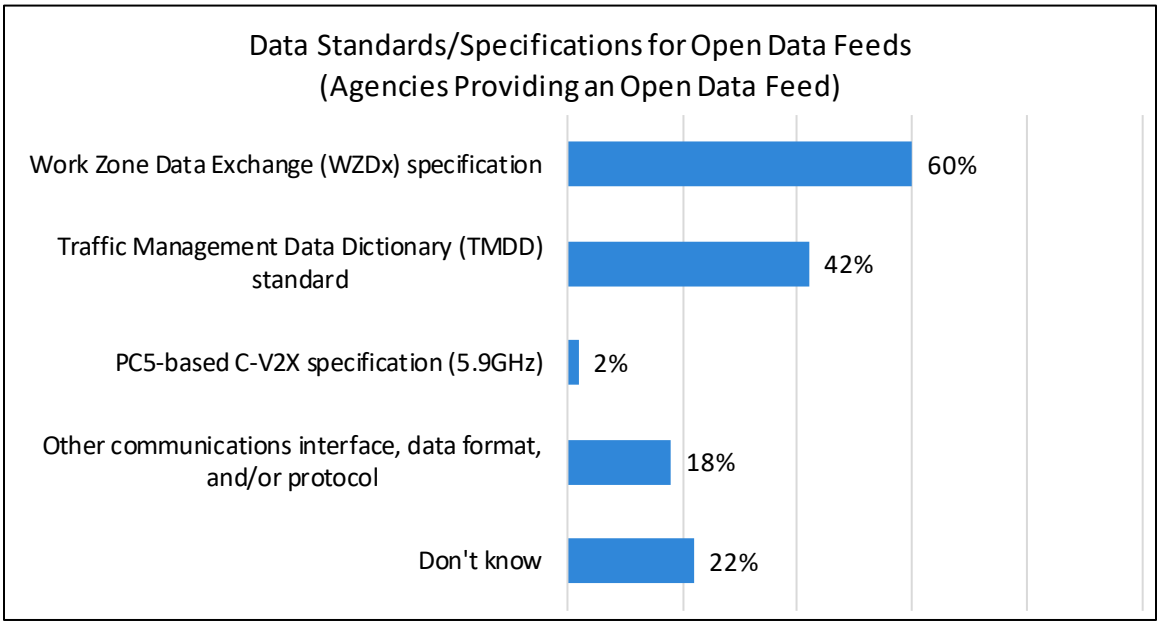
State DOT districts are significantly more likely to *provide an open data feed* than toll authorities (44 percent compared to 26 percent).

Among State DOT districts, half of the State DOT districts with a large urban area (50 percent) *provide an open data feed*, which is significantly higher than the percentage of State DOT districts without a large urban area (38 percent).

For the first time in 2023, freeway management agencies providing an open data feed were asked about the data standards/specifications used to share real-time transportation data in their open data feed.

As shown in Figure 33, the *Work Zone Data Exchange (WZDx) specification* (60 percent) is used by a majority of the 129 freeway management agencies with an open data feed. The *Traffic Management Data Dictionary (TMDD) standard* is used by 42 percent of agencies with an open data feed.

Only 2 percent of these agencies reported using *PC5-based C-V2X specification (5.9GHz).* In addition, 18 percent of freeway management agencies with an open data feed reported *other communications interface, data format, and/or protocols* (23 agencies), of which 15 agencies wrote in "XML" or "XML feed". About one fifth of agencies with an open data feed reported *don't know* (22 percent).



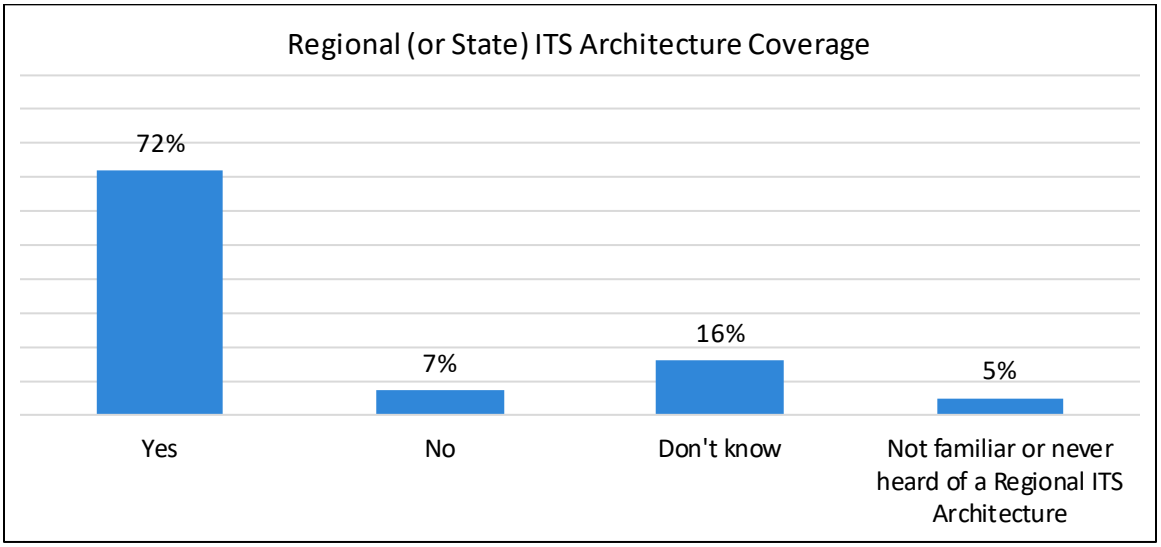
2023 Q20a; (n=129; 1% missing) *Source: USDOT*

Figure 33. Data Standards/Specifications for Open Data Feeds (Agencies Providing an Open Data Feed)

Regional (or State) ITS Architecture

Surveyed freeway management agencies were asked if their agency/region is covered by a Regional (or State) ITS Architecture.[22] Figure 34 shows that about three fourths of agencies reported being *covered by a Regional (or State) ITS Architecture* (72 percent).

Sixteen (16) percent of agencies reported *don't know*. Fewer than 10 percent of agencies reported their agencies/region were *not covered* (7 percent) or that they were *not familiar with or never heard of a Regional ITS Architecture* (5 percent).



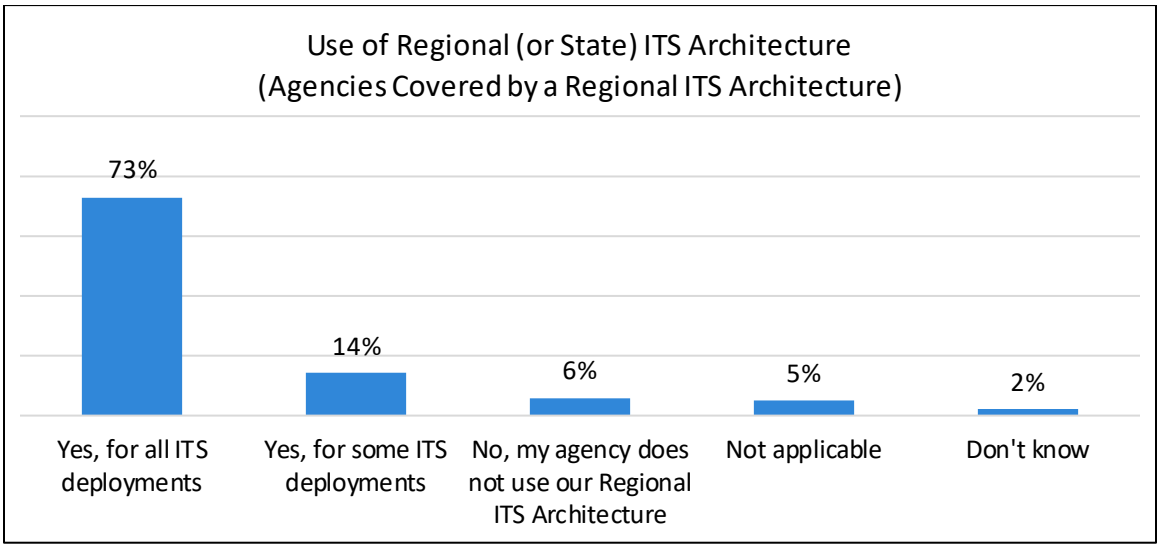
2023 Q47; (n=311; 0.6% missing) *Source: USDOT*

Figure 34. Regional (or State) ITS Architecture Coverage

[22] A Regional (or State) ITS Architecture is defined as "A specific, tailored framework for ensuring institutional agreement and technical integration for the implementation of ITS projects or groups of projects in a particular region. It functionally defines what pieces of the system are linked to others and what information is exchanged between them." For more information, see https://ops.fhwa.dot.gov/plan4ops/regional_its.htm.

Figure 35 shows to what extent the 224 freeway management agency respondents covered by a Regional (or State) ITS Architecture use it to support ITS deployments on freeways. About three fourths of covered agencies use their Regional (or State) ITS Architecture *for all ITS deployments* (73 percent), and 14 percent use it *for some ITS deployments*.

Six (6) percent of covered agencies reported *my agency does not use our Regional ITS Architecture*, and 5 percent reported *not applicable (i.e., my agency does not use federal funds for ITS deployment OR my agency has not deployed ITS).*

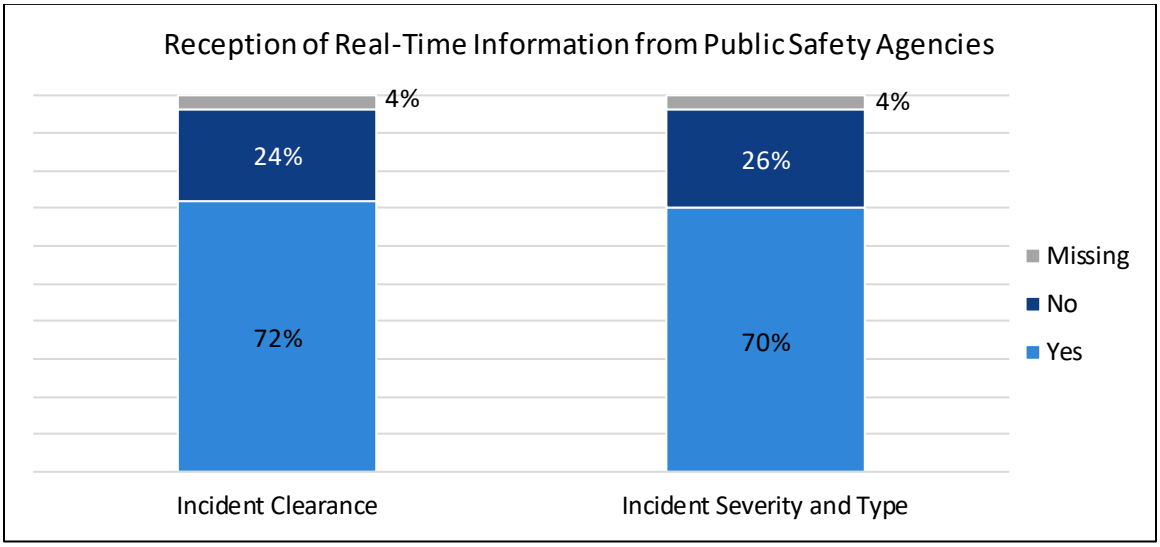


2023 Q48; (n=224; 0% missing) *Source: USDOT*

Figure 35. Use of Regional (or State) ITS Architecture (Agencies Covered by a Regional ITS Architecture)

Agency Coordination

Figure 36 shows nearly three fourths of freeway management agency respondents receive real-time *incident clearance* (72 percent) and *incident severity and type* (70 percent) information from public safety agencies. About one fourth of freeway management agencies each report *not receiving incident clearance* information (24 percent) and *not receiving incident severity and type* information (26 percent).



2023 Q51; (n=311) *Source: USDOT*

Figure 36. Reception of Real-Time Information from Public Safety Agencies

Along with receiving real-time information, freeway management agencies also provide real-time information on incidents (e.g., type and severity) and traffic to several different types of agencies.

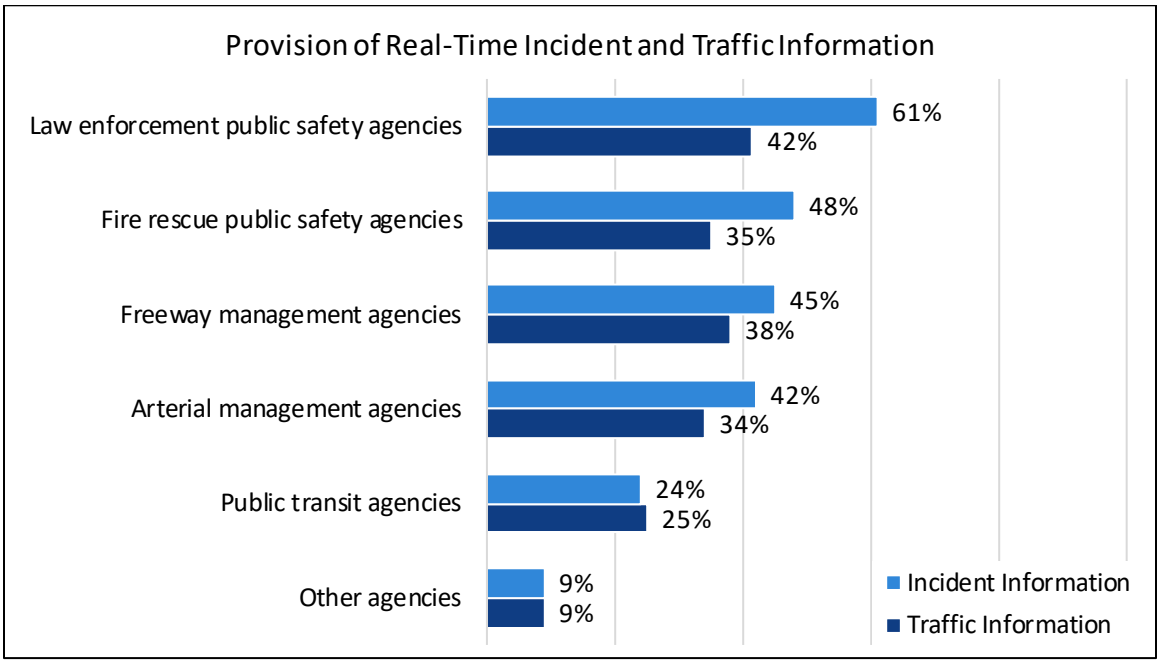
Figure 37 compares the provision of incident information to the provision of traffic information. A majority of freeway management agencies provide incident information to *law enforcement public safety agencies* (61 percent).

Nearly one half provide incident information to *fire rescue public safety agencies* (48 percent), *freeway management agencies* (45 percent), and *arterial management agencies* (42 percent). About one fourth of freeway management agencies provide incident information to *public transit agencies* (24 percent).

Fewer freeway management agencies provide traffic information to other agencies. Forty-two (42) percent of freeway management agencies provide real-time traffic information to *law enforcement public safety agencies*, and 38 percent provide real-time traffic information to *freeway management agencies*.

Over one third of respondents provide real-time traffic information to *fire rescue public safety agencies* (35 percent) and *arterial management agencies* (34 percent). One fourth of freeway management agencies provide real-time traffic information to *public transit agencies* (25 percent).

Both real-time incident and traffic information are provided to *other agencies* by 9 percent of freeway management agencies. Common write-in responses for both include "MPOs" (8 agencies each) and other emergency services agencies, such as "emergency medical services" (5 agencies for incident and 6 agencies for traffic information).

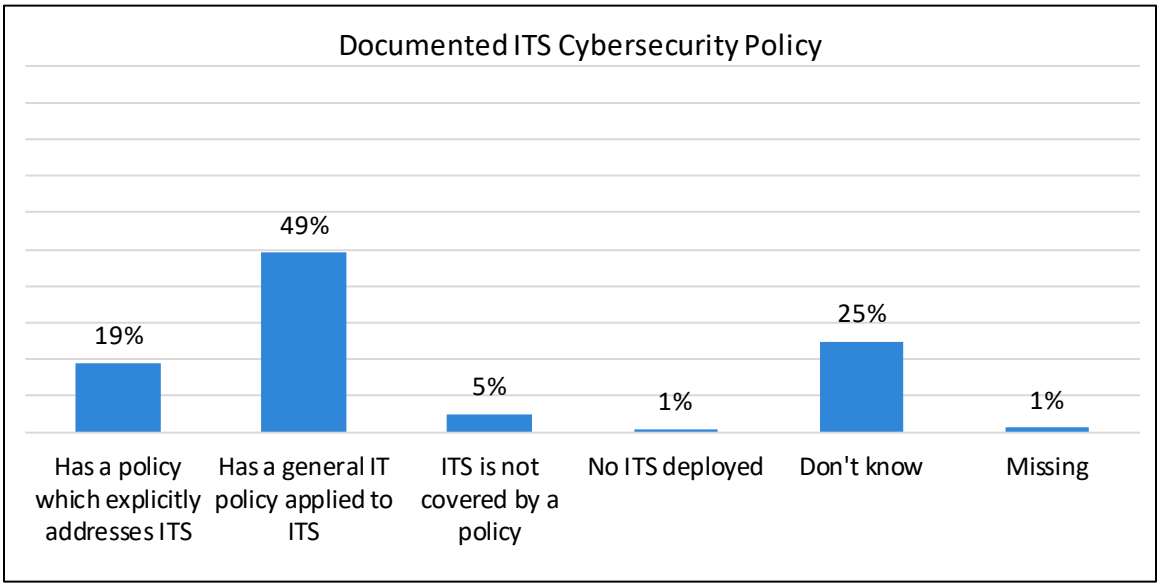


2023 Q52, Q53; (n=311) *Source: USDOT*

Figure 37. Provision of Real-Time Incident and Traffic Information

ITS Cybersecurity

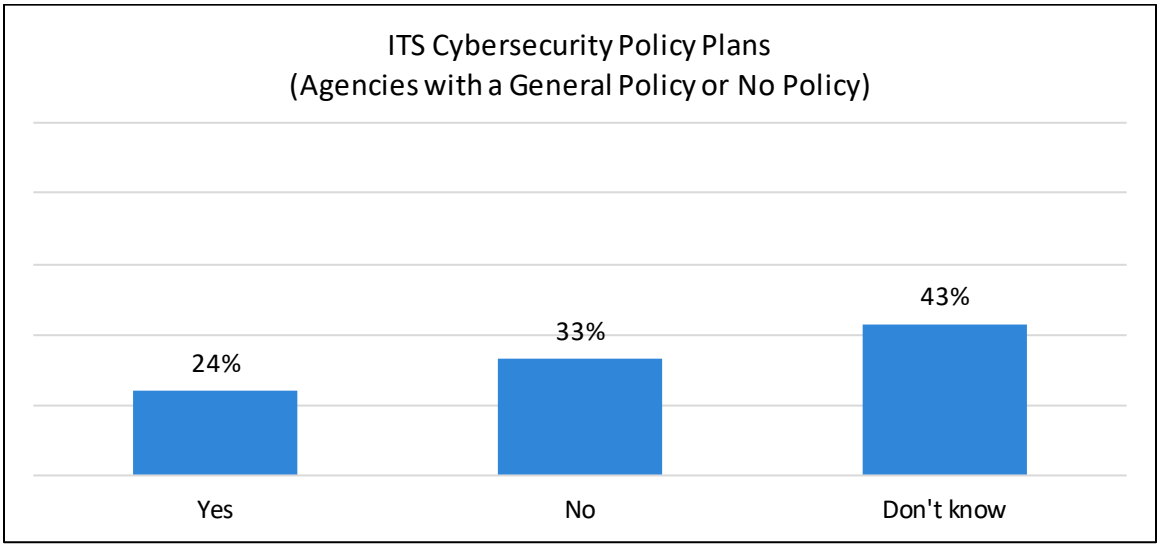
Figure 38 shows that about one fifth of all responding freeway management agencies *have a cybersecurity policy which explicitly addresses ITS* (19 percent), while nearly half *have a general information technology (IT) cybersecurity policy which applies to ITS* (49 percent). Five (5) percent reported that *ITS is not covered by a cybersecurity policy.* One fourth of freeway management agencies reported *don't know* (25 percent).



2023 Q41; (n=311) *Source: USDOT*

Figure 38. Documented ITS Cybersecurity Policy

For the 168 freeway management agency respondents that either have a general IT cybersecurity policy which applies to ITS or for which ITS is not covered by a cybersecurity policy, Figure 39 shows that one fourth *have plans to develop a cybersecurity policy that explicitly addresses ITS* (24 percent). One third reported *no plans to develop such a policy* (33 percent). Notably, 43 percent of freeway management agency respondents reported *don't know*.



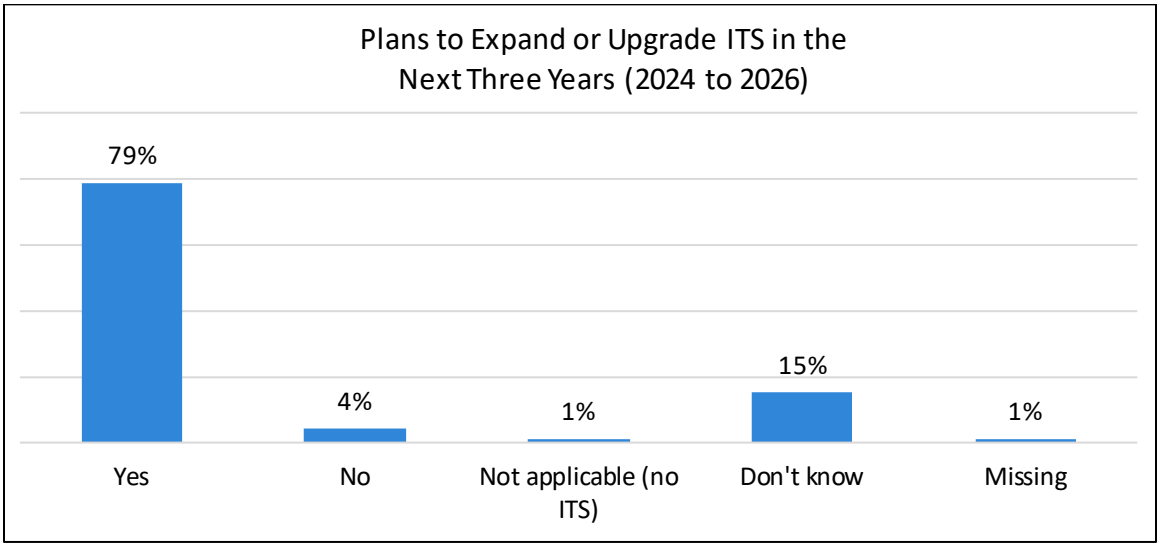
2023 Q42; (n=168; 0% missing) *Source: USDOT*

Figure 39. ITS Cybersecurity Policy Plans (Agencies with a General Policy or No Policy)

Future Deployment Planning

All 2023 freeway management agency respondents were asked about their ITS deployment plans in the next three years (2024 through 2026).

Figure 40 shows that a large majority of freeway management agencies *plan to expand or upgrade their ITS* (79 percent), and 4 percent reported *no plans to expand or upgrade their ITS*. Fifteen (15) percent of respondents reported *don't know*. Only 1 percent of freeway management agencies reported *not applicable, my agency has not deployed ITS.*



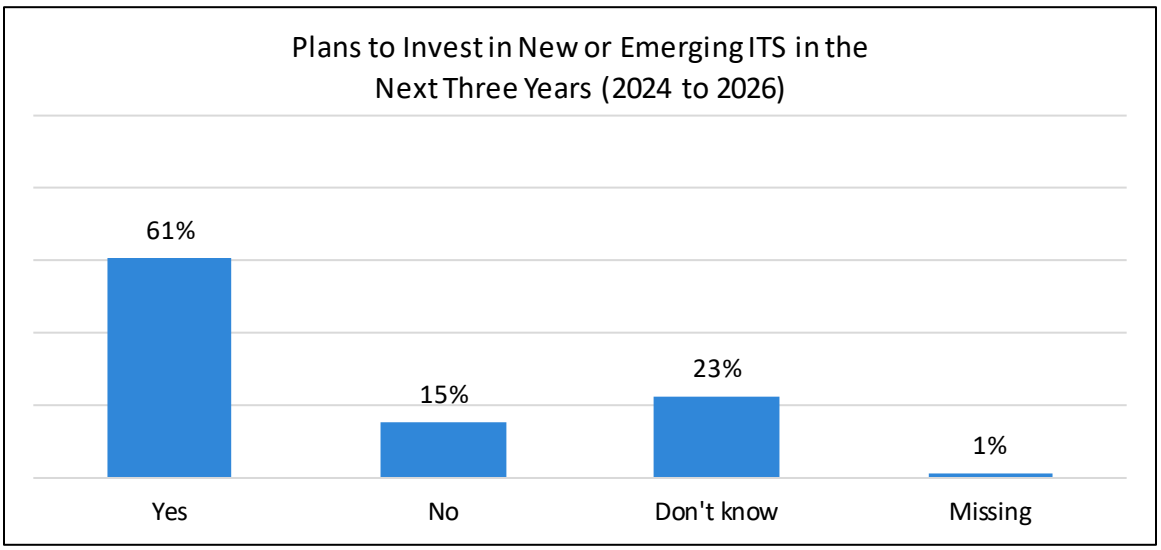
2023 Q54; (n=311) *Source: USDOT*

Figure 40. Plans to Expand or Upgrade ITS in the Next Three Years (2024 to 2026)

State DOT districts are significantly more likely than toll authorities to report *plans to expand or upgrade their ITS* (81 percent compared to 63 percent).

State DOT districts with a large urban area are significantly more likely to report *plans to expand or upgrade their ITS* compared to State DOT districts without a large urban area (88 percent compared to 75 percent).

Figure 41 shows a majority of freeway management agencies reported *plans to invest in new or emerging ITS* (61 percent) in the next three years (2024 to 2026). Twenty-three (23) percent of agencies reported *don't know*. Only 15 percent reported *no plans to invest in new or emerging ITS*.



2023 Q55; (n=311) *Source: USDOT*

Figure 41. Plans to Invest in New or Emerging ITS in the Next Three Years (2024 to 2026)

State DOT districts with a large urban area are significantly more likely to report *plans to invest in new or emerging ITS* in the next three years (2024 to 2026) compared to State DOT districts without a large urban area (72 percent compared to 53 percent).

Chapter 4. Freeway Management Agency Trend Analysis

This chapter provides trend analysis (where applicable and available) for the 2023 Freeway Management Survey and previous Freeway Management Surveys (1999-2020). The trend analysis provides valuable information to the ITS JPO and its stakeholders on how ITS technologies are evolving, including which technologies have low levels of deployment, which are gaining traction, and which may have reached maturity and are mainstream.

Trend analyses are available for the subset of 2023 State DOT districts and toll authorities in large metropolitan areas that have been previously surveyed as part of the historical Deployment Tracking Survey (i.e., part of the sample from 1999-2020). This subgroup within the 2023 Deployment Tracking Survey, referred to as "historically surveyed freeway management agencies," includes 98 freeway respondents. [23]

Since the 2023 ITS Deployment Tracking Survey is the first year in which the survey population was expanded to include agencies in smaller urban and rural areas, trend data are not available for the "total" response this year. The trend for the total (i.e., expanded) freeway population will be reported with the next ITS Deployment Tracking Survey.

Reporting Notes

This chapter is organized by ITS technologies and topics for which trend is available. The 2023 ITS Deployment Tracking Survey question number is referenced at the bottom of each figure. The number of respondents is referenced in each figure with the respective survey year.

Trend may be shown for an indicator (i.e., the percentage of agencies that deployed at least one technology of a given type of ITS, such as at least one ITS safety systems technology) or be shown for a list of response options for a given type of ITS.

In the historical ITS Deployment Tracking Survey (1999-2020), data only included the responses of freeway management agencies from large metropolitan areas, which have a higher incidence of ITS deployment than smaller urban and rural areas. As a result, the percentages shown in the trend tend to be higher than the percentages reported for all respondents in Chapter 3, which also include the responses of agencies in smaller urban and rural areas.

[23] Trends shown for previous Deployment Tracking Survey (e.g., 2020 and 2016 Deployment Tracking Survey) include the data for the responding agencies of each respective survey. While the overall sample of agencies invited to participate in the historical Deployment Tracking Survey (1999-2020) remained stable across surveys, the agencies responding to the survey varied, to some degree, with each survey effort. Some agencies consistently responded to the Deployment Tracking Survey, whereas others did not. The trend for a given year represents the data of responding agencies for that year.

When reporting trends, significance testing was performed at a significance level of 0.05, with a 95 percent confidence interval.

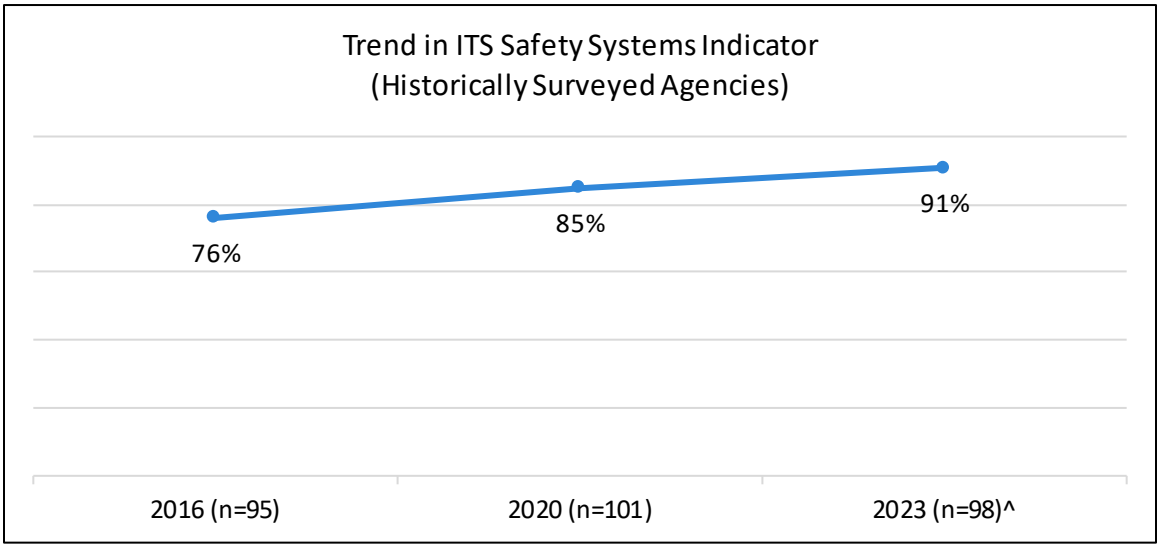
Safety-Related ITS Trend Analysis

The trends available for safety-related ITS include:

- ITS safety systems technologies
- Work zone ITS technologies
- Automated enforcement technologies
- Incident detection and verification methods

ITS Safety Systems Technologies

Figure 42 shows that while the trend has remained relatively stable since 2020, there has been significant growth since 2016 in the deployment of ITS safety systems technologies among the historically surveyed freeway management agencies (from 76 percent in 2016 to 91 percent in 2023). In 2023, almost all historically surveyed freeway management agencies deploy at least one safety system. [24]

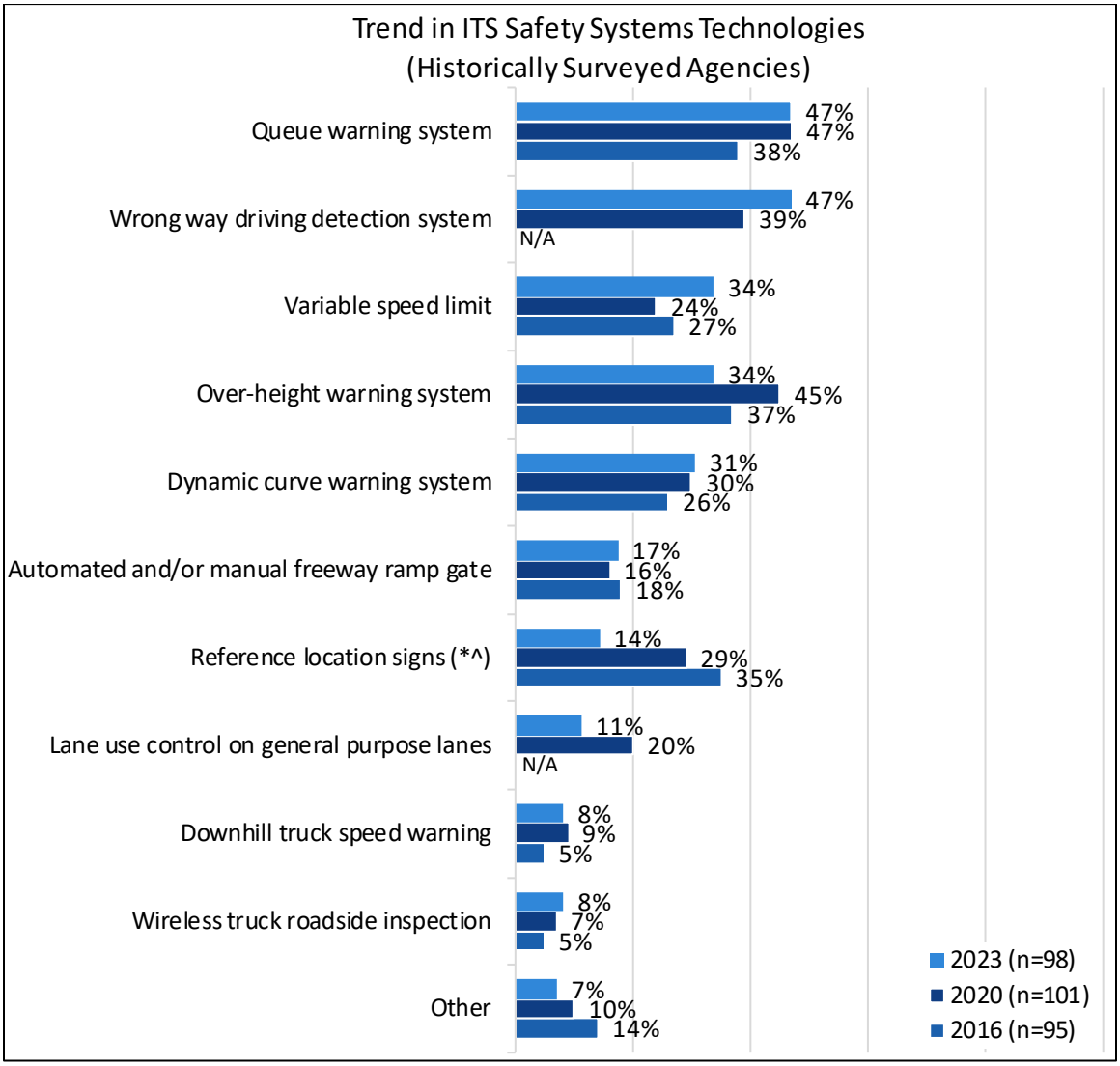


2023 Q13 *Source: USDOT*
^statistically significant difference between 2016 & 2023

Figure 42. Trend in ITS Safety Systems Indicator (Historically Surveyed Agencies)

[24] The 2013 safety systems use is not shown because the data are not comparable (i.e., surveyed technologies were substantially different in 2013 than in subsequent years).

Historically surveyed freeway management agencies deploy an average of 3.2 different ITS safety systems technologies in 2023. As shown in Figure 43, *queue warning systems* (47 percent) remains one of the most widely deployed safety system technologies among historically surveyed freeway management agencies, and deployment levels are consistent between 2020 and 2023. The only significant change in ITS safety system technology deployment since 2020 is the decreased use of *reference location signs* (from 29 percent in 2020 to 14 percent in 2023). New response options in 2023 do not have trend and therefore are not shown in the figure below. [25]



2023 Q13 *Source: USDOT*

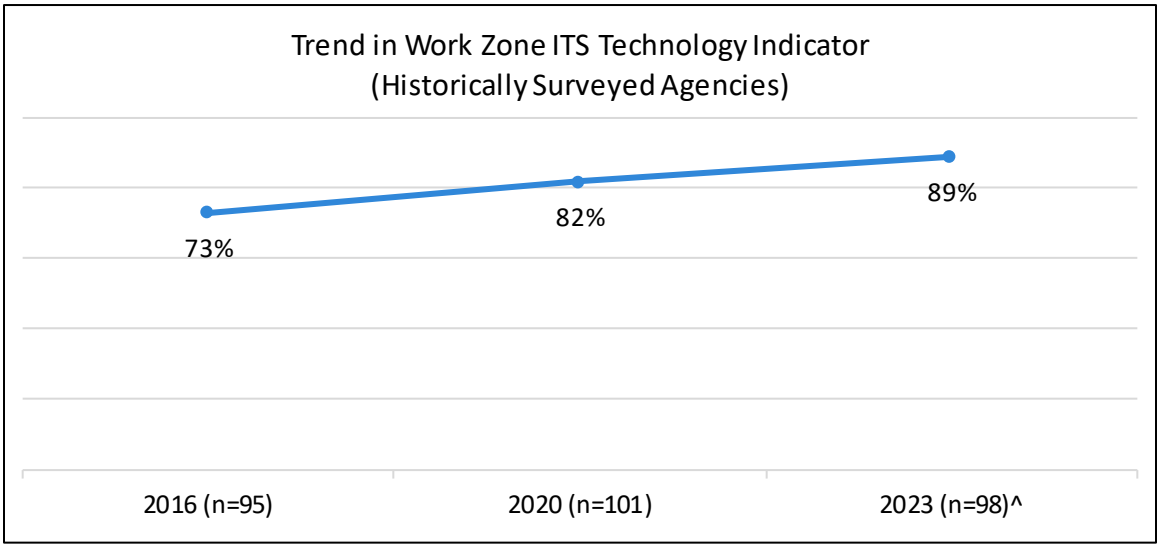
** statistically significant difference between 2020 & 2023;*
^statistically significant difference between 2016 & 2023

Figure 43. Trend in ITS Safety Systems Technologies (Historically Surveyed Agencies)

[25] New response options in 2023 were *automated visibility warning systems* (deployed by 24 percent of historically surveyed agencies), and *wildlife warning systems* (deployed by 5 percent of historically surveyed agencies).

Work Zone ITS Technologies

Similar to ITS safety systems, Figure 44 shows that the deployment of work zone ITS technologies among historically surveyed freeway management agencies has grown significantly since 2016 (from 73 percent in 2016 to 89 percent in 2023) but has remained stable since 2020.



2023 Q17 *Source: USDOT*
^statistically significant difference between 2016 & 2023

Figure 44. Trend in Work Zone ITS Technology Indicator (Historically Surveyed Agencies)

Historically surveyed freeway management agencies deploy an average of 5.0 work zone ITS technologies in 2023, which is significantly higher than the average of 2.8 work zone ITS technologies in 2020. The increase is likely due, in part, to the addition of two new response options – *portable DMS* (82 percent) and *portable dynamic speed feedback/speed radar trailers* (63 percent). These technologies were frequent write-in responses to the *Other* response in the 2020 ITS Deployment Tracking Survey, and as a result were added to the 2023 survey. New response options do not have trend and therefore are not shown in the figure below. [26]

[26] New response options in 2023 include *portable DMS* (deployed by 82 percent of historically surveyed agencies), and *portable dynamic speed feedback/speed radar trailer* (deployed by 63 percent of historically surveyed agencies).

Figure 45 shows that the work zone ITS technologies with significant increases in deployment between 2020 and 2023 include *variable speed limits,* up 18 percentage points since 2020 to 34 percent in 2023, and *dynamic lane merge systems,* up 15 percentage points since 2020 to 25 percent in 2023.

Other responses decreased significantly since 2020, but this may be due to the addition of the new response categories, which had been frequent write-in responses to the *Other* response in the 2020 ITS Deployment Tracking Survey.

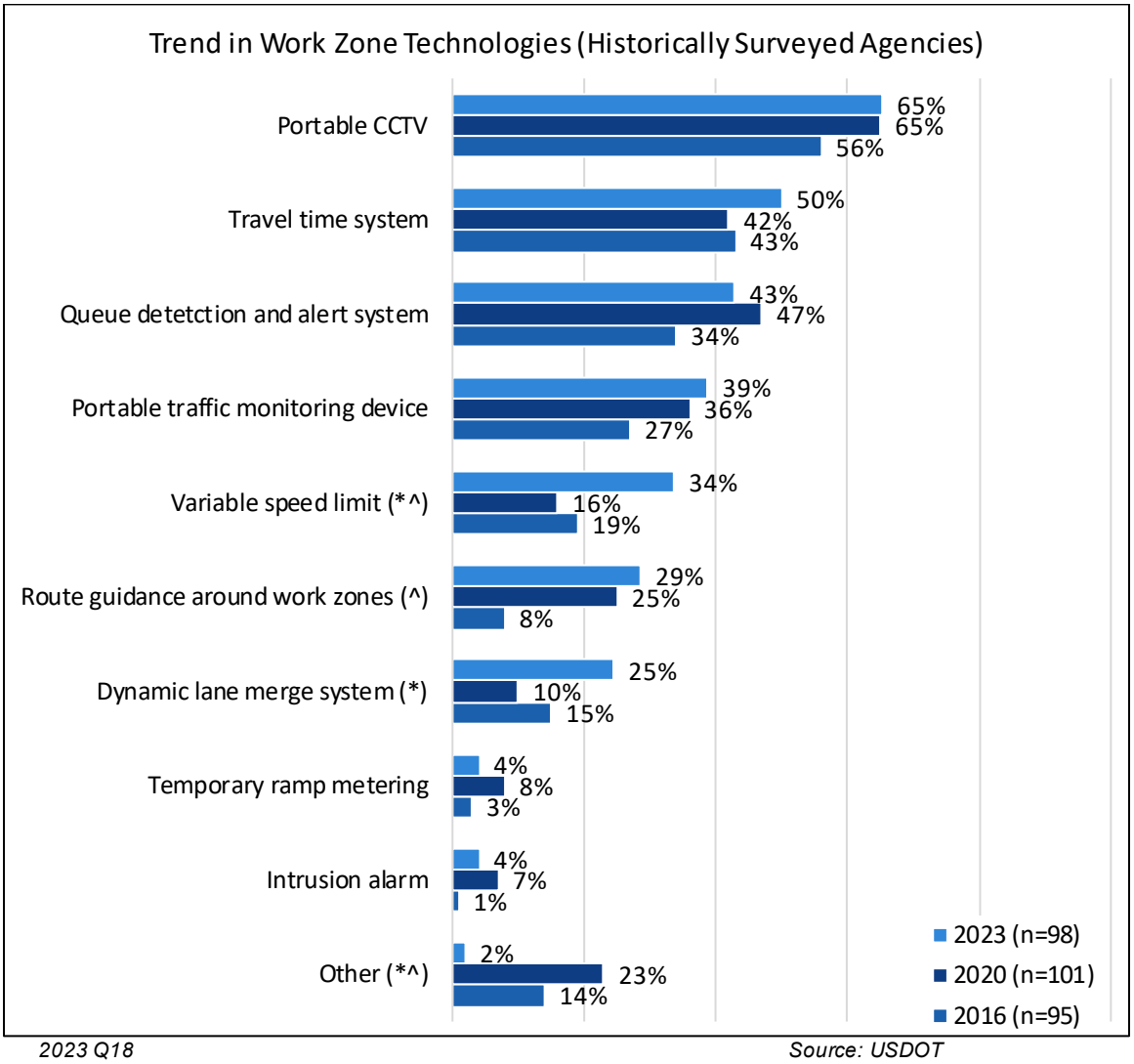


Figure 45. Trend in Work Zone Technologies (Historically Surveyed Agencies)

Automated Enforcement

Deployment of automated enforcement technologies on freeways was stable over the period from 2016 to 2023, with no significant differences among historically surveyed freeway management agencies, as shown in Figure 46.

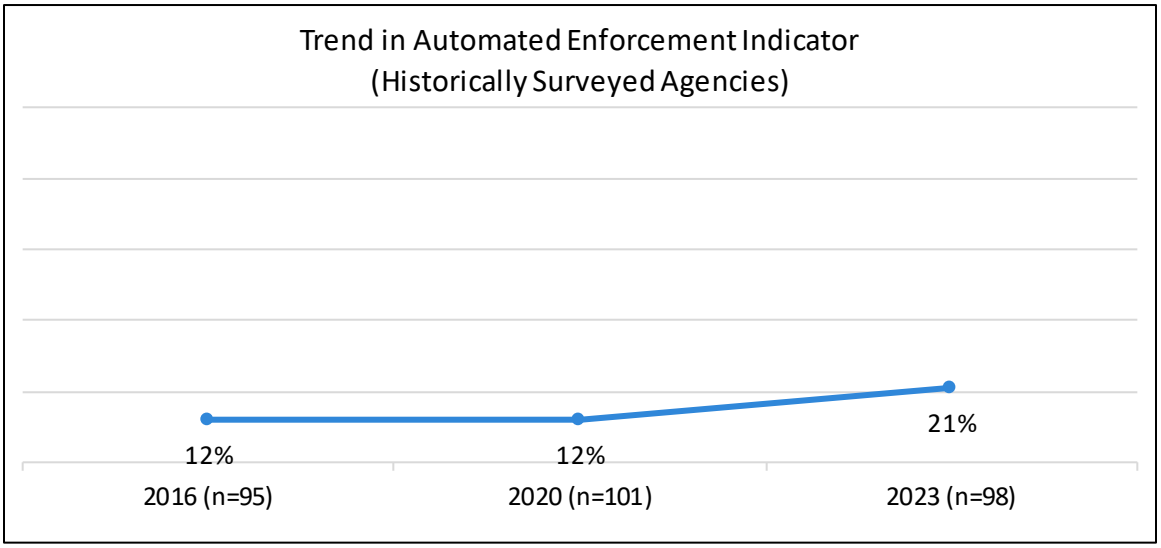


Figure 46. Trend in Automated Enforcement Indicator (Historically Surveyed Agencies)

Incident Detection and Verification

All historically surveyed freeway management agencies deploy at least one incident detection or verification method (100 percent). This is a significant increase from 93 percent of agencies in 2020.

Figure 47 shows *CCTV* has neared universal adoption among historically surveyed freeway management agencies, growing from 90 percent in 2020 to 98 percent in 2023. The use of *external data (e.g., data provided by crowdsourcing, commercial providers, or citizen-reported)* by historically surveyed freeway management agencies also grew significantly from 40 percent in 2020 to 66 percent in 2023.

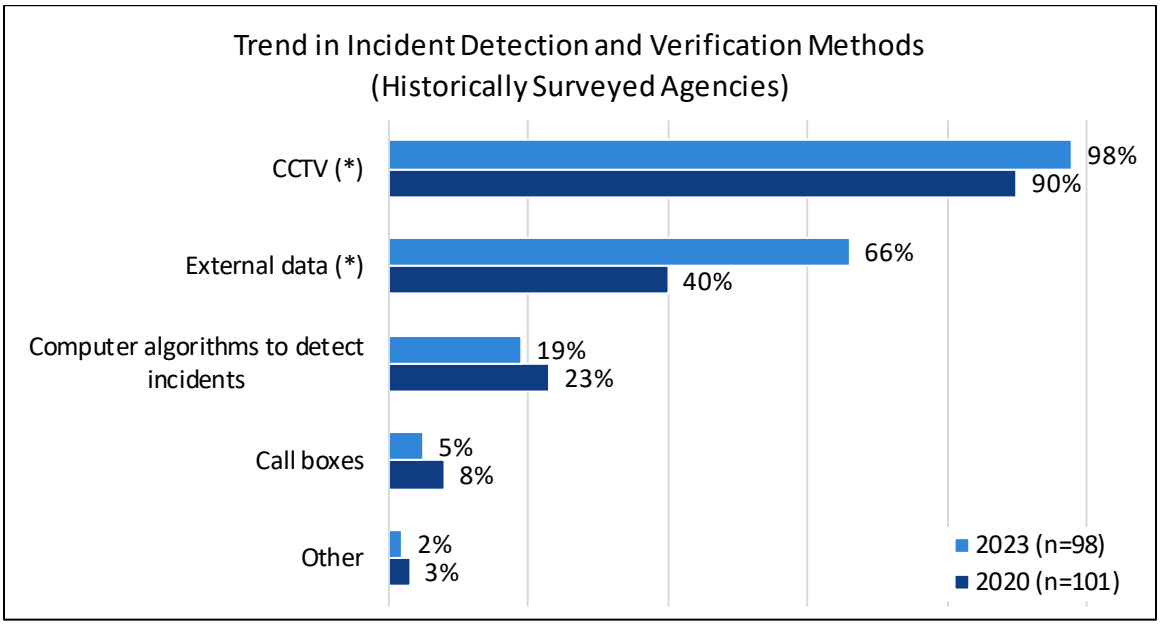


Figure 47. Trend in Incident Detection and Verification Methods (Historically Surveyed Agencies)

Real-Time Data Collection Trend Analysis

The trends available for real-time data collection include:

- Roadside ITS infrastructure technologies
- Vehicle probe readers
- External data sources

Roadside ITS Infrastructure Technologies

The percentage of historically surveyed freeway management agencies deploying at least one roadside ITS infrastructure technology to collect real-time data grew significantly from 74 percent in 2020 to 92 percent in 2023 – an increase of 18 percentage points. [27]

Figure 48 shows that, among historically surveyed freeway management agencies, the deployment of *inductive loops*, *video imaging detection,* and *magnetometers* grew significantly since 2020. The deployment of *video imaging detection* increased the most (27 percentage points from 13 percent in 2020 to 40 percent 2023). Deployment of *inductive loops* increased by 17 percentage points from 42 percent in 2020 to 59 percent in 2023, and the deployment of *magnetometers* nearly doubled from 9 percent in 2020 to 19 percent in 2023.

Given this increase in roadside infrastructure deployment, there is a corresponding significant decrease in historically surveyed freeway management agencies reporting *no roadside infrastructure technologies are deployed* (from 24 percent in 2020 to 7 percent in 2023). [28]

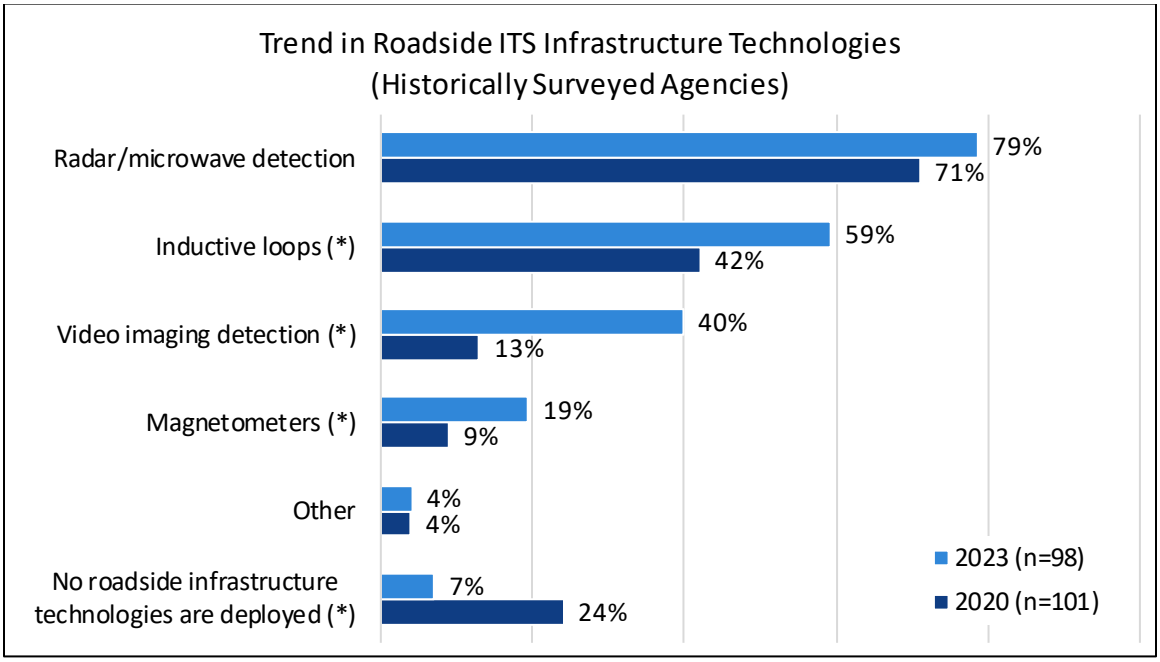


Figure 48. Trend in Roadside ITS Infrastructure Technologies (Historically Surveyed Agencies)

[27] Trend prior to 2020 is not shown due to changes in question format. Previous ITS Deployment Tracking Surveys asked respondents to enter the number of each technology deployed, while the 2020 and 2023 question asked respondents to select specific technologies deployed, without asking for the number of each.

[28] New response option in 2023 is *Infrared/thermal detection* deployed by 17 percent of historically surveyed agencies

Vehicle Probe Readers

Figure 49 shows that among historically surveyed freeway management agencies, deployment of *license plate readers* grew significantly from 4 percent in 2020 to 13 percent in 2023.

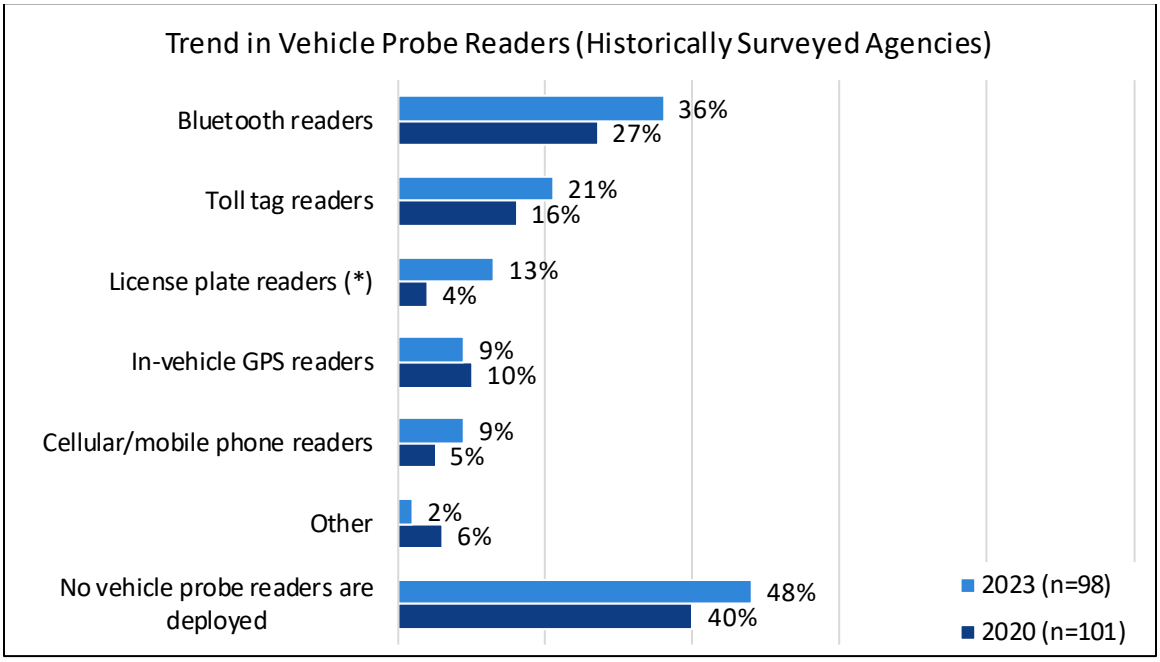
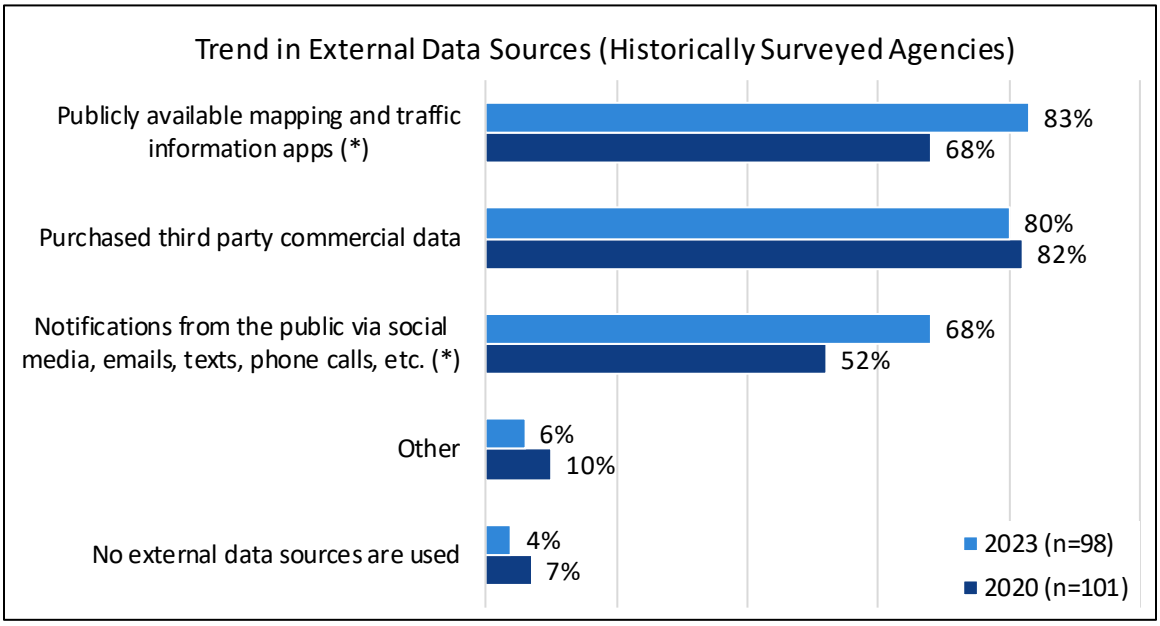


Figure 49. Trend in Vehicle Probe Readers (Historically Surveyed Agencies)

External Data Sources

The use of at least one external data source for freeway management is nearly universal among historically surveyed freeway management agencies (96 percent) and is similar to the percentage of agencies in 2020 (93 percent).

With the overall use of external data sources being stable, a significant increase in the usage of two types of external data sources since 2020 suggests agencies are more likely to be using multiple sources of external data. Figure 50 shows use of *publicly available mapping and traffic information apps* increased 15 percentage points from 68 percent in 2020 to 83 percent in 2023, and use of *notifications from the public* increased 16 percentage points from 52 percent in 2020 to 68 percent in 2023 among historically surveyed freeway management agencies. [29]



2023 Q3 *Source: USDOT*

**statistically significant difference between 2020 & 2023*

Figure 50. Trend in External Data Sources (Historically Surveyed Agencies)

Telecommunications Technologies Trend Analysis

Similar to the findings from 2020, almost all historically surveyed freeway management agencies report using at least one wired telecommunications technology (96 percent in 2023 and 94 percent in 2020), and a similar percentage report using at least one wireless telecommunications technology (93 percent in 2023 and 93 percent in 2020).

[29] New response option in 2023 is *Other transportation agency data (e.g., Other State DOTs or districts, MPOs, etc.)* deployed by 46 percent of historically surveyed freeway management agencies.

However, since 2020, there has been a significant increase in the deployment of *5G New Radio and small cell infrastructure* among historically surveyed freeway management agencies, increasing 17 percentage points (from 19 percent in 2020 to 36 percent in 2023). By contrast, deployment of *cellular (GPRS-2G or 3G)* decreased significantly by 18 percentage points since 2020, from 27 percent to 9 percent as shown in Figure 51.

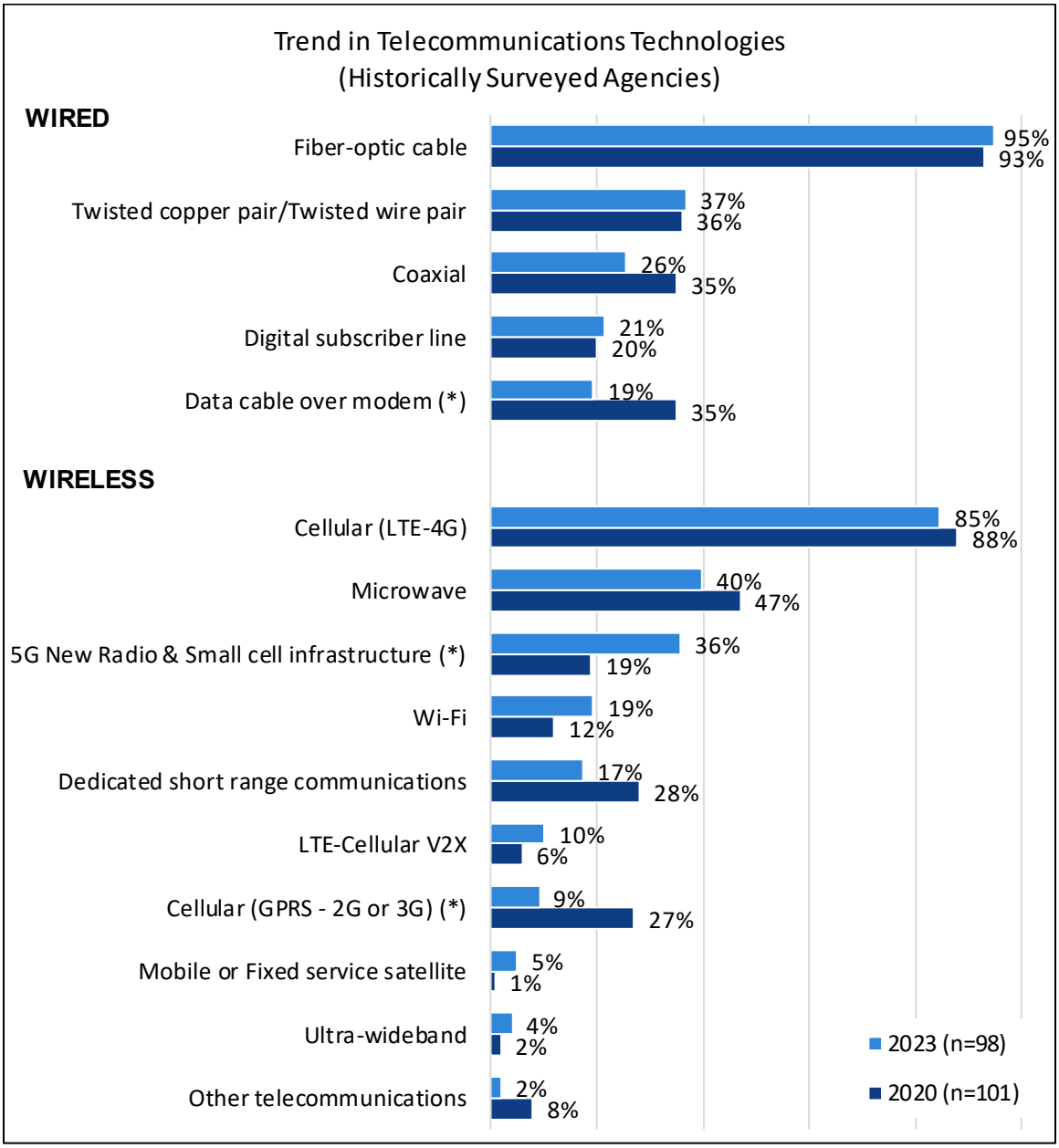


Figure 51. Trend in Telecommunications Technologies (Historically Surveyed Agencies)

Traffic Management Trend Analysis

The trends available for traffic management technologies and strategies include:

- Managed lanes
- Ramp metering
- ICM

Managed Lanes

Among historically surveyed freeway management agencies in 2023, 40 percent reported either *their agency* and/or *another entity (e.g., public/private partnership) operate managed lanes* on freeways. This is consistent compared to the percentage of agencies that reported doing so in 2020.

However, Figure 52 shows that the deployment of *hard shoulder running* technologies increased significantly since 2020 (from 5 percent to 13 percent). There were no other statistically significant changes since 2020. [30]

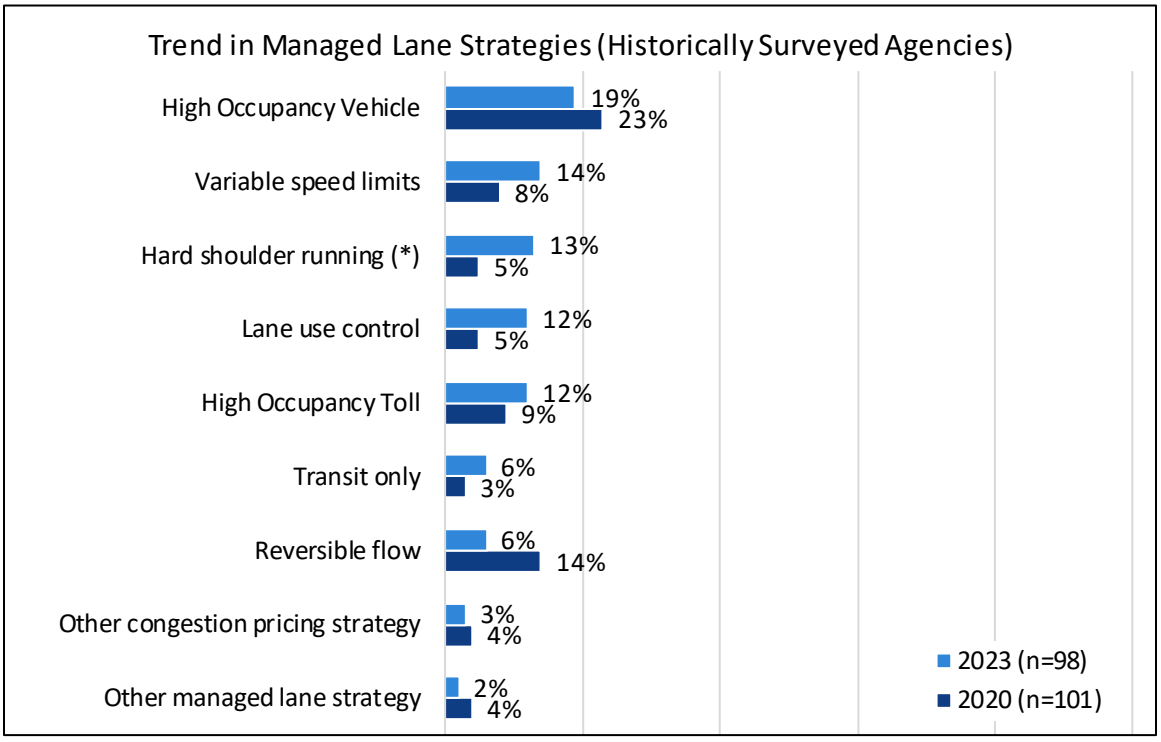


Figure 52. Trend in Managed Lane Strategies (Historically Surveyed Agencies)

[30] New response option in 2023 is *Truck Only* deployed by 1 percent of historically surveyed freeway management agencies.

Ramp Metering

The trend for the deployment of ramp metering among historically surveyed freeway management agencies remained stable between 2020 and 2023.

In each survey, over one third of agencies with ramps deploy *entrance ramp metering* (39 percent in 2023 and 37 percent in 2020), and nearly two thirds reported *not deploying ramp metering* (61 percent in 2023 and 63 percent in 2020) as shown in Figure 53.

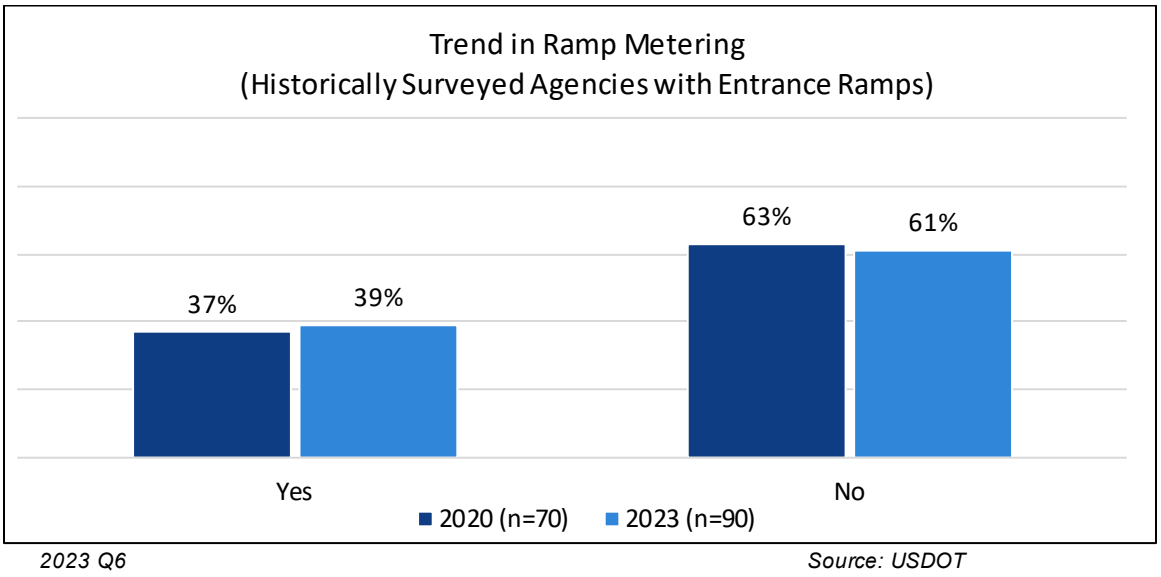
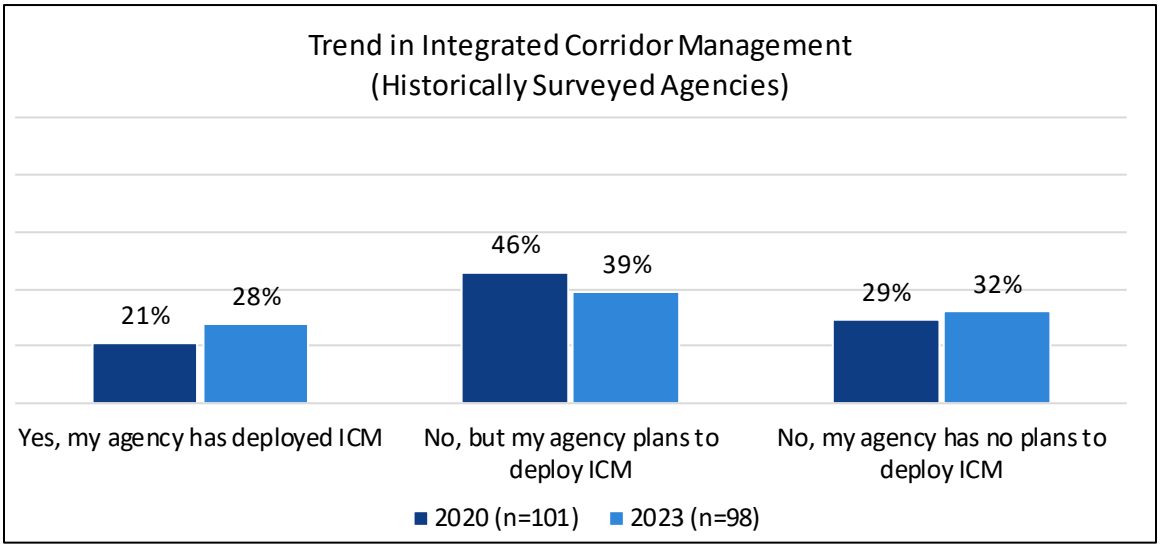


Figure 53. Trend in Ramp Metering (Historically Surveyed Agencies with Entrance Ramps)

Integrated Corridor Management

Figure 54 shows over one fourth of historically surveyed freeway management agencies *deploy ICM* (28 percent) in 2023, and trend since 2020 is stable across all response options, with no statistically significant changes.



2023 Q50 *Source: USDOT*

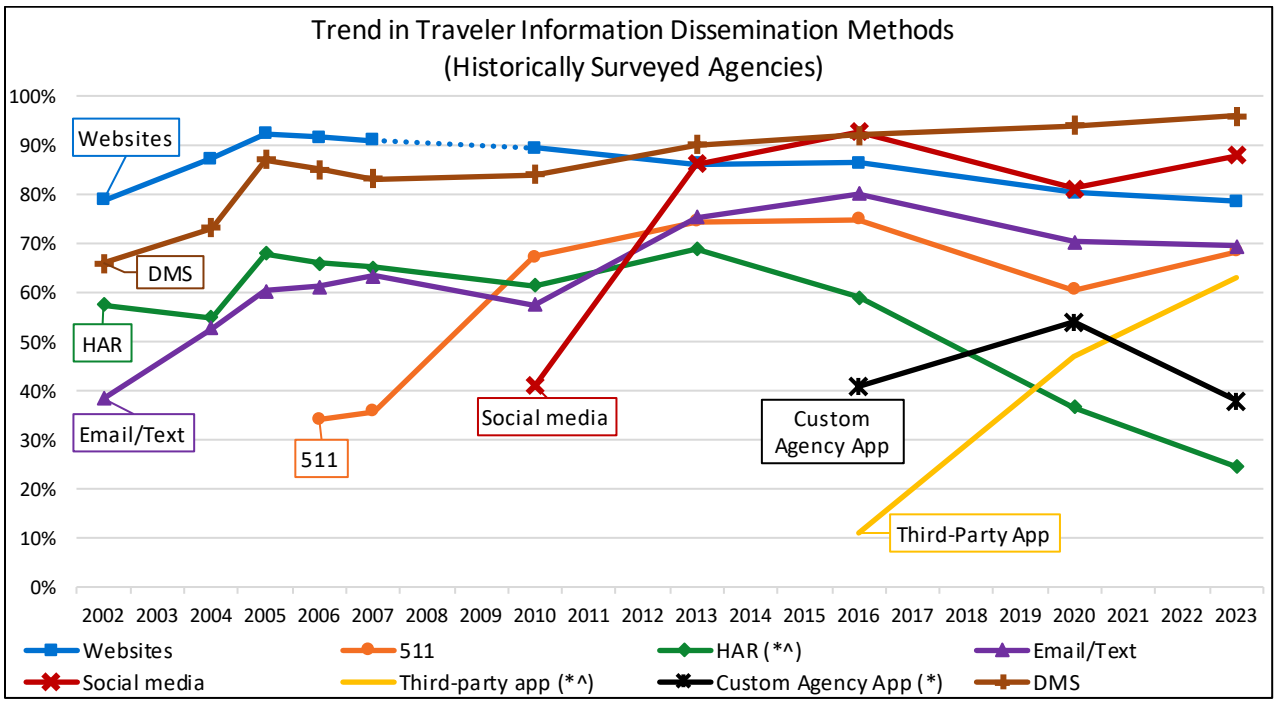
Figure 54. Trend in Integrated Corridor Management (Historically Surveyed Agencies)

Traveler Information Dissemination Trend Analysis

Similar to the 2020 Deployment Tracking Survey results, dissemination of real-time traveler information is nearly universal among historically surveyed freeway management agencies (98 percent in 2020 and 99 percent in 2023), reflecting the maturity of traveler information dissemination technologies and methods.

Figure 55 shows that since 2013, *DMS* (96 percent) and *social media* (88 percent) have remained the most deployed traveler information dissemination methods among historically surveyed freeway management agencies. From 2020 to 2023, *third-party mobile apps* increased a significant 16 percentage points (from 47 percent in 2020 to 63 percent in 2023) while *agency-branded mobile apps* decreased significantly (from 54 percent in 2020 to 38 percent in 2023). *HAR* also decreased by a significant 12 percentage points between 2020 and 2023 (from 37 percent to 24 percent).

Further, the use of HAR has appeared to decline significantly over the lifecycle of the Deployment Tracking Survey, from nearly 70 percent in the early 2000s to under 30 percent in 2023. Changes in the use of *websites*, *social media*, *email/text*, and *511* were not significant between 2020 and 2023.



2023 Q19 *Source: USDOT*

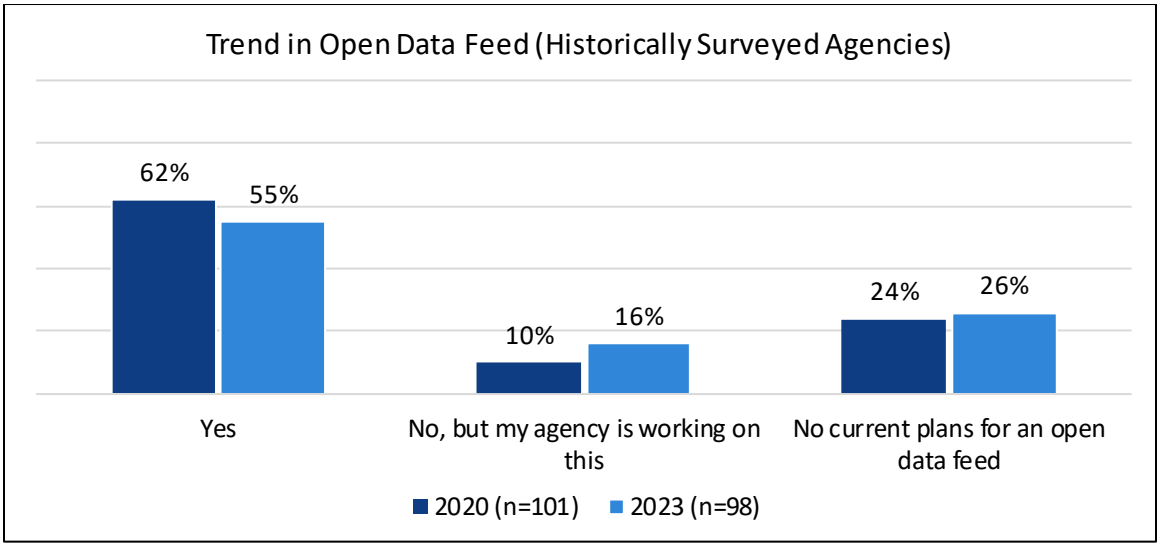
**statistically significant difference between 2020 & 2023; ^statistically significant difference between 2016 & 2023*

Note: In 2007 "websites" was not a response option, so data for that survey year were imputed, as represented by the dashed line between 2006 and 2010.

Figure 55. Trend in Real-Time Traveler Information Dissemination Methods (Historically Surveyed Agencies)

Open Data Feed

Figure 56 shows over half of historically surveyed freeway management agencies provide an *open data feed* (55 percent) in 2023. While lower, this decrease is not significantly different from the 62 percent of agencies that reported an open data feed in 2020. There were no significant changes across responses.

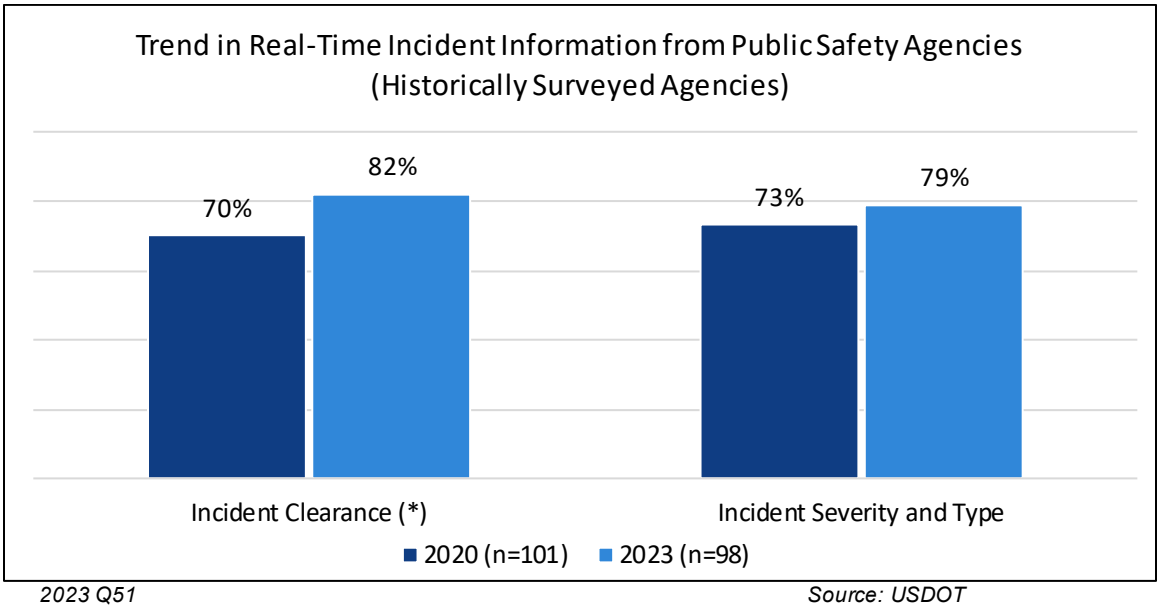


2023 Q20 *Source: USDOT*

Figure 56. Trend in Open Data Feed (Historically Surveyed Agencies)

Agency Coordination Trend Analysis

Figure 57 shows that in 2023, a large majority of historically surveyed freeway management agencies receive real-time *incident clearance* (82 percent) and *incident severity and type* (79 percent) information from public safety agencies. Reception of *incident clearance* information increased a significant 12 percentage points from 2020 to 2023.



2023 Q51 *Source: USDOT*

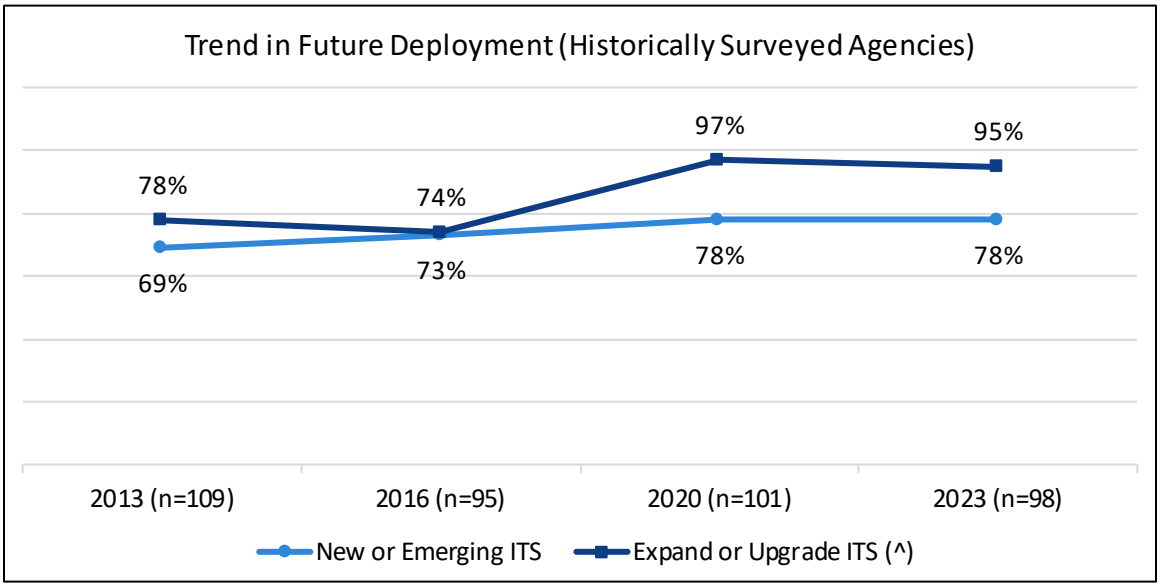
**statistically significant difference between 2020 & 2023*

Figure 57. Trend in Real-Time Incident Information from Public Safety Agencies (Historically Surveyed Agencies)

Future Deployment Planning Trend Analysis

Figure 58 shows that in both 2020 and 2023 consistently high levels of historically surveyed freeway management agencies plan to *invest in new or emerging ITS* (97 percent in 2020 and 95 percent in 2023) and plan to *expand or upgrade current ITS* (78 percent in 2020 and 2023) over the next three years.

The percentage of historically surveyed freeway management agencies with plans to *expand or upgrade current ITS* has significantly increased since 2016.



2023 Q54, Q55 *Source: USDOT*
^statistically significant difference between 2016 & 2023

Figure 58. Trend in Future Deployment (Historically Surveyed Agencies)

Chapter 5. Conclusions

With the 2023 ITS Deployment Tracking Survey, the ITS JPO significantly expanded the geographic coverage of the Freeway Management Survey to include all State DOT districts and toll authorities that manage freeways, enabling the reporting of ITS deployment data on a nationwide basis. The 2023 survey found that most responding freeway management agencies are deploying ITS, with a large majority of freeway management agencies having deployed at least one ITS safety systems technology, work zone ITS technology, roadside ITS infrastructure technology, and/or incident detection technology. Mature ITS technologies deployed by a large majority of responding agencies in 2023 include:

- **Roadside ITS infrastructure technologies**: *radar/microwave detection* (69 percent); *inductive loops* (57 percent)
- **Incident detection**: *CCTV* (85 percent)
- **Work zone ITS technologies**: *portable DMS* (70 percent); *portable dynamic speed feedback signs* (59 percent); *portable CCTV* (51 percent)
- **ITS for road weather management**: *permanent RWIS/ESS* (79 percent)
- **Telecommunications technologies**: *fiber-optic cable* (79 percent); *cellular LTE-4G* (79 percent)

In addition, the survey found that the deployment of ITS technologies tends to be higher among State DOT districts with at least one large urban area (either a city with 100,000 or more people or a county with 950,000 or more people) compared to State DOT districts without a large urban area (with the notable exception of road weather ITS).

Among historically surveyed freeway management agencies (i.e., from a subset of large metropolitan areas), it is possible to assess some ITS deployment trends because these agencies were surveyed as part of the ITS Deployment Tracking Survey in previous years. The trend data for these historically surveyed freeway management agencies show increased deployment levels for a range of ITS technologies since the 2020 survey.

The following ITS technologies experienced increased deployment since 2020:

- **Work zone ITS technologies**: *variable speed limit signs* (from 16 percent in 2020 to 34 percent in 2023) and *dynamic lane merge systems* (from 10 percent in 2020 to 25 percent in 2023)
- **Incident detection and verification methods:** *CCTV* (from 90 percent in 2020 to 98 percent in 2023) and *external data* (from 40 percent in 2020 to 66 percent in 2023)
- **External data sources:** *publicly available mapping and traffic information apps* (from 68 percent in 2020 to 83 percent in 2023) and *notifications from the public via social media, email, texts, and phone* (from 52 percent in 2020 to 68 percent in 2023)

- **Roadside ITS infrastructure:** *inductive loops* (from 42 percent in 2020 to 59 percent in 2023), *video imaging detection* (from 13 percent in 2020 to 40 percent in 2023), and *magnetometers* (from 9 percent in 2020 to 19 percent in 2023)

- **Vehicle probe readers:** *license plate readers* (from 4 percent in 2020 to 13 percent in 2023)

- **Telecommunication technologies:** *5G New Radio and small cell infrastructure* (from 19 percent in 2020 to 36 percent in 2023)

- **Traveler information:** *third-party mobile apps* (from 47 percent in 2020 to 63 percent in 2023)

Given the 2023 survey is the first ITS Deployment Tracking Survey in which smaller urban and rural areas were surveyed, there are no trend data for these new populations. The 2023 ITS Deployment Tracking Survey establishes a baseline for freeway management agencies' deployment of ITS nationwide. With the next ITS Deployment Tracking Survey (anticipated in 2026), it will be possible to assess trends for this nationwide sample.

Appendix A. Changes in the Freeway Management Survey Methodology

As summarized in this report, the geographic coverage of the 2023 Deployment Tracking Survey was greatly expanded. The historical Deployment Tracking Survey (1999 – 2020) included a subset of large metropolitan areas, including 114 large metropolitan areas in the 2020 Deployment Tracking Survey.[31] In 2023, survey coverage was expanded to include small metropolitan, micropolitan, and rural areas, in addition to previously surveyed large metropolitan areas. The changes to the survey methodology are described in Table 16.

Table 16. Summary of Methodology Changes to the Freeway Survey and the Resulting Benefits

Historical Deployment Tracking Survey (1999 – 2020)	New Methodology (2023+)	Benefits
A panel of State DOT districts and toll authorities in large metropolitan areas (n=139)	A census of all State DOT districts and toll authorities that manage freeways (n=400)	Enables the nationwide measurement of State DOT districts' and toll authorities' ITS deployment on freeways.

[31] Originally the survey was administered to agencies in 78 large metropolitan areas, and in 2002, the survey was expanded to include 108 large metropolitan areas. Following the 2010 Census, updates were made to metropolitan area definitions, resulting in the addition of six new metropolitan areas to the 2013 Deployment Tracking Survey, for a total of 114 surveyed metropolitan areas. These 114 large metropolitan areas continued to be surveyed in 2016 and 2020.

Appendix B. 2023 Freeway Management Survey Additional Findings

This Appendix includes the findings for questions that are not reported in the main body of the report.

Q36: Please indicate how your agency is using Twisted copper pair/Twisted wire pair to enable ITS on freeways.

Table 17. Telecommunications Technologies: Use of Twisted copper pair/Twisted wire pair

Uses	Percent of Freeway management agencies Base: Agencies using Twisted copper pair/Twisted wire pair
Commercial Vehicle Operations	14%
Data Management	47%
Maintenance and Construction	36%
Parking Management	11%
Public Safety	21%
Public Transportation	14%
Support	30%
Sustainable Travel	7%
Traffic Management	61%
Traveler Information	53%
Vehicle Safety	16%
Weather	41%
Other	1%
Don't know	4%
Missing	25%

2023 Q36; (n=98) *Source: USDOT*

Q36: Please indicate how your agency is using Digital subscriber line to enable ITS on freeways.

Table 18. Telecommunications Technologies: Use of Digital subscriber line

Uses	Percent of Freeway management agencies Base: Agencies using Digital subscriber line
Commercial Vehicle Operations	37%
Data Management	61%
Maintenance and Construction	39%
Parking Management	4%
Public Safety	37%
Public Transportation	12%
Support	41%
Sustainable Travel	12%
Traffic Management	80%
Traveler Information	82%
Vehicle Safety	16%
Weather	71%
Other	2%
Don't know	4%
Missing	6%

2023 Q36; (n=49) *Source: USDOT*

Q36: Please indicate how your agency is using Data cable over modem to enable ITS on freeways.

Table 19. Telecommunications Technologies: Use of Data cable over modem

Uses	Percent of Freeway management agencies Base: Agencies using Data cable over modem
Commercial Vehicle Operations	22%
Data Management	40%
Maintenance and Construction	20%
Parking Management	2%
Public Safety	18%
Public Transportation	6%
Support	20%
Sustainable Travel	2%
Traffic Management	54%
Traveler Information	50%
Vehicle Safety	14%
Weather	44%
Other	0%
Don't know	12%
Missing	32%

2023 Q36; (n=50) *Source: USDOT*

Q36: Please indicate how your agency is using 5G New Radio and Small cell infrastructure to enable ITS on freeways.

Table 20. Telecommunications Technologies: Use of 5G New Radio and Small cell infrastructure

Uses	Percent of Freeway management agencies Base: Agencies using 5G New Radio and Small cell infrastructure
Commercial Vehicle Operations	14%
Data Management	37%
Maintenance and Construction	36%
Parking Management	8%
Public Safety	29%
Public Transportation	15%
Support	13%
Sustainable Travel	2%
Traffic Management	58%
Traveler Information	54%
Vehicle Safety	7%
Weather	43%
Other	0%
Don't know	9%
Missing	18%

2023 Q36; (n=93) *Source: USDOT*

Q36: Please indicate how your agency is using Cellular (LTE-4G) to enable ITS on freeways.

Table 21. Telecommunications Technologies: Use of Cellular (LTE-4G)

Uses	Percent of Freeway management agencies Base: Agencies using Cellular (LTE-4G)
Commercial Vehicle Operations	16%
Data Management	34%
Maintenance and Construction	39%
Parking Management	9%
Public Safety	31%
Public Transportation	14%
Support	20%
Sustainable Travel	5%
Traffic Management	74%
Traveler Information	64%
Vehicle Safety	13%
Weather	58%
Other	1%
Don't know	5%
Missing	7%

2023 Q36; (n=233) *Source: USDOT*

Q36: Please indicate how your agency is using Cellular (GPRS - 2G or 3G) to enable ITS on freeways.

Due to the small sample size, this table shows counts of agencies rather than percentages.

Table 22. Telecommunications Technologies: Use of Cellular (GPRS - 2G or 3G)

Uses	Number of Freeway management agencies Base: Agencies using Cellular (GPRS - 2G or 3G)
Commercial Vehicle Operations	8
Data Management	5
Maintenance and Construction	8
Parking Management	0
Public Safety	8
Public Transportation	2
Support	5
Sustainable Travel	0
Traffic Management	13
Traveler Information	13
Vehicle Safety	9
Weather	13
Other	0
Don't know	5
Missing	5

2023 Q36; (n=24) *Source: USDOT*

Q36: Please indicate how your agency is using LTE-Cellular V2X to enable ITS on freeways.

Due to the small sample size, this table shows counts of agencies rather than percentages.

Table 23. Telecommunications Technologies: Use of LTE-Cellular V2X

Uses	Number of Freeway management agencies Base: Agencies using LTE-Cellular V2X
Commercial Vehicle Operations	1
Data Management	10
Maintenance and Construction	2
Parking Management	0
Public Safety	11
Public Transportation	3
Support	6
Sustainable Travel	0
Traffic Management	21
Traveler Information	18
Vehicle Safety	7
Weather	8
Other	0
Don't know	3
Missing	2

2023 Q36; (n=31) *Source: USDOT*

Q36: Please indicate how your agency is using Dedicated short range communications to enable ITS on freeways.

Due to the small sample size, this table shows counts of agencies rather than percentages.

Table 24. Telecommunications Technologies: Use of Dedicated short range communications

Uses	Number of Freeway management agencies Base: Agencies using Dedicated short range communications
Commercial Vehicle Operations	1
Data Management	10
Maintenance and Construction	9
Parking Management	0
Public Safety	16
Public Transportation	1
Support	8
Sustainable Travel	0
Traffic Management	21
Traveler Information	19
Vehicle Safety	3
Weather	6
Other	0
Don't know	5
Missing	5

2023 Q36; (n=33) *Source: USDOT*

Q36: Please indicate how your agency is using Wi-Fi to enable ITS on freeways.

Table 25. Telecommunications Technologies: Use of Wi-Fi

Uses	Percent of Freeway management agencies Base: Agencies using Wi-Fi
Commercial Vehicle Operations	6%
Data Management	31%
Maintenance and Construction	18%
Parking Management	4%
Public Safety	14%
Public Transportation	6%
Support	12%
Sustainable Travel	2%
Traffic Management	47%
Traveler Information	37%
Vehicle Safety	8%
Weather	25%
Other	2%
Don't know	10%
Missing	37%

2023 Q36; (n=49) *Source: USDOT*

Q38: Does your agency utilize an asset management system to track Intelligent Transportation Systems (ITS) inventory and/or ITS maintenance and operations activity on freeways? *Please select all that apply.*

Table 26. Asset Management System

Response	Percent of Freeway management agencies
Yes, system tracks inventory of ITS field devices	70%
Yes, system tracks inventory of ITS central systems/software	36%
Yes, system tracks maintenance and operations of ITS field devices	60%
Yes, system tracks maintenance and operations of ITS central systems/software	33%
No, my agency does not have an ITS asset management system	20%
Not applicable, my agency has not deployed ITS	1%
Missing	3%

2023 Q38; (n=311) *Source: USDOT*

Q39: What is your agency's primary approach for conducting maintenance activities on freeway ITS assets? *Please select one.*

Table 27. Primary Approach for Conducting Maintenance

Response	Percent of Freeway management agencies Base: Agencies Indicating ITS (i.e., exclude agencies responding Not Applicable to Q38)
My agency primarily schedules maintenance based on the regularly monitored condition of freeway ITS	28%
My agency primarily schedules maintenance of freeway ITS assets based on regular intervals	30%
My agency primarily conducts maintenance in response to reported freeway ITS asset failures or events, such as a vehicle collision or component failure	26%
Other	5%
Don't know	5%
Missing	6%

2023 Q39; (n=307) *Source: USDOT*

Q49a. What are key reasons for NOT using your Regional (or State) ITS Architecture to support freeway ITS deployments? *Please select all that*

Due to the small sample size, this table shows counts of agencies rather than percentages.

Table 28. Key Reasons for Not Using Regional (or State) ITS Architecture

Response	Number of Freeway management agencies Base: Agencies Not Using Architecture
Lack of experience/technical expertise with the Regional ITS Architecture	5
The Regional ITS Architecture is out of date	5
The scope and/or scale of my agencies' ITS projects are generally too small	4
No perceived technical or operational benefit to using the Regional ITS Architecture	9
Other	0
Missing	1

2023 Q49a; (n=14) *Source: USDOT*

Q49b. What are key reasons for NOT using your Regional (or State) ITS Architecture to support all of your freeway ITS deployments? *Please select all that apply.*

Due to the small sample size, this table shows counts of agencies rather than percentages.

Table 29. Key Reasons for Not Using Regional (or State) ITS Architecture for All Deployments

Response	Number of Freeway management agencies Base: Agencies Using Architecture for Some Deployments
Lack of experience/technical expertise with the Regional ITS Architecture	6
The Regional ITS Architecture is out of date	8
The scope and/or scale of my agencies' ITS projects are generally too small	12
No perceived technical or operational benefit to using the Regional ITS Architecture	3
Other	4
Missing	1

2023 Q49b; (n=31) *Source: USDOT*

Appendix C. 2023 Freeway Management Survey Questionnaire

Prior to administering the 2023 Freeway Management Survey, the ITS JPO consulted with subject matter experts (SMEs) on the survey content to determine if any questions should be revised, or if questions should be eliminated or added. This appendix contains the 2023 Freeway Management Survey Questionnaire.

New questions in the 2023 Deployment Tracking Survey are marked with a (+).

Notably, questions 21 through 34 were adapted from the 2019 Connected Vehicle and Automated Vehicle Survey. [32]

[32] See: https://www.itskrs.its.dot.gov/deployment/othersurveys_surta_2019.

Welcome to the Freeway Management Survey!

Before you get started, please review the following definitions:

Intelligent Transportation Systems (ITS) encompass the electronic, communication, and information processing technologies that enable transportation agencies to collect and transmit data in real time (or near real time) for use in transportation operations. ITS are deployed to support safety, mobility, environmental, and other goals.

This survey asks about ITS deployed on **Freeways**, which include **controlled access roads, such as interstates and other freeways and expressways** (i.e., functional classifications 1 and 2 of Federal Highway Administration's Highway Functional Classification). For more information click: https://www.fhwa.dot.gov/planning/processes/statewide/related/highway_functional_classifications/section00.cfm

Navigating the Survey:

Use the "Next" and "Previous" buttons below to navigate the survey. Answers from each survey page are automatically saved when you go to the **next** survey page.

To return to the dashboard, click on the "Return to Dashboard" button on the bottom of the page.

For many questions, there will be terms that are underlined. In this reference PDF, additional information for these terms is provided in a box below the question.

Note: The instructions in red font show the survey skip logic, which is automated in the online survey.

Real-Time Traffic Data Collection on Freeways

1. [ASK ALL] **Does your agency deploy any roadside infrastructure technologies to collect real-time traffic data on freeways?** *Please select all that apply.*

   - ❑ Inductive Loop
   - ❑ Radar/microwave detection
   - ❑ Video imaging detection
   - ❑ Magnetometers
   - ❑ Infrared/thermal detection
   - ❑ Other (please specify): _____
   - ❑ No roadside infrastructure technologies are deployed

DEFINITIONS SHOWN IN HOVER BOXES:

Inductive loop detectors are comprised of a series of wired loops that sense the presence of a vehicle on the roadway and transfer the signal to an electronic unit housed in a controller cabinet on the side of the roadway.

Radar/microwave detection identifies vehicles by transmitting an electromagnetic signal that is reflected to the radar sensor once a vehicle passes through the area.

Video imaging detection (e.g., traffic and infrared cameras) uses cameras above traffic to capture images of passing vehicles. These images are analyzed by a vision processor using application specific algorithms to detect vehicles and monitor traffic.

Magnetometers detect a vehicle whenever a sufficient portion of its magnetic shadow falls on a sensor probe.

Infrared/Thermal detection identifies vehicles by transmitting infrared light or heat from a transmitter to a receiver placed on the opposite side of the road perpendicular to the direction of travel.

2. [ASK ALL] **Has your agency deployed any vehicle probe readers to collect real-time traffic data on freeways?** *Please select all that apply.*
   *Please note that your response should include your agency's deployed equipment only; please **do not** include vehicle probe reader data purchased or obtained from an external source.*

   - ❑ Toll tag readers
   - ❑ License plate readers
   - ❑ Bluetooth readers
   - ❑ Cellular/mobile phone readers
   - ❑ In-vehicle GPS readers
   - ❑ Other (please specify): _____
   - ❑ No vehicle probe readers are deployed

DEFINITIONS SHOWN IN HOVER BOXES:

Toll tag readers match tag numbers read at the starting and ending points of the segment of road to estimate travel times.

License plate readers use optical cameras to capture images of oncoming or receding traffic and use video image processing to "read" the license plates. License plate numbers can also be matched at sensor locations downstream.

Bluetooth readers work by actively searching for in-range Bluetooth devices and capturing the unique address of each device.

Cellular/mobile phone readers automatically and anonymously downloaded phone location information from cellular network switching centers in real time. The location of a cell phone on a roadway is determined by cell phone network handoff or signal tower triangulation and compared to a map database.

In-vehicle GPS readers are used in vehicles equipped with GPS to transmit positional information via GPS signal to a central control center.

3. [ASK ALL] **Does your agency use any external data sources (i.e., collected outside of your agency) for freeway management (e.g., incidents, road weather, traffic)?** *Please select all that apply.*
   - ❑ Notifications from the public via social media, emails, texts, phone calls, etc.
   - ❑ Publicly available mapping and traffic information apps (e.g., Google Maps, Waze, etc.)
   - ❑ Purchased third-party commercial data (e.g., Inrix, HERE, TomTom)
   - ❑ Other transportation agency data (e.g., Other State DOTs or districts, MPOs, etc.)
   - ❑ Other (Please specify): _____
   - ❑ No external data sources are used – SKIP TO Q6
   - ❑ Don't know – SKIP TO Q6

4. (+) [IF Q3 = RESPONSES 1,2, 3, 4, or 5] **How is your agency using the freeway data obtained from external sources?** *Please select all that apply.*
   - ❑ Traffic incident management
   - ❑ Work zone management
   - ❑ Road weather management
   - ❑ Traveler information
   - ❑ Freeway management
   - ❑ Performance management/measurement
   - ❑ Road/ITS asset management
   - ❑ Emergency management
   - ❑ Traffic studies and/or project prioritization
   - ❑ Safety analytics/management
   - ❑ Other (please specify): _____

5. (+) [IF Q3 = PURCHASED THIRD PARTY COMMERCIAL DATA] **You indicated that your agency purchases third-party commercial data. What type(s) of freeway data is your agency purchasing?** *Please select all that apply.*
   - ❑ Vehicle probe data
   - ❑ Connected vehicle data
   - ❑ Multimodal probe data
   - ❑ Origin-destination (trip) data
   - ❑ Non-recurring event data (e.g., incidents, closures, road weather events)
   - ❑ Other (please specify): _____

Ramp Metering Control

6. [ASK ALL] **Has your agency deployed freeway entrance ramp metering?** *Please select one.*

- ○ Yes
- ○ No – SKIP TO Q9
- ○ Not applicable (agency does not manage ramps) – SKIP TO Q9

7. (+) [IF Q6 = YES] **Which of the following capabilities applies to your agency's freeway ramp metering system?**

- ❑ Fixed/pre-timed (e.g., based on historical data) – SKIP TO Q9
- ❑ Local adaptive/responsive based on real time traffic conditions in local vicinity of the ramp
- ❑ Corridor or system-wide adaptive/responsive based on real time traffic conditions along a facility, corridor, or system
- ❑ Other (please specify): _____ – SKIP TO Q9

DEFINITIONS SHOWN IN HOVER BOXES:
Ramp metering uses traffic signals installed on freeway on-ramps to control the frequency at which vehicles enter the flow of traffic on the freeway.

Fixed/pre-timed ramp metering controls the frequency of vehicles at fixed times. Does not use traffic detection or respond to real-time conditions.

Local adaptive/responsive ramp metering relies on real-time surveillance of traffic present on the freeway on-ramp and adjacent freeway location(s) to select metering rates.

Corridor or system-wide adaptive/responsive ramp metering relies on real-time traffic surveillance of traffic upstream and downstream from the ramp to calculate a metering rate.

8. (+) [IF Q7 = LOCAL ADAPTIVE OR CORRIDOR/SYSTEM ADAPTIVE]: **Does your agency deploy any advanced ramp metering technologies (i.e., ramp metering integrated with other traffic management tools/strategies)?** *Please select all that apply.*

- ❑ Dynamic bottleneck identification
- ❑ Automated incident detection
- ❑ Integration with adjacent arterial traffic signals
- ❑ Other (please specify): _____
- ❑ No advanced metering technologies are deployed

DEFINITIONS SHOWN IN HOVER BOXES:

Dynamic bottleneck identification sets ramp metering rates for a series of ramps based on an algorithm that identifies active bottlenecks on the freeway, and those metering rates are adjusted based on changes to the bottlenecks (i.e., location and time).

Automated incident detection sets ramp metering rates based on an automated incident detection algorithm that uses traffic monitoring equipment (e.g., detectors and CCTV cameras) to identify freeway

incidents in real-time. If an incident is detected, the metering rates will adjust to account for the loss of capacity at the incident location.

Integration with adjacent arterial traffic signals occurs when ramp meter signals are integrated with adjacent arterial traffic signals based on ramp and adjacent arterial queues and volumes. Ramp metering rates and/or arterial traffic signals will adjust to reduce backups on the ramps and adjacent arterials for vehicles entering the freeway.

Managed Lanes

9. [ASK ALL] **Does your agency and/or another entity (e.g., public/private partnership) operate managed lanes on freeways?** *Please select all that apply.*

- ❑ Yes, my agency
- ❑ Yes, other entity (e.g., public/private partnership)
- ❑ No, neither – SKIP TO Q11

DEFINITION SHOWN IN HOVER BOX:

Managed lanes is a concept where a "freeway-within-a-freeway" is created by separating a set of lanes within the freeway cross section from the general-purpose lanes. The operation of and demand on the facility is managed using a combination of tools and techniques (e.g., pricing, vehicle eligibility, and access control) in order to continuously achieve an optimal condition, such as free-flow speeds.

10. [IF Q9=YES] **Which managed lane strategies are used on freeways?** *Please select all that apply.*

- ❑ Hard shoulder running
- ❑ High Occupancy Toll (HOT)
- ❑ High Occupancy Vehicle (HOV)
- ❑ Lane use control (open/closed/direction arrow or chevron)
- ❑ Reversible flow
- ❑ Transit only
- ❑ Truck only
- ❑ Variable speed limits
- ❑ Other congestion pricing strategy
- ❑ Other managed lane strategy (please specify): _____

Automated Enforcement

11. [ASK ALL] **Does your agency deploy automated enforcement on freeways?** *Please select one.*

- ○ Yes
- ○ No – SKIP TO Q13

12. [IF Q11 = YES] **What automated enforcement technologies does your agency use on freeways?** *Please select all that apply.*

- ❑ License plate recognition
- ❑ Cameras
- ❑ Toll tag readers
- ❑ Radar
- ❑ Other (please specify): _____

DEFINITIONS SHOWN IN HOVER BOXES:

License plate recognition uses optical cameras to capture images of oncoming or receding traffic and use video image processing to "read" the license plates. License plate numbers can also be matched at sensor locations downstream.

Toll tag readers match tag numbers read at the starting and ending points of the segment of road to estimate travel times.

Radar detects vehicles by transmitting an electromagnetic signal that gets reflected to the radar sensor once a vehicle passes through the area.

Safety and Road Weather Management

13. [ASK ALL] **Has your agency deployed any Intelligent Transportation Systems (ITS) safety systems on freeways?** *Please select all that apply.*

- ❑ Automated and/or manual freeway ramp gate
- ❑ Automated visibility warning system
- ❑ Downhill truck speed warning
- ❑ Dynamic curve warning system
- ❑ Lane use control on general purpose lanes
- ❑ Over-height warning system (e.g., bridge, tunnel, gantries)
- ❑ Queue warning system
- ❑ Reference location sign
- ❑ Variable speed limit
- ❑ Wildlife warning system
- ❑ Wireless truck roadside inspection
- ❑ Wrong way driving detection system
- ❑ Other (Please specify): _____
- ❑ No ITS safety systems are deployed

DEFINITIONS SHOWN IN HOVER BOXES:

Automated and/or manual freeway ramp gate controls access to selected ramps to all traffic or specific vehicle classes, limiting the periods of access or permanently restricting access.

Automated visibility warning system uses weather sensors to detect reduced visibility conditions and then triggers a dynamic message sign with a warning indicating the adverse driving conditions.

Downhill truck speed warning alerts drivers (e.g., illuminated signs) to slow down if their vehicle speed is too high to travel safely downhill.

Dynamic curve warning system detects vehicles approaching a curve and activates a warning to drivers (e.g., illuminated signs, flashing beacons, etc.) to slow down if their vehicle speed is too high to travel safely through the curve.

Lane use control on general purpose lanes dynamically closes individual lanes during incidents or opens shoulders for part-time travel to increase capacity during congestion periods.

Over-height warning system detects vehicles and activates a warning to drivers (e.g., illuminated signs, flashing beacons, etc.) identifying upcoming tunnels, bridges, or other obstacles that may limit the size of the vehicle that can pass.

Queue warning system uses sensors to display messages on dynamic message signs to warn drivers about stopped or slowed traffic ahead.

Variable speed limit uses current traffic conditions to determine the appropriate speed at which drivers should be traveling and displays this information on dynamic message signs.

Wildlife warning system detects the presence of an animal on or near the road and activates a warning to drivers (e.g., illuminated signs, flashing beacons, etc.).

Wireless truck roadside inspection wirelessly and electronically assesses the safety of a truck and its driver without requiring them to stop.

Wrong way driving detection system detects vehicles traveling in the wrong direction and alerts the driver. May also have a traffic or CCTV camera to record the incident.

14. [ASK ALL] **Does your agency use any ITS Road Weather Information Systems (RWIS)/Environmental Sensor Stations (ESS) to collect weather and road condition data on freeways?** *Please select all that apply.*

- ❑ Mobile (vehicle-mounted)
- ❑ Permanent (stationary)
- ❑ Transportable (temporary use for work zones, recurring problem spots, etc.)
- ❑ Other (Please specify): _____
- ❑ No ITS (RWIS/ESS) are deployed to collect weather and road condition data

DEFINITIONS SHOWN IN HOVER BOXES:

Environmental sensor stations (ESS) are at a fixed roadway location with one or more sensors measuring atmospheric, pavement, and/or water level conditions.

Road Weather Information Systems (RWIS) are comprised of environmental sensor stations (ESS), a communication system for data transfer, and a central system to collect and process the field data. The data is used to disseminate road weather information.

15. (+) [ASK ALL] **Does your agency use any tools and/or strategies to manage adverse road weather impacts on freeways?** *Please select all that apply.*

- ❑ Automated vehicle location (AVL)
- ❑ Decision support systems
- ❑ Dynamic message signs (permanent and/or portable)
- ❑ Pathfinder
- ❑ Queue warning systems
- ❑ Ramp metering
- ❑ Resource pre-positioning (e.g., pre-positioning trucks for plowing)
- ❑ Route optimization
- ❑ Traffic modeling and/or analysis
- ❑ Variable speed limits
- ❑ Other (please specify): _____
- ❑ No tools or strategies are used to manage adverse road weather impacts

DEFINITIONS SHOWN IN HOVER BOXES

Pathfinder is a communication and collaboration strategy developed by Federal Highway Administration and supported by National Weather Service. For more information, see: https://ops.fhwa.dot.gov/publications/fhwahop18034/index.htm.

Route Optimization is a static or adaptive routing response tool and/or strategy based on road weather conditions, incidents, recurring problem areas, etc.

Incident Detection

16. [ASK ALL] **Does your agency use any incident detection/verification methods on freeways?** *Please select all that apply.*

- ❑ Closed Circuit Television (CCTV)
- ❑ Call boxes
- ❑ Computer algorithms to detect incidents
- ❑ External data (e.g., data provided by crowdsourcing, commercial providers, or citizen-reported)
- ❑ Other (Please specify): _____
- ❑ No incident detection/verification methods are used

Work Zone Management

17. [ASK ALL] **Does your agency deploy Intelligent Transportation Systems (ITS) technology at work zones on freeways?** *Please select one.*

- ○ Yes
- ○ No – SKIP TO Q19

18. [IF Q17 = YES] **Which ITS technologies does your agency deploy at work zones on freeways?**
Please select all that apply.

- ❑ Dynamic lane merge system
- ❑ Intrusion alarm
- ❑ Portable CCTV
- ❑ Portable dynamic message sign
- ❑ Portable dynamic speed feedback/speed radar trailer
- ❑ Portable traffic monitoring device
- ❑ Queue detection and alert system
- ❑ Route guidance around work zones
- ❑ Travel time system
- ❑ Temporary ramp metering
- ❑ Variable speed limit
- ❑ Other (please specify): _____

DEFINITIONS SHOWN IN HOVER BOXES:

Dynamic lane merge system uses dynamic message signs and other devices to control vehicle merging behavior.

Intrusion alarm detects errant vehicles entering the work zone and alerts workers.

Portable CCTV system provides visual surveillance and is typically mounted in a light truck or van or on a trailer.

Portable dynamic message sign (DMS) displays a variety of messages to inform motorists of unusual driving conditions.

Portable dynamic speed feedback/speed radar trailer systems are portable traffic control devices that display a driver's speed or provide a message to drivers exceeding a certain speed threshold.

Portable traffic monitoring device uses radar or microwave detection to collect traffic-related data and communicates this information in real-time to a central server, which can also be automatically conveyed to motorists via a public website or portable dynamic message signs.

Queue detection and alert system uses sensors upstream of a work zone and displays messages on dynamic message signs to warn drivers about stopped or slowed traffic ahead.

Route guidance around work zones advises drivers of alternative routes when work zones necessitate lane closures or other types of diversions.

Travel time system measures actual traffic flow conditions using vehicle travel time detectors and displays current travel time information (e.g., on messaging signs, websites, etc.).

Temporary ramp metering involves temporarily installing signals on freeway on-ramps to control the frequency at which vehicles enter the flow of traffic on the freeway.

Variable speed limit uses current traffic conditions to determine the appropriate speed at which drivers should be traveling and displays this information on dynamic message signs.

Traveler Information

19. [ASK ALL] **What methods does your agency use to disseminate real-time traveler information about freeways?** *Please select all that apply.*

- ❑ 511
- ❑ Social media
- ❑ Email or text/SMS alert
- ❑ Agency-branded mobile application (e.g., white-label commercial app, custom built)
- ❑ Third party mobile app (e.g., Google Maps, Waze)
- ❑ Dynamic message signs (permanent and/or portable)
- ❑ Website
- ❑ Highway Advisory Radio
- ❑ Other (please specify): _____
- ❑ No real-time traveler information about freeways is disseminated

20. [ASK ALL] **Does your agency provide an open data feed that shares real-time transportation-related data using data standards/specifications?** *Please select one.*

- o Yes
- o No, but my agency is working on this
- o No current plans for an open data feed

20a. (+) [IF Q20=YES] **What data standards/specifications are used to share real-time transportation-related data in your agency's open data feed?**

- ❑ Work Zone Data Exchange (WZDx) specification
- ❑ Traffic Management Data Dictionary (TMDD) standard
- ❑ PC5-based C-V2X specification (5.9GhZ)
- ❑ Other communications interface, data format, and/or protocol (please specify: _____)
- ❑ Don't know

DEFINITIONS SHOWN IN HOVER BOXES:

Work Zone Data Exchange (WZDx) specification enables infrastructure owners and operators (IOOs) to make harmonized work zone data available for third-party use. The goal of WZDx is to enable widespread access to up-to-date information about dynamic conditions occurring on roads such as construction events.

Traffic Management Data Dictionary (TMDD) standards were developed to support center-to-center communications. TMDD provides the dialogs, message sets, data frames, and data elements to manage the shared use of Intelligent Transportation Systems (ITS) devices and the regional sharing of data and incident management responsibility.

PC5-based C-V2X specification (5.9GhZ) uses device-to-device radio access technology for direct low latency connectivity between user equipment within a wide-area network independent of the traditional cellular network.

Connected Vehicle Technologies

This section includes questions about your agency's deployment of connected vehicle (CV) technologies. Your responses should only include CV technologies deployed on **freeways** (i.e., do not include CV deployment on arterial roads).

21. (+) [ASK ALL] **Is your agency currently developing, testing, or deploying connected vehicle (CV) technology on freeways?** *Please select one.*
- o Yes – SKIP TO Q24
- o No, but my agency is planning for CV
- o No plans for CV – SKIP TO Q29
- o Don't know – SKIP TO Q29

DEFINITION SHOWN IN HOVER BOX:

Connected vehicle (CV) technologies enable vehicles, roadway infrastructure, and mobile devices to wirelessly exchange data and "talk" to one another. Connected vehicles encompass vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), and vehicle-to-pedestrian (V2P) communications, collectively known as "V2X." When integrated into a vehicle, roadway infrastructure, or mobile device, these technologies can deliver significant transportation safety, mobility, and environmental benefits.

22. (+) [IF Q21 = NO, BUT PLANNING FOR CV] **Does your agency have any documented plans (e.g., internal planning documents, State Transportation Improvement Plan (STIP), etc.) to develop, test, or deploy connected vehicle technology on freeways?** *Please select one.*
- o Yes
- o No
- o Don't know

23. (+) [IF Q21 = NO, BUT PLANNING FOR CV] **When do you expect to begin developing, testing, or deploying connected vehicle technology on freeways?** *Please select one.*
- o Within the next 3 years – SKIP TO Q29
- o In 3 to 6 years – SKIP TO Q29
- o In 7 or more years – SKIP TO Q29
- o Don't know – SKIP TO Q29

24. (+) [IF Q21 = YES] **Is your agency deploying roadside units (RSUs) on freeways to support connected vehicle and/or automated vehicle testing/deployment?** *Please select one.*
- o Yes
- o No – SKIP TO Q27
- o Don't know – SKIP TO Q27

25. (+) [IF Q24 = YES] **Approximately how many roadside units (RSUs) is your agency currently testing or deploying on freeways?** *Please select one.*
- o 1-10
- o 11-50
- o 51-150
- o 151 or more

26. (+) [IF Q24 = YES] **On freeways, what standard data structures are being transmitted for your connected vehicle system (e.g., from your roadside units, connected vehicles, etc.)?** *Please select all that apply.*

- ❑ Basic Safety Message (BSM)
- ❑ MAP data (e.g., ramp metering)
- ❑ Position Correction Message (RTCM)
- ❑ Roadside Safety Message (RSM)
- ❑ Sensor Data Sharing Message (SSDM)
- ❑ Signal Phase and Timing (SPaT) (e.g., ramp metering)
- ❑ Traveler Information Messages (TIM)
- ❑ Other (please specify): _____
- ❑ Don't know

27. (+) [IF Q21 = YES] **Is your agency developing, testing, or deploying any connected vehicle applications for use on freeways - (i.e., using an in-vehicle onboard unit (OBU), Human Machine Interface (HMI), handheld device, or similar)?** *This may include applications that your agency is testing either on its own fleet or in partnership with automakers/original equipment manufacturers.*

- ○ Yes
- ○ No – SKIP TO Q29
- ○ Don't know – SKIP TO Q29

28. (+) [IF Q27 = YES] **Which connected vehicle (CV) applications is your agency developing, testing, or deploying on freeways?** *This may include applications that your agency is testing either on its own fleet or in partnership with automakers/original equipment manufacturers. Please select all that apply.*

Safety Applications (Vehicle to Infrastructure (V2I)):

- ❑ Curve Speed Warning (CSW)
- ❑ Reduced Speed/Work Zone Warning (RSWZ)

Safety Applications (Vehicle to Vehicle (V2V)):

- ❑ Blind Spot/Lane Change Warning (BSW/LCW)
- ❑ Emergency Electronic Brake Lights (EEBL)
- ❑ Forward Collision Warning (FCW)

Mobility Applications:

- ❑ Queue Warning (Q-WARN)

Environment Applications:

- ❑ Dynamic Eco Routing

Agency and Road Weather Applications:

- ❑ Agency Data Applications (e.g., probe data collection, CV-enabled data collection etc.)
- ❑ Road Weather Warnings (e.g., Motorist Advisories and Warnings (MAW); Enhanced Maintenance Decision Support System (MDSS))

Other CV applications being developed, tested, deployed:

- ❑ Please specify any other CV applications: _____

DEFINITIONS SHOWN IN HOVER BOXES:

Curve Speed Warning (CSW) alerts a driver if current speed is too fast for an approaching curve.

Reduced Speed/Work Zone Warning (RSWZ) alerts a driver to use caution when traveling through a work zone.

Blind Spot/Lane Change Warning (BSW/LCW) alerts a driver changing lanes if there is a vehicle in the driver's blind spot.

Emergency Electronic Brake Lights (EEBL) application notifies a driver if there is a sudden-braking vehicle ahead (or several vehicles ahead).

Forward Collision Warning (FCW) alerts a driver when a vehicle ahead is stopped or traveling slower and there is a risk of a rear-end collision.

Queue Warning (Q-WARN) provides a vehicle operator with sufficient warning of an impending queue backup, allowing the operator to brake safely, change lanes, or modify the route such that secondary collisions can be minimized or even eliminated. It is distinct from collision warning, which pertains to events or conditions that require immediate or emergency actions.

Dynamic Eco-Routing application determines the most eco-friendly route, in terms of minimum fuel consumption or emissions, for individual travelers. This application recommends routes that produce the fewest emissions or reduce fuel consumption based on historical, real-time, and predicted traffic and environmental data (e.g., prevailing weather conditions).

Agency Data Applications include applications used to collect, transmit, analyze, or report local data related to traffic conditions, road conditions, travel patterns, or other metrics. Examples include: Probe-based Pavement Maintenance, Probe-based Traffic Monitoring, CV-enabled Origin-destination Studies, Work Zone Travel Information applications, etc.

Road Weather Warnings issue alerts and advisories to travelers about deteriorating road and weather conditions on specific roadway segments.

Automated Vehicle Technologies

This section asks about automated vehicle tests and deployments **on freeways**; your responses should also include any pilots or demonstrations related to automated vehicles.

29. (+) [ASK ALL] **Has your agency participated in any automated vehicle (AV) tests or deployments on freeways in the last five years?** *Please select all that apply.*

- ○ Yes, my agency is leading or has led AV testing/deployment (i.e., completed or in progress) – SKIP TO Q32
- ○ Yes, my agency is supporting or has supported the planning or execution of the AV testing/deployment – SKIP TO Q32
- ○ No, my agency is not participating in any AV testing or deployment
- ○ Don't know

DEFINITION SHOWN IN HOVER BOX:
Automated vehicles (AVs) are those in which at least some aspect of a safety-critical control function (e.g., steering, throttling, or braking) occurs without direct driver input. AVs may include light duty vehicles, transit vehicles, commercial motor vehicles, and small delivery devices, among others.

Automated vehicles are widely categorized by their levels of driving automation defined by the Society of Automotive Engineers (SAE). These levels begin with Level 0 (no driving automation) and conclude with Level 5 (full driving automation).

30. (+) [IF Q29 = NO or DON'T KNOW] **Does your agency have any documented plans (e.g., internal planning documents, State Transportation Improvement Plan (STIP), etc.) to participate in automated vehicle (AV) testing or deployment on freeways in the future?** *Please select one.*

- ○ Yes, my agency has a documented plan
- ○ No, but my agency is considering AV testing or deployment
- ○ No, my agency is not considering AV testing or deployment – SKIP TO Q35
- ○ Don't know – SKIP TO Q35

31. (+) [IF Q30 =YES HAS DOCUMENTED PLAN OR CONSIDERING] **When does your agency expect to participate in automated vehicle testing or deployment on freeways?** *Please select one.*

- ○ Within the next 3 years – SKIP TO Q35
- ○ In 3 to 6 years – SKIP TO Q35
- ○ In 7 or more years – SKIP TO Q. 35
- ○ Don't know – SKIP TO Q. 35

32. a. (+) [IF Q29 = AGENCY SUPPORTING (OPTION 2 ONLY)] **Which entity(ies) are/were leading the automated vehicle testing or deployment on freeways?** *Please select all that apply.*

32. b. (+) [IF Q29 = AGENCY LEADING (OPTION 1 ONLY OR BOTH OPTIONS 1 AND 2)] **For the automated vehicle testing or deployments on freeways that your agency is/was leading, what other entity(ies) are/were you partnering with?** *Please select all that apply.*

- ❑ Automakers or Original Equipment Manufacturers (OEMs), including Transit Vehicle Manufacturers
- ❑ Advanced Driver Assistance Systems (ADAS) Developers (or Driver Support Features Developers)
- ❑ Automated Driving Systems (ADS) Developers
- ❑ Transportation Network Companies (TNCs) (e.g., Uber or Lyft)
- ❑ State agencies
- ❑ Metropolitan Planning Organizations (MPOs)
- ❑ Universities
- ❑ Transit agencies
- ❑ Other local agencies
- ❑ Private sector consultants (please specify):_____,
- ❑ Other (please specify): _____
- ❑ Don't know

33. (+) [IF Q29 = AGENCY LEADING OR SUPPORTING] **Which of the following automated vehicle (AV) tests or deployments on freeways has your agency led or supported in the last five years?** Please include Advanced Driver Assistance Systems (ADAS) or Automated Driving Systems (ADS) tests or deployments. *Please select all that apply.*

Automated Transit/On-Demand Tests/Deployments:

- ❑ Automated Bus Rapid Transit (BRT)
- ❑ Automated Passenger Fixed Route
- ❑ Automated Passenger On-Demand
- ❑ Automated Maintenance and Bus Yard Operations

Automated Delivery/Freight/Commercial Motor Vehicle Tests/Deployments:

- ❑ Automated Last Mile Delivery (e.g., light duty vehicle) – OMIT FROM Q34
- ❑ Automated Regional or Long-Haul Trucking – OMIT FROM Q34
- ❑ Truck Platooning – OMIT FROM Q34
- ❑ Automated Logistics Yard Operations (e.g., automated yard trucks) – OMIT FROM Q34
- ❑ Construction or Maintenance Operations (e.g., automated truck-mounted attenuators) – OMIT FROM Q34

Automated Light Duty Passenger Vehicle Tests/Deployments:

- ❑ Automated light duty passenger vehicle test/deployment – OMIT FROM Q34

Other AV Test/Deployments on freeways:

- ❑ Other AV test/deployment (please specify): _____ – OMIT FROM Q34

DEFINITIONS SHOWN IN HOVER BOXES:

Automated Bus Rapid Transit (BRT) applies rail transit concepts to automated buses to deliver fast and efficient service. These concepts focus on eliminating causes of delay that typically slow regular bus services and may include dedicated lanes, busways, traffic signal priority, off-board fare collection, platforms, and enhanced stations.

Automated Passenger Fixed Route service provides rides along a single route with pre-defined stops and a set schedule. The route may be limited to closed environments, such as parking lots, busways, campuses, and retirement communities, or it may operate in mixed traffic on public roads in areas, such as business parks or downtown districts.

Automated Passenger On-Demand provides on-demand service between any two addresses within a defined service area. The concept is similar to the automated passenger fixed route service; however, it is not restricted to predefined routes or schedules - users can request pick-ups and drop-offs on demand (e.g., using an application on a smartphone, tablet, or kiosk).

Automated Maintenance and Bus Yard Operations is the deployment of automated driving systems (ADS) on transit vehicles for use within the domain of the bus yard. Use cases may include precision movement for fueling/recharging, maintenance, disinfection/bus wash, or automated parking and recall.

Automated Last Mile Delivery (e.g., light duty vehicle) uses automation to deliver goods over short distances on local roadways from business to consumer.

Automated Regional or Long-Haul Trucking applies automation to trucking. Automated trucking generally refers to SAE Level 3-5 automation, where the automated driving system is primarily responsible for monitoring the driving environment.

Truck Platooning incorporates on-board computers, vehicle sensors, and automated driving technology, allowing equipped long-haul trucks to communicate with each other and travel closely together on the highway (40 to 50 feet apart) to improve fuel efficiency and reduce vehicle emissions.

Automated Logistics Yard Operation is the deployment of automation (e.g., robots, yard trucks with automated driving systems) to perform logistics tasks in the yard. For example, this may include moving trailers from one part of the yard to another.

Construction or Maintenance Operations (e.g., automated truck mounted attenuator) is the deployment of automated driving systems (ADS) on commercial vehicles for the purpose of performing construction and maintenance activities on the road.

Automated light duty passenger vehicle test/deployment: Use this category for any light-duty passenger vehicle test/deployment not covered in other categories.

34. (+) **For your** [Q33 = AUTOMATED BUS RAPID TRANSIT / AUTOMATED PASSENGER FIXED ROUTE / AUTOMATED PASSENGER ON DEMAND / AUTOMATED MAINTENANCE AND BUS YARD OPERATIONS] **test or deployment, which type of vehicle is being used?** *Please select all that apply.*

- ❑ Full-sized transit bus
- ❑ Articulated bus
- ❑ Motorcoach (over the road bus)
- ❑ Cutaway bus or minibus
- ❑ Novel-design low-speed shuttle
- ❑ Light-duty passenger vehicle (e.g., car, van, SVU)
- ❑ Other (please specify): _____
- ❑ Don't know

Telecommunications

35. [ASK ALL] **What type of telecommunications technologies does your agency use to enable ITS on freeways?** *Please select all that apply.*

Wired:

- ❑ Coaxial – OMIT FROM Q36
- ❑ Fiber-optic cable – OMIT FROM Q36
- ❑ Twisted copper pair/Twisted wire pair
- ❑ Digital subscriber line (DSL)
- ❑ Data cable over modem

Wireless:

- ❑ 5G New Radio and small cell infrastructure
- ❑ Cellular (LTE-4G)
- ❑ Cellular (GPRS – 2G or 3G)
- ❑ LTE-Cellular V2X (LTE-CV2X)
- ❑ Dedicated short range communications (DSRC)
- ❑ Wi-Fi
- ❑ Mobile or Fixed service satellite (FSS) – OMIT FROM Q36
- ❑ Ultra-wideband (UWB)
- ❑ Microwave – OMIT FROM Q36
- ❑ Other telecommunications (wired and/or wireless) (please specify): _____ – OMIT FROM Q36
- ❑ Don't know – SKIP to Q37
- ❑ No telecommunications used to enable ITS on freeways – SKIP to Q37
- ❑ Not applicable, no ITS infrastructure or devices are deployed – SKIP to Q37

DEFINITIONS SHOWN IN HOVER BOXES:

Coaxial cable is mainly used to provide communications between field controllers and a central controller. Coaxial cables have an inner conductor, insulating layer, conductive shielding, and protective outer jacket.

Fiber-optic cables are made up of many super thin strands of optical glass fiber that make it possible to transmit large amounts of information over long distances (e.g., camera images).

Twisted copper pair/Twisted wire pair is composed of two insulated copper wires twisted around one another. This is mainly used to provide basic telephone services and ethernet over short distance.

Digital subscriber line (DSL) is a wireline transmission technology that uses existing infrastructure to provide integrated traffic video and field device communications. This includes all forms of DSL (e.g., ADSL, RADSL, HDSL, SDSL).

Data cable over modem service enables operators to provide broadband using standard cable lines (e.g., 56 kilobits/second).

5G New Radio and 5G small cell infrastructure (which communicates over very short distances) represents the newest generation of cellular data communication. The 5G New Radios can operate within and share existing 4G LTE infrastructure in non-standalone (NSA) mode (e.g., cell towers). The other critical component of 5G, small cell infrastructure, consists of small antennae placed in the

public right-of-way to act as a high-speed intermediary between a field device and the larger cell tower.

Cellular (LTE-4G) is the fourth generation of cellular data communication. LTE (Long Term Evolution) is standard to 4G and is both forward and backward compatible. Cellular LTE 4G operates in: 600 MHz, 700 MHz, 850 MHz, 1.7 GHz, 1.9 GHz, 2.3 GHz, 2.5 GHz spectrum.

Cellular GPRS – 2G or 3G are the older generations of cellular data communications and are being phased out. These generations of cellular rely on radio signals in a digital format and operate in the 470-690 MHz, 690-805 MHz, 1.850-1.995 GHz spectrum.

LTE-Cellular V2X (LTE-CV2X) operates in the reduced 5.895-5.925 GHz spectrum, known as the Safety Band (dedicated for safety-of-life and public benefit transportation purposes). LTE-CV2X is intended to service connected vehicle technology.

Dedicated short range communications (DSRC) is two-way radio communication operating in the reduced 5.895-5.925 GHz spectrum, currently known as the Safety Band (dedicated for safety-of-life and public benefit transportation purposes). The Federal Communications Commission (FCC) is planning to phase out DSRC in the future.

Wi-Fi provides wireless high-speed internet access or communications between devices (point-to-point or point-to-multipoint). It includes agency-installed Wi-Fi access points and client devices, or subscription-based Wi-Fi in the 2.4 GHz, 5.8 GHz, and (recently) 6 GHz spectrum.

Mobile or Fixed service satellite (FSS) provides radio communication between two or more fixed or mobile receivers. MSS or FSS allows uploading/downloading data across a wide range (137 MHz-51.4 GHz) of spectrum in the form of space-to-earth, earth-to-space, or broadcast communications.

Ultra-wideband (UWB) is a short-range communication technology ideal for transmitting data at high speeds between devices 10 to 30 meters apart, using any spectrum as unlicensed communications (similar to radar).

Microwave (also known as Ultra High Frequency (UHF) or Extremely High Frequency (EHF)) communicates as fixed point-to-point backhaul or as very short-range, line-of-sight radar/Lidar communications, typically between 300 MHz and 300 GHz spectrum.

36. (+) [IF Q35 = EACH TELECOM TECH CHECKED EXCEPT FOR COAXIAL, FIBER OPTIC CABLE, FSS, and MICROWAVE OPTIONS] **Please indicate how your agency is using the telecommunication technology(ies) shown below to enable ITS on freeways.**
Each of the use cases listed is based on Architecture Reference for Cooperative and Intelligent Transportation (ARC-IT) service packages. Click this link for more information: https://www.arc-it.net/html/servicepackages/servicepackages-areaspsort.html. *Please select all that apply in each column.*

- ❑ Commercial Vehicle Operations
- ❑ Data Management
- ❑ Maintenance and Construction
- ❑ Parking Management
- ❑ Public Safety
- ❑ Public Transportation
- ❑ Support
- ❑ Sustainable Travel
- ❑ Traffic Management
- ❑ Traveler Information
- ❑ Vehicle Safety
- ❑ Weather
- ❑ Other (please specify):_____
- ❑ Don't know

EXAMPLES SHOWN IN HOVER BOXES:

Commercial Vehicle Operations: Examples include commercial vehicle parking, smart roadside and weigh in motion, roadside commercial vehicle operator safety, freight-specific dynamic travel planning, hazmat management, etc.

Data Management: Two relevant service packages are ITS data warehouse and performance monitoring.

Maintenance and Construction: Examples include maintenance and construction vehicle maintenance, winter maintenance, roadway maintenance and construction, work zone management, asset tracking, etc.

Parking Management: Examples include parking space management, smart park and ride system, parking electronic payment, regional parking management, etc.

Public Safety: Examples include emergency response, mayday notification, incident scene safety monitoring, disaster response and recovery, disaster traveler information, etc.

Public Transportation: Examples include dynamic transit operations, transit fare collection management, transit security, transit fleet management, transit signal priority, intermittent bus lanes, etc.

Support: Examples include connected vehicle system monitoring and management, map management, ITS communications, location and time, security and credentials management, field equipment maintenance, etc.

Sustainable Travel: Examples include emissions monitoring, eco-traffic metering, roadside lighting, electric charging stations management, HOV/HOT lane management, eco-lanes management, etc.

Traffic Management: Examples include infrastructure-based traffic surveillance, vehicle based traffic surveillance, connected vehicle traffic signal system, traffic incident management system, electronic toll collection, variable speed limits, speed harmonization, etc.

Traveler Information: Examples include broadcast traveler information, dynamic route guidance, infrastructure- provided trip planning and route guidance, dynamic ridesharing, and shared use transportation, etc.

Vehicle Safety: Examples include autonomous vehicle safety systems, V2V basic safety, situational awareness, curve speed warning, queue warning, restricted lane warnings, automated vehicle operations, etc.

Weather: Examples include weather data collection, weather information processing and distribution, spot weather impact warning, etc.

37. [ASK ALL] **If your agency has any notes or additional information about its use of telecommunications, please provide below.**

Maintenance of Freeway ITS Technology

38. [ASK ALL] **Does your agency utilize an asset management system to track Intelligent Transportation Systems (ITS) inventory and/or ITS maintenance and operations activity on freeways?** *Please select all that apply.*

- ❑ Yes, system tracks inventory of ITS field devices
- ❑ Yes, system tracks inventory of ITS central systems / software
- ❑ Yes, system tracks maintenance and operations of ITS field devices
- ❑ Yes, system tracks maintenance and operations of ITS central systems / software
- ❑ No, my agency does not have an ITS asset management system
- ❑ Not applicable, my agency has not deployed ITS – SKIP TO Q40

DEFINITION SHOWN IN HOVER BOX:

An ITS **asset management system** is a software system, procedure, or tool that assists an agency in managing and maintaining data on ITS assets across the entire lifecycle of these assets, from acquisition to disposal. For more information see: https://ops.fhwa.dot.gov/publications/fhwahop20047/chap4.htm.

39. (+) [EXCLUDE IF Q38 = OPTION 6 NO ITS] **What is your agency's primary approach for conducting maintenance activities on freeway ITS assets?** *Please select one.*

- ○ My agency primarily schedules maintenance based on the regularly monitored condition of freeway ITS assets.
- ○ My agency primarily schedules maintenance of freeway ITS assets based on regular intervals.
- ○ My agency primarily conducts maintenance in response to reported freeway ITS asset failures or events, such as a vehicle collision or component failure.
- ○ Other (please specify): _____
- ○ Don't know

Transportation Systems Management and Operations (TSMO) Plan

40. [ASK ALL] **Does your agency have a Transportation Systems Management and Operations (TSMO) Plan?** *Please select one.*

- o Yes
- o No, but my agency plans to develop a TSMO Plan
- o No current plans to develop a TSMO plan

Cybersecurity

41. [ASK ALL] **Does your agency have a documented cybersecurity policy that explicitly addresses Intelligent Transportation Systems (ITS) technologies/equipment?** *Please select one.*

- o My agency has a cybersecurity policy which explicitly addresses ITS. – SKIP TO Q43
- o My agency's general cybersecurity policy (i.e., for information technology (IT)) is applied to ITS.
- o My agency's ITS is not covered by a cybersecurity policy.
- o My agency has not deployed ITS technologies/equipment. – SKIP TO Q44
- o Don't know – SKIP TO Q43

42. [IF Q41 = OPTIONS 2 or 3] **Is your agency planning to develop a cybersecurity policy that explicitly addresses ITS?** *Please select one.*

- o Yes
- o No
- o Don't know

43. (+) [EXCLUDE IF Q41=OPTION 4 (NO ITS)] **In the last five years, has your agency conducted incident response exercises that include ITS equipment/technologies to prepare for ITS cybersecurity events?** *Please select one.*

- o Yes, my agency's incident response exercises have included ITS equipment/technologies
- o No, my agency's incident response exercises have **not** included ITS equipment/technologies
- o No, my agency has not conducted incident response exercises in the last five years
- o Don't know

DEFINITION SHOWN IN HOVER BOX:

Incident response exercises are agency-run tests of protocols that mitigate violations of security policies and recommended practices.

44. a. [EXCLUDE IF Q 41 = OPTION 4 (NO ITS)] **In the last three years, has your agency had any cybersecurity events or attacks (e.g., ransomware, data breach) that affected its information technology (IT) system and/or ITS technologies/equipment on freeways?** *Please select all that apply.*

If your agency has experienced multiple events or attacks, please respond based on all experiences.

- ❑ Yes, affecting IT system
- ❑ Yes, affecting ITS technologies/equipment
- ❑ No – SKIP TO Q47
- ❑ Don't know – SKIP TO Q47

44. b. [ASK IF Q 41= OPTION 4 (NO ITS)] **In the last three years, has your agency had any cybersecurity events or attacks (e.g., ransomware, data breach) that affected its information technology (IT) system?** *Please select one.*

If your agency has experienced multiple events or attacks, please respond based on all experiences.

- ○ Yes – SKIP TO Q46
- ○ No – SKIP TO Q47
- ○ Don't know – SKIP TO Q47

DEFINITION SHOWN IN HOVER BOX:

Information technology (IT) systems include personal computers or commercial servers along with the network equipment to connect this equipment together.

45. (+) [IF Q44a = YES (OPTIONS 1 OR 2)] **What was (or were) the initial point(s) of entry for the cybersecurity event(s) or attack(s)?** *Please select all that apply.*

If your agency has experienced multiple events or attacks, please respond based on all experiences.

- ❑ IT system
- ❑ ITS equipment/technologies
- ❑ Don't know

46. [IF Q44a = YES (OPTIONS 1 OR 2) OR Q44b = YES] **Did any of the cybersecurity event(s) or attack(s) affect transportation system operations on freeways?** *Please select one.*

- ○ Yes
- ○ No
- ○ Don't know

Regional ITS Architecture

47. (+) [ASK ALL] **Is your agency/region covered by a Regional (or State) Intelligent Transportation Systems (ITS) Architecture?** *Please select one.*

- o Yes
- o No – SKIP TO Q50
- o Don't know – SKIP TO Q50
- o Not familiar or never heard of a Regional ITS Architecture – SKIP TO Q50

DEFINITIONS SHOWN IN HOVER BOXES:

A **Regional ITS Architecture** is a plan for institutional and technical integration of ITS in a region or state. A Regional ITS Architecture uses the National ITS Architecture (which provides a common framework for planning, defining, and integrating ITS deployments) as the template for its definition, including only the systems and services that are planned for implementation in the local area or state. For more information about the Regional ITS Architecture, see: https://ops.fhwa.dot.gov/its_arch_imp/index.htm. For more information about the National ITS Architecture see: https://www.arc-it.net/.

48. (+) [IF Q47 = YES] **Is your agency using your Regional (or State) ITS Architecture to support ITS deployments on freeways?** *Please select one.*

- o Yes, for all ITS deployments – SKIP TO Q50
- o Yes, for some ITS deployments – GO TO Q49b
- o No, my agency does not use our Regional ITS Architecture – GO TO Q49a
- o Not applicable (i.e., my agency does not use federal funds for ITS deployment OR my agency has not deployed ITS) – SKIP TO Q50
- o Don't know – SKIP TO Q50

49. a. (+) [IF Q48=OPTION 3 (NO DOES NOT USE)] **What are key reasons for NOT using your Regional (or State) ITS Architecture to support freeway ITS deployments?** *Please select all that apply.*

49. b. (+) [IF Q48= OPTION 2 (YES FOR SOME ITS DEPLOYMENTS)] **What are key reasons for NOT using your Regional (or State) ITS Architecture to support all of your freeway ITS deployments?** *Please select all that apply.*

- ❑ Lack of experience/technical expertise with the Regional ITS Architecture
- ❑ The Regional ITS Architecture is out of date
- ❑ The scope and/or scale of my agencies' ITS projects are generally too small
- ❑ No perceived technical or operational benefit to using the Regional ITS Architecture
- ❑ Other (please specify): _____

Integrated Corridor Management

This question focuses on Integrated Corridor Management (ICM). ICM is an approach that manages a transportation corridor as a multimodal system (freeway, arterial, and public transit), integrating operations such as traffic incident management, work zone management, traffic signal timing, managed lanes, real-time traveler information, and active traffic management to maximize the capacity of all facilities and modes across the corridor.

For the purposes of this survey, a corridor is defined as: a largely linear geographic band and a bounded travel shed of (mostly) commute and daily trips. The corridor must include **freeway**, **arterial**, and **public transit facilities**, with cross-facility connections.

You can find more information about ICM at https://rosap.ntl.bts.gov/view/dot/38816.

50. [ASK ALL] **Has your agency deployed Integrated Corridor Management (ICM) in one or more corridors (i.e., integrating operations across freeway, arterial, and public transit networks) to actively manage travel demand and capacity in the corridor as a whole?** *Please select one.*

- ○ Yes, my agency has deployed ICM
- ○ No, but my agency plans to deploy ICM
- ○ No, my agency has no plans to deploy ICM

Agency Coordination

51. [ASK ALL] **Does your agency RECEIVE the following incident information in real-time from any public safety agency?** *Please select one response for each item.*

	Yes	*No*
Incident clearance	○	○
Incident severity and type	○	○

52. [ASK ALL] **Does your agency PROVIDE real-time incident information (e.g., type, severity) to the following types of agencies?** *Please select one response for each agency type.*

Freeway Incident Information

	Yes	*No*
Freeway management agencies	○	○
Arterial management agencies	○	○
Public transit agencies	○	○
Law enforcement public safety agencies	○	○
Fire rescue public safety agencies	○	○
Other agencies (please specify)	○	○

53. [ASK ALL] **Does your agency PROVIDE real-time freeway traffic information (e.g., travel times, speed, and condition) to the following types of agencies?** *Please select one response for each agency type.*

	Freeway Traffic Information	
	Yes	*No*
Freeway management agencies	○	○
Arterial management agencies	○	○
Public transit agencies	○	○
Law enforcement public safety agencies	○	○
Fire rescue public safety agencies	○	○
Other agencies (please specify)	○	○

Future Deployment Planning

54. [ASK ALL] **Does your agency plan to expand or upgrade current ITS on freeways during the next three years (2024 through 2026)?** *Please select one.*

- ○ Yes
- ○ No
- ○ Don't know
- ○ Not applicable, my agency has not deployed ITS

55. [ASK ALL] **Does your agency plan to invest in new or emerging ITS on freeways during the next three years (2024 through 2026)?** *Please select one.*

- ○ Yes
- ○ No – SKIP TO Q57
- ○ Don't know – SKIP TO Q57

56. [IF Q55 = YES] **Please describe new or emerging ITS technologies your agency plans to invest in:**

Additional Comments

57. Please use the space below to provide any additional comments regarding your agency's deployment, operations, or maintenance of ITS. Please be as specific as possible when commenting on particular ITS technologies.

58. Can we contact you if we have any follow-up questions about your agency's experience deploying ITS? *Please select one.*

- ○ Yes
- ○ No – SKIP TO Q60

How can we best reach you if we have follow-up questions about your agency's experience deploying ITS?

59. a. The phone number we have on file is [RESPONDENT PHONE]**. If this is not your preferred phone number, please provide your preferred phone number below:**

59 b. The email address we have on file is [RESPONDENT EMAIL]**. If this is not your preferred email, please provide your preferred email address below:**

60. Please confirm if you are ready to submit your responses. *Please select one.*

- Yes, I have completed the survey and I would like to submit my final responses (Note: if you click this button, you will not be able to return to the survey).
- No, I am still working on the survey and will complete it later.

Thank you for your time and effort in

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