Deployment of Intelligent Transportation Systems: A Summary Of the 2016 National Survey Results

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16. Abstract

This report presents summary results of the 2016 ITS Deployment Tracking survey, the most recent survey conducted through the ITS Deployment Tracking Project. The U.S. Department of Transportation and the ITS Joint Program Office have pursued a research and development agenda, the Intelligent Transportation System (ITS) Program, designed to integrate the latest in information technologies to improve the safety, mobility, and reliability of surface transportation modes. Within metropolitan areas, implementation of these advanced technologies has been carried out by a variety of state and local transportation agencies. In order to measure the status of ITS deployment within the nation's largest metropolitan areas, the ITS Deployment Tracking Project has conducted a nationwide survey of state and local transportation agencies periodically since 1997.

The results presented in this report are a summary of the database from the 2016 survey. Access to the complete survey results and results from previous national surveys is available on-line at http://www.itsdeployment.its.dot.gov. The website also provides access to survey results in the form of downloadable reports, including a survey summary for each survey type and fact sheets. More than 900 surveys were distributed to state and local transportation agencies in 2016. Three survey types were distributed: Freeway Management, Arterial Management, and Transit Management.

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The conclusions expressed in this document reflect solely the opinions of the authors and do not represent the opinions of the U.S. Department of Transportation.

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Introduction

Advances in communications, electronics, and computing offer the opportunity to revolutionize the management and operation of the surface transportation system. The U.S. Department of Transportation (DOT) and its member agencies have pursued a research and development agenda, the Intelligent Transportation System (ITS) Program, managed by the ITS Joint Program Office (JPO), designed to deploy and integrate applicable technologies to improve the safety, mobility, and reliability of surface transportation.

In order to track progress and manage the national ITS program, the ITS JPO created the National ITS Deployment Tracking Survey to gather deployment data from state and local agencies nationwide on a regular basis. The survey has been conducted since 1998 and is currently updated every three years, with the most recent data collection held in 2016. The survey targets transportation agencies in 108 metropolitan areas and in 2016 included 849 state and local agencies supporting freeway management, arterial management, and transit management.

This report summarizes the results of the 2016 National ITS Deployment Tracking survey. Access to the complete database of the survey results is available through the ITS Deployment Tracking Website at: http://www.itsdeployment.its.dot.gov/.

Executive Summary

As summarized in Table ES-0-1, 849 surveys were distributed to state and local transportation agencies in 108 cities in 2016. Surveys were sent to three types of transportation agencies: freeway management, arterial management, and transit management.

Table ES-0-1 2016 ITS Metropolitan Deployment Tracking Survey Response Rate by Agency Type

Survey	Agency Type	Sent	Returned	% Returned
Freeway Management	Freeway	142	99	70%
Arterial Management	Arterial	503	272	54%
Transit Management	Transit	204	99	49%
Totals		849	470	55%

The 2016 survey covered ITS deployment status and trends as well as a variety of related topics, including connected vehicles (CV), traffic management strategies, data collection and dissemination, operations performance management, safety and enforcement, road weather systems, integrated corridor management, joint planning for operations, and maintenance of ITS devices. The trade-off for collecting such a rich variety of data is the effort required of respondents. The authors are very grateful for respondents taking the time and care required to complete the surveys.

This report has four chapters. The first chapter covers a new topic area, Connected Vehicles (CV). The second chapter covers deployment trends for key ITS technologies by each agency type. The third chapter covers data for a variety of applications, many of which involve more than one agency type. Chapter 4 repeats the summary findings emerging from the survey data.

Connected Vehicles

Deployment of Connected Vehicle (CV) technology is in its infancy; therefore, survey questions on this topic are aimed at issues related to planning for deployment: CV awareness, the readiness of transportation agencies to deploy CV technology, future plans for CV deployment, and issues impacting those plans.

<u>Planned CV Deployments.</u> As with much ITS technology, freeway agencies lead arterial and transit agencies in CV deployment planning. While more than half (59%) of freeway agencies currently have plans to deploy CV technology, only 25% of arterial and 14% of transit agencies do so. Applications most frequently cited by freeway agencies are: traveler information, road weather, intelligent traffic signals, work zone safety, incident and emergency management, commercial vehicle applications, and safety warning systems. Arterial agencies focus on intelligent traffic signal systems, followed by traveler information, incident and emergency management, pedestrian and bicycle warning, and road weather. Transit agencies plan to deploy advanced traffic signal priority systems, advanced traveler information, fee payments, and safety warning systems for pedestrians, collision avoidance, and work zones. Arterial and transit agencies most often plan one to five CV applications; freeway agencies have a more aggressive plan for deployment with half of freeway agencies planning six or more applications. More than half of all agency types plan to deploy CV applications within the next three years. The main reasons reported by agencies for not deploying CV technology are cost, lack of

qualified staff, institutional incompatibility, and lack of confidence in benefits of deployment. Agencies report that the type of assistance most needed to spur further deployment is funding, this is followed by help with procurement, deployment guidance, training, and information on return on investment.

Readiness. A critical goal for the survey was to develop an accurate assessment of the readiness of agencies to deploy CV systems. This was accomplished by tracking progress in six categories that cover important steps agencies will need to take to deploy CV technology. The results show that Freeway agencies are the furthest along, showing three times the progress in achieving the readiness factors for arterial and transit agencies.

Levels of familiarity with SET-IT and CVRIA. One factor evaluated in more detail was familiarity with foundational CV systems: the Connected Vehicle Reference Implementation Architecture (CVRIA) and the System Engineering Tool Intelligent Transportation (SET-IT). A quarter of freeway, 15% of arterial, and less than 10% of transit agencies reported having a moderate or better familiarity with these systems.

Communications. A connected vehicle infrastructure is tied together by high capacity wired and wireless communications. As a measure of readiness for CV, the survey covered several aspects of communications. As expected, freeway agencies lead in the adoption of communications media, particularly fiber, cellular, digital subscriber line, and microwave. Arterial agencies have focused on fiber and cellular communications, as had transit agencies, which also have a significant investment in Wi-Fi. Freeway agencies also lead by a very wide margin in the use of devices with backhaul capability. Freeway agencies have a security policy for communications with field devices covering cyber security about twice as often as arterial and transit agencies.

Partnerships for CV Deployment. As a final measure of readiness, the survey also covered the extent that agencies have begun discussions with other agencies concerning partnerships to coordinate CV deployment and operations. About half of the freeway and arterial agencies are working with both public and private partners, with a smaller portion working with public sector agencies only and private sector partners only. Overall three fourths of freeway agencies, and more than half of arterial and transit agencies are participating in these discussions.

Deployment Trends

As in previous surveys, the 2016 ITS deployment tracking survey continued to gather a consistent set of data elements designed to track progress in deploying key ITS technologies in major cities.

Freeway Management

The coverage of surveillance systems reported on freeways in 2016 continues an upward trend, with three fourths of the freeway miles reported covered by electronic surveillance to monitor traffic conditions and over two thirds of freeway mileage reported covered by closed circuit television (CCTV) cameras to detect and evaluate incidents. The sophistication of traffic detection systems deployed by freeway agencies to monitor traffic conditions is evolving. The percentage of agencies reporting the use of radar stations is leveling off at 62% of freeway agencies, while use of loop detectors, an older detection technology, is reported by only a third of freeway agencies and has been declining. The adoption of probe readers to monitor traffic conditions is rapidly expanding and was reported by 52% of freeway agencies, (up from only 24% six years ago), with the most common variety being Bluetooth readers, reported in use by a third of freeway agencies. The use of dynamic message signs (DMS) deployed to disseminate traveler information continues its upward trend and is now virtually universal. Over 6,000 DMS are used nationally, averaging 70 signs per agency (up from an average of 50 in 2013). Finally, the use of highway advisory radio (HAR) is clearly being supplanted by other media and is in decline, but still reported by more than half of freeway agencies.

Arterial Management

The adoption of ITS technologies in general by arterial agencies is increasing and is catching up to freeway agencies. The use of electronic surveillance systems deployed to monitor traffic conditions by arterial agencies continues rapid growth, having expanded to cover three fourths of signalized intersections in 2016, up from less than half in 2010. A variety of traffic detection technologies are employed by arterial agencies. The adoption of loop detectors is essentially universal, while 78% of agencies report the use of video imaging detectors, up from only 58% in 2010. The use of Bluetooth readers is growing rapidly, from only 2% of arterial agencies in 2010 to 20% in 2016, as is that of radar stations, reported by 39% of arterial agencies, up from 13% in 2010. Nearly a third of arterial agencies disseminate the data gathered by these detection systems to travelers by DMS. The use of traffic adaptive signaling continues to expand rapidly and is reported by 23% of agencies, up from only 2% in 2010. The only reduction in rate of adoption measured is with red light running cameras, down from 26% of agencies in 2010 to only 15% in 2016.

Incident Management

Technology supporting incident management includes CCTV to detect and evaluate incidents and a service patrol system to respond and clear incidents. The coverage of CCTV on freeways continues to expand and in 2016 covered 68% of freeway miles reported (up from 46% in 2010). Service patrol coverage on freeways also increased, but more gradually, now covering 56% of reported freeway miles (up from 48% in 2010). Incident management deployment by arterial agencies is at an early stage but is growing. Reported deployment of CCTV on arterials covers nearly 20% of arterial miles and coverage for service patrols is 16% of arterial miles.

Transit Management

Some ITS technologies have become standard in transit management, while others are slowly expanding. Among the responding agencies the deployment of automatic vehicle location (AVL) systems on fixed route buses has expanded to 76% of transit agencies, up from only 54% in 2010. The use of electronic fare payment by transit agencies is now reported by 57% of agencies for magnetic stripe readers and 42% of agencies for smart card readers. The adoption of signal priority capability on fixed route buses is virtually unchanged at 26% of transit agencies in 2016.

Future Deployment Plans

Agencies were asked to report their plans to expand existing ITS deployments or to invest in new technologies. Plans for both investing in new and existing technology were reported by three fourths of the freeway agencies. Arterial agencies were different with the deployment of new technologies reported by 45% of the agencies but expansion by only 13%. About half of the transit agencies reported plans to invest in both new and existing technology. Agencies were also asked about the specific technologies they plan to deploy in the next three years. Freeway agencies most often report planning to expand coverage of DMS and CCTV. Next in frequency is CV technology, a major change from 2013 when only a few agencies reported planning CV deployments. Additional planned deployments on freeways include detectors, road weather information systems (RWIS) and variable speed limits. The top three technologies planned by arterial agencies, CCTV, traffic adaptive signals and DMS, mirrors the 2013 results. As with freeway agencies, the planned deployment of CV technology increased substantially from 2013, moving to fifth of 15 technologies from last of 15 in 2013. Arterial agencies also plan to implement truck parking support and make upgrades to communications with fiber optic cable and wireless systems. Transit agencies report planning to deploy traffic signal priority most often, followed by expansion of AVL, automatic passenger counters, and electronic fare payment systems.

ITS Applications

The 2016 survey covered a wide range of topics, from maintenance of ITS technology to the use of technology to improve transportation management, data handling, and safety as well as the support of interagency coordination in planning and operations. Since these additional topics are typically not strictly limited to one agency type, it is more useful to report results by the application rather than separately for each agency type. These applications include:

- Management and Operations Strategies
- Data Collection and Dissemination
- Operations Performance Management
- Safety, Enforcement, and Work Zone Systems
- Road Weather Systems
- Integrated Corridor Management (ICM)
- Planning for Operations
- Maintenance of ITS Technology

Management and Operations Strategies

Ramp Metering. The agencies that have adopted ramp metering are increasingly employing sophisticated strategies to control timing. The use of dynamic timing based on traffic conditions is very widespread, with more than three fourths of the agencies that employ ramp metering using timing based on conditions near the ramp or the more sophisticated strategy of integrating ramp meters and basing timing on traffic conditions along a corridor.

Managed Lanes. Deployment of managed lanes by freeway agencies remains fairly limited, and is focused on control of high occupancy vehicles (HOV) with 16% reporting the use of HOV lanes and 13% reporting the use of high occupancy toll (HOT) lanes. The use of other managed lane strategies is only lightly reported.

Traffic Signal Control. ITS technologies enable a variety of management strategies for traffic signals. More than 80% of arterial agencies feature traffic signal preemption for emergency vehicles and 56% enhance safety through preemption for clearing a vehicle queue at an active highway-rail at grade crossing. Additionally, about a quarter of agencies support priority for transit vehicles and 2% provide signal priority for trucks. .

Parking Management. Arterial agencies are beginning to support parking management, with 9% of agencies monitoring and disseminating parking availability information to travelers. A smaller number (4%) support advanced strategies including allowing travelers to make parking reservations and the use of a parking pricing strategy to manage congestion.

Transit Interface with Traffic Signals. Transit vehicles can improve schedule adherence by the use of traffic signal priority and preemption. By far, the most common type of signal override is for fixed route buses having signal priority capability, which is reported by 26% of transit agencies. Signal preemption by fixed route buses is also reported, but by only 4% of transit agencies. A smaller number of transit agencies report traffic signal priority (3%) and preemption (2%) capability for light rail vehicles.

Transit Management Strategies. A growing number of transit management agencies employ ITS technology to improve customer service. Half of the transit agencies can hold vehicles to facilitate the coordination of passenger transfers between vehicles. Four in ten transit agencies employ technology to adjust routing and scheduling in real time and a third report being capable of detecting scheduling issues and adjusting the assignment of vehicles in real time to cover overcrowded sections of the network.

Transport of People with Disabilities. Transit agencies have adopted a wide variety of technologies to support the transport of people with disabilities. More than half of transit agencies have automated audio and visual announcements of routes and stops. One fourth of the agencies offer audio and braille equipped fare vending machines. Some of these systems are quite sophisticated, including navigation apps using global positioning system (GPS) enabled mobile phones (11% of agencies), interactive voice response (12% of agencies), and audio-tactile mapping tools supporting wayfinding (3% of transit agencies).

Electronic Fare Payment. The adoption of electronic fare payment systems by transit agencies in the form of smart cards and magnetic stripe readers has become widespread. Two-thirds of agencies use smart cards or magnetic stripe readers in some capacity for fixed route buses, as well as heavy rail, rapid rail, or light rail stations. Coverage is 30% for commuter rail stations and less than a tenth of transit for paratransit vehicles or at bus stations.

Freeway and Arterial Decision Support Systems. Both freeway and arterial agencies employ decision support systems to assist in traffic management. Freeway agencies most often use these systems to support management of incidents (47%) and road weather (43%), followed by management of emergencies, roadside device maintenance and evacuation. Use of decision support systems by arterial agencies is not far behind freeway agencies with management of incidents (27%), emergencies (23%), followed by road weather, evacuation and device maintenance.

Data Collection and Dissemination

Probe Readers. The use of probe readers has expanded quickly to the point that they are an important source of traffic data. Bluetooth readers are most widely adopted and are reported by 33% of freeway and 20% of arterial agencies. Adoption of cellular phone readers, toll tag readers, and GPS readers are reported in use by 16% of freeway agencies, but, with the exception of cellular phone readers, are lightly deployed on arterials. License plate recognition systems are in use as well, but less often.

Crowdsourced Data. The availability of data from social media and smartphones has revolutionized data collection. The primary providers of crowdsourced data for freeways are Waze (41%), commercial providers (31%) and Google maps traffic (16%). These same sources are in use by 6% to 10% of arterial agencies. Some freeway agencies also collect data from travelers through a dedicated cellular phone number (7%) or a smartphone app (4%).

Traveler Information Dissemination Media. Transportation agencies have made a major commitment to the use of social media to distribute data in addition to more traditional methods. The media most commonly employed by freeway agencies is Twitter (91% of agencies), followed by DMS, website, email, 511, and Facebook (all reported by 70% or more of freeway agencies). Arterial agencies most frequently report the use of a website (49% of agencies), followed by Twitter, Facebook, email, and DMS. Transit agencies rely on a website most often (70% of agencies), followed by email, DMS, Twitter, and apps for mobile devices.

Operations Performance Management

Performance Management. Three fourths of freeway agencies and one fifth of arterial agencies use archived operational data to track system performance. Just over half of freeway agencies and a quarter of arterial agencies create targets for performance measures to diagnose and overcome specific issues impacting quality of service.

Performance Measures. A performance management approach enables agencies to not only detect problems but also to learn from successes and failures in dealing with them. The use of performance measures is widespread. Freeway agencies most often report the use of travel time (62% of agencies), average speed (56%), travel time reliability (49%), and vehicles per hour (39%). Arterial agencies also most often report the use of travel time (40% of agencies), followed by average speed (29%), vehicles per hour (23%) and average delay per vehicle (16%). Transit agencies have adopted a number of performance measures as well, including vehicle time and location (73% of agencies), passenger counts (51%), incidents (40%), vehicle diagnostics and health (29%), and vehicle status (27%).

Archived Data. Agencies use archived data to support multiple functions. Two-thirds of freeway agencies and a quarter of arterial agencies archive performance data to support analysis of operation's planning and, to a slightly lesser extent, analysis of work zones, capital planning, real-time operational decision making, and dissemination to the public.

Safety, Enforcement, and Work Zone Systems

Work Zone Safety Systems. ITS technologies are used to detect hazardous conditions and provide warnings to travelers at work zones. Freeway agencies deploy a variety of sophisticated technologies at work zones: portable CCTV (reported by 56% of agencies), travel time systems (43%), queue detection systems (34%) as well as portable traffic monitoring devices, variable speed limits and dynamic lane merge. Arterial agencies also report the use of these same technologies but less frequently (about one fifth as often as freeway agencies for most systems).

Transit Surveillance Systems. Transit agencies enhance safety through the use of audio or video surveillance at facilities and on vehicles. Facility surveillance is well established with 51% of transit agencies reporting the use of surveillance cameras at bus stations, 37% at mutli-modal stations, 20% at rail stations, and 18% at bus stops. Surveillance in vehicles is also widely reported, with fixed route bus and light rail surveillance reported by 80% of transit agencies and commuter and paratransit surveillance by half of the reporting of agencies.

Freeway and Arterial Safety Systems. Freeway and arterial agencies have deployed a variety of sophisticated safety warning systems. About a quarter of freeway agencies and 5% to 10% of arterial agencies have deployed over-height warning systems, queue warning systems, and variable speed limits. A small percentage of agencies have deployed speed harmonization systems as well.

Automated Enforcement. Freeway and arterial agencies are beginning to deploy technology to assist in enforcement. A variety of technologies are employed to identify violators. Cameras are most often deployed and are reported by 9% of freeway agencies and 16% of arterial agencies. License plate recognition and toll tag readers are also reported, but less frequently. The targets for automated enforcement include toll booths, and to speed enforcement; however, adoption is light, involving only 3%-5% of agencies. To a lesser extent these systems are reported by freeway agencies to enforce HOV and HOT lanes and truck lanes. Arterial agencies are more active in the use of automated enforcement, with 16% of agencies using this technology to detect red light running along with limited deployment of speeding and school zone systems.

Road Weather Systems

The National Weather Service is the most often reported source of weather information by freeway agencies (79%) and arterial agencies (73%), followed by agency field sensors, reported by 67% of freeway agencies and 24% of arterial agencies. Private providers and agency field personnel are also important sources of weather data. Technologies employed to support transportation include environmental sensor stations (ESS), deployed by 68% of freeway agencies and 20% of arterial agencies. These sensors detect a wide variety of weather data, most frequently temperature, wind speed, humidity, pavement temperature, and precipitation (rain). Weather safety warning systems are deployed by 66% of freeway and 19% of arterial agencies, and the hazards most frequently detected by these systems are icy roads, high wind, and fog. A quarter of freeway agencies and 4% of arterial agencies employ a Maintenance Decision Support System to manage weather maintenance.

Integrated Corridor Management

The Integrated Corridor Management (ICM) concept envisions freeway, arterial, and transit agencies integrating operations within a designated corridor. Most commonly, agencies are part of only a single corridor—reported by 46% of freeway, 41% arterial, and 59% of transit agencies. However, a substantial number of agencies are part of three or more corridors, reported by 33% of freeway, 46% of arterial, and 36% of transit agencies.

Generally, corridor agencies are informally coordinated, either through ad hoc or regular but informal meetings. Less than 10% of freeway, arterial, or transit agencies report being part of a corridor that is legally organized. However, while coordination is not formal, a high percentage of corridor agencies (88% of freeway, 50% of arterial, and 53% of transit) report being a member of a working group to coordinate operations. Additionally, 48% of freeway agencies, 31% of arterial agencies, and 47% of transit agencies report having developed a concept of operations for the corridor or being in the process doing so. In addition, about a third of corridor agencies report working together to develop response plans for specific situations including congested conditions or emergency situations. Another indicator of commitment to coordinated traffic management is the development and use of corridor-level/multimodal performance measures, which are complete or in progress by about half of the corridor agencies.

Inter-Agency Data Sharing. The most common type of data sharing is manual, reported by 72% of freeway agencies, 23% of arterial agencies, and 42% of transit agencies. A smaller number of agencies report being involved with automated real-time sharing of video and data (40% freeway, 13% arterial, and 7% transit). The ultimate in data sharing is being part of an information exchange network that all agencies can access, which is reported by 23% of freeway, 5% of arterial, and 4% of transit agencies.

Joint Planning for Operations

Planning for Operations Planning for Operations encompasses interagency coordination outside formal integrated corridors and includes coordination between operations and planning. Coordination for planning and operations is widespread, with 92% of freeway agencies and 61% of arterial agencies reporting being part of a regional ITS architecture, with a similar percentage being included in a regional concept for transportation operations.

Levels of Coordination. The formality of coordination varies, with about two-thirds of freeway and one-third of arterial agencies participating in regular meetings to coordinate planning and operations. A smaller portion of the agencies participate in a formal agreement to coordinate data sharing (24% of freeway and 10% of arterial) and operations (16% of freeway and 8% of arterial).

Coordination and Management of Traffic Signal Systems. The coordination among arterial agencies concerning management and operation of signals is widespread. About half of arterial agencies report employing a documented plan covering maintenance and coordination of signal timing across jurisdictional boundaries, including regional programs managed by state DOT, MPO, or other regional authority.

Open Data. The DOT has implemented an Open Data Policy to promote openness and data sharing with both the public as well as other agencies. About three fourths of freeway and transit agencies have adopted or are in the process of developing an Open Data Policy. Arterial agencies have made less progress, with about a third of agencies adopting or developing an Open Data Policy.

Maintenance of ITS Technologies

System maintenance for ITS technology refers to a series of methodical, ongoing activities designed to minimize the occurrence of systemic failures and to mitigate their impacts when failures do occur. Freeway and arterial agencies employ multiple methods to track the operational health of ITS devices, including real-time monitoring (69% freeway, 45% arterial), inspections (46% freeway and 50% arterial), and complaint calls (67% freeway and 42% arterial). Once the operational health of devices is determined the three main factors used in deciding to take maintenance action for freeway agencies are reaction to failure, inspections, and planned program of preventive maintenance, while for arterials the main factors are reaction to failure, inspection, and obsolescence.

Summary Findings

- Interest in CV technology has advanced very rapidly, although unevenly, with freeway agencies planning CV deployments more than twice as often as arterial or transit agencies.
- The focus of planned CV deployments is safety and mobility applications: Freeway agencies most often plan to deploy advanced traveler information, road weather, work zone warning, and incident and emergency management. Top four CV applications for arterial agencies are intelligent traffic signal systems, advanced traveler information, incident and emergency management, and pedestrian and bicycle warning systems. Transit agencies most often plan to employ CV systems to support signal priority, fee payments, advanced traveler information, and pedestrian warning systems. As yet, there is little emphasis on Eco (environmental) applications.
- Planned timing for CV deployments covers a wide range. Most agencies plan to deploy CV in the next three years but a third of the agencies plan to deploy later, in some cases in seven or more years. This may reflect uncertainty reflected in reasons for not deploying or lack of confidence that required assistance will be provided.
- There is no single reason why agencies do not plan to deploy CV in the near term. Agencies not deploying CV were asked about their reasons for this decision. Many issues were raised and a total of six issues were cited by at least a quarter of the agencies. Having other higher priorities, limitations in staffing capability, and cost were most commonly cited, followed closely by institutional issues, technical risks, and unclear benefits. On the other hand, privacy and security concerns were only lightly selected as important factors.
- Agencies not deploying CV require a variety of types of assistance to choose to deploy. The same agencies not deploying CV were asked about specific types of assistance or resources they would need to change their position and decide to deploy CV technology. Funding was most often cited, but also frequently selected were procurement information, cost data, benefit-cost analysis, training, and technical assistance.
- The readiness status of agencies for CV deployment is mixed. A majority of agencies planning to deploy CV have hired a chief technology or chief information officer. Most freeway and arterial agencies have obtained a license for DSRC or are planning to do so. More than half of all agency types in incorporating CV in planning documents and implementing CV interfaces. On the other hand, more than half of the agencies planning to deploy are only slightly familiar or not at all familiar with the Connected Vehicle Reference Implementation Architecture or the Systems Engineering Tool-Intelligent Transportation (SET-IT).
- Data dissemination with social media has become widespread. Four of the top six media used by all three agencies are social media. Twitter, websites, email, and Facebook are very widely used to distribute traveler information.
- Crowdsourced data collection is expanding, particularly for freeway agencies. Sources like Waze, commercial providers, and Google maps traffic are widely used. Arterial agencies employ the same sources but about one fourth as often as freeway agencies.
- ITS technology is being used in a variety of safety and security applications. Systems deployed at work zones include portable CCTV, travel time, queue detection and warning, traffic monitoring, and dynamic lane merge. Transit agencies deploy audio/visual surveillance at bus and rail stations, transfer stations, and bus stops.

- Arterial agencies are rapidly catching up with freeway agencies in the deployment of ITS technology. Just short of 80% of signalized intersections are under surveillance. The use of Bluetooth readers and radar sensors has doubled in three years and nearly a quarter of agencies have adopted traffic adaptive signaling.
- Transit agencies have also made significant progress in the use of technology. The adoption of AVL and electronic fare payment nearly doubled since 2013. In addition, transit agencies have deployed a suite of sophisticated technologies to aid handicapped travelers including audio and visual announcements, audio and Braille fare vending machines, interactive voice systems, and the use of smartphone apps to aid navigation within a station.
- Freeway agencies employing ramp metering get the maximum benefit through the use of sophisticated control strategies. Three fourths of agencies using ramp metering employ dynamic timing based on traffic conditions along a corridor.
- ITS technology has enabled agencies to employ decision support systems for a variety of situations. Both freeway and arterial agencies report the use of decision support systems to manage incidents, road weather, emergencies, maintenance of field devices, and evacuation.
- Agencies operating in an integrated corridor are developing documents governing combined operations. Currently, most agencies involved with integrated corridor management do so informally, with only a small portion reporting being part of a formal or legal organization. However, in spite of the lack of formality, more than 80% of all agencies involved with integrated corridor management have developed a concept of operations, are in the process, or plan to do so. A similarly high percentage of agencies have developed or plan to develop a documented set of response plans and strategies to optimize performance in the corridor as whole. In addition, at least half of the agencies operating in a corridor are developing corridor-level/multimodal performance measures.
- ITS technology has revolutionized the ability of traffic managers to measure performance. More than half of freeway and a quarter of arterial agencies have adopted a performance management approach. These agencies have adopted a suite of performance measures and compare operational data to performance targets in order to diagnose and overcome specific issues impacting quality of service.
- ITS technology supports operations coordination for agencies operating outside an integrated corridor as well. More than half of freeway agencies and a third of arterial agencies report meeting regularly to coordinate planning and operations. Just under half of the arterial agencies also participate in regional coordination programs to coordinate traffic signal timing across jurisdictional boundaries.

Chapter 1 Connected Vehicles

For the first time, the 2016 Deployment Tracking Survey included a section covering connected vehicle (CV) applications. CV applications enable vehicles, roadside infrastructure, and personal communication devices to interoperate in real time to improve traffic management and enhance safety. At this point in the CV program, the data gathered covered preparation for deployment including plans for deployment, barriers to deployment, assistance required to accelerate deployment, and an assessment of readiness for deployment.

Plans to Deploy Connected Vehicles

This section focuses on those agencies with plans to deploy CV and explores the specific applications involved as well as the number and timing of planned deployments.

Agencies were asked to indicate their plans to deploy CV technology. As summarized in Figure 1-1, the majority of freeway management agencies reported plans to deploy CV applications, substantially more often than arterial and transit agencies.

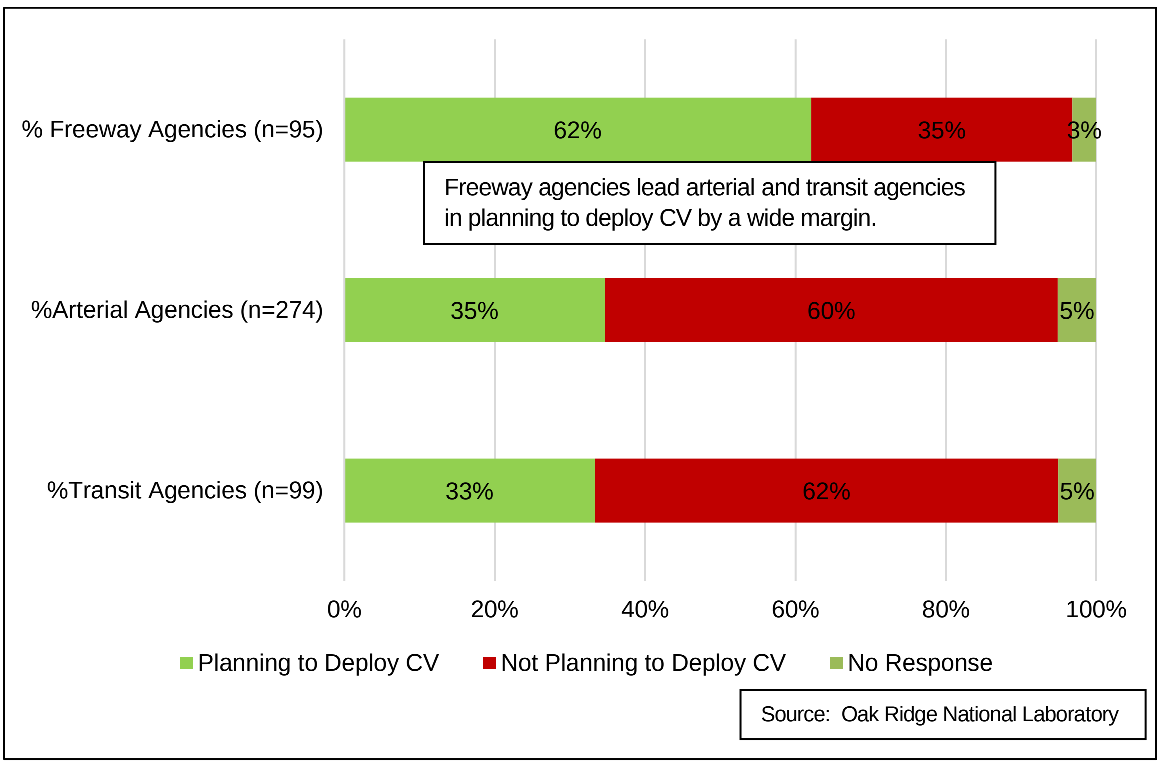


Figure 1-1. Agencies Planning to Deploy CV Applications

Priorities for Agencies Planning to Deploy CV

The agencies that reported they were planning to deploy CV applications in the next three years were asked about the types of applications they would deploy. By a wide margin, freeway and arterial agencies cite safety as the focus for these initial CV deployments. Transit agencies were equally split between safety and mobility. Environment focused (Eco) applications are not a priority for any of the agencies.

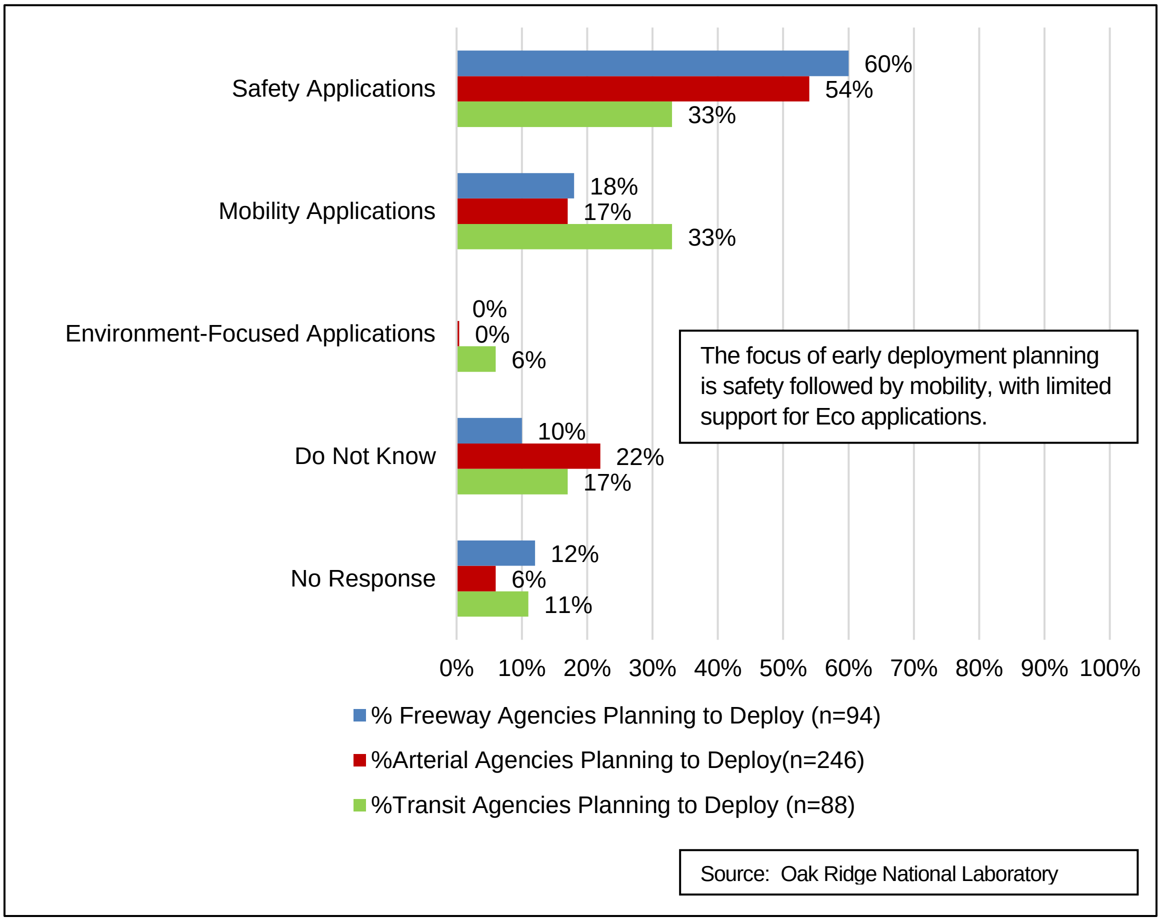


Figure 1-2. Application Priorities for Agencies Planning to Deploy CV

Future Freeway CV Deployments

Agencies planning to deploy CV technology were asked to specify the specific applications they are targeting. The results are summarized in **Error! Reference source not found.** for freeway agencies, Figure 1-4 for arterial agencies, and Figure 1-5 for transit agencies. Among the most frequently selected applications for the freeway agencies planning to deploy CV technologies are advanced traveler information systems, road weather applications, intelligent traffic signal systems, and reduced speed/work zone warning, and incident and emergency management (all cited by more than half of the agencies planning to deploy). Commercial vehicle systems, curve warning systems, and performance data collection are also planned by many agencies. Environmental (Eco) applications are included, with Eco-signal operations cited by 19% of the freeway agencies.

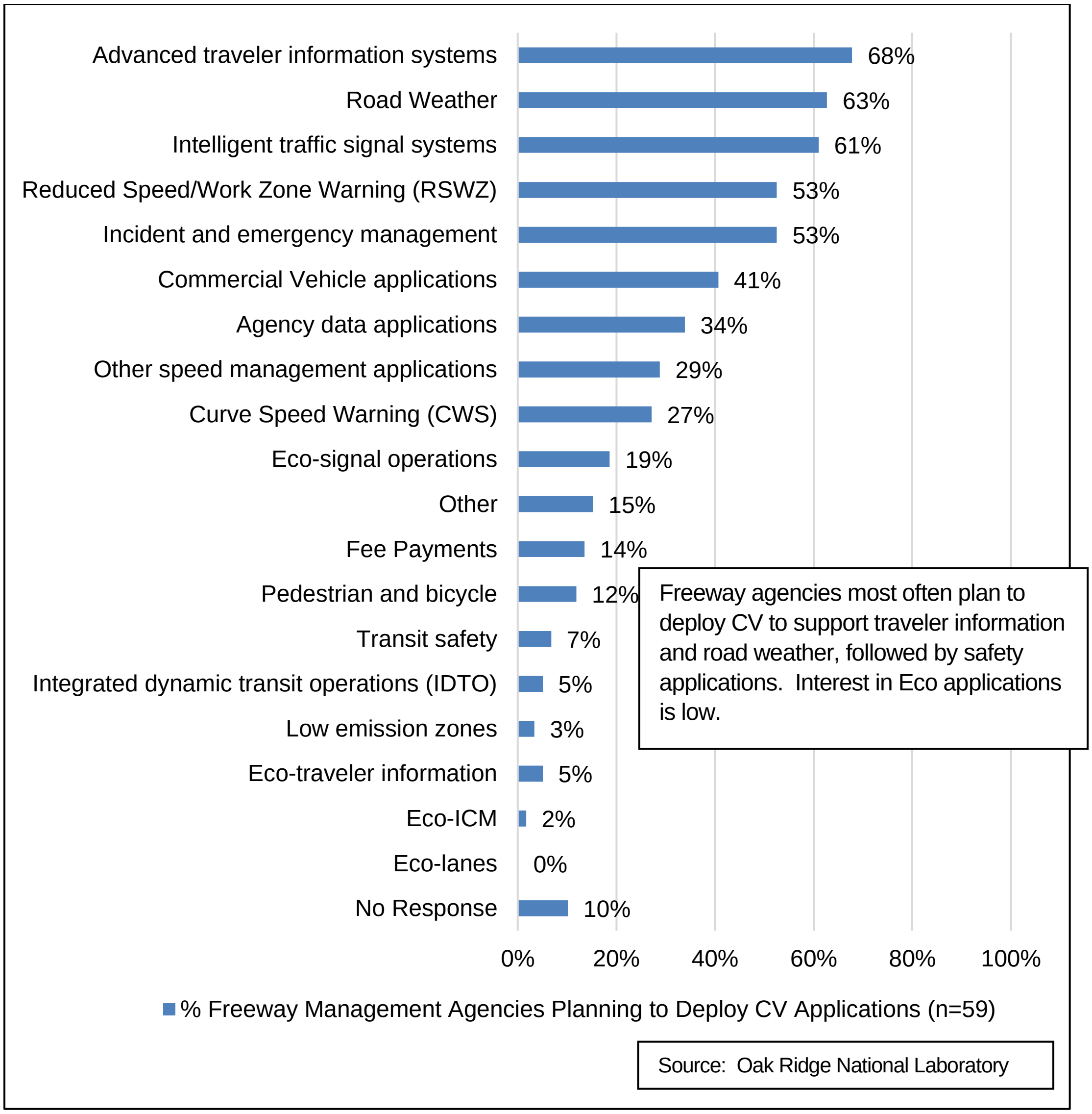


Figure 1-3. CV Applications Planned to be Deployed by Freeway Agencies

Future Arterial CV Deployments

The arterial agencies planning to deploy CV applications reported that they planned to deploy intelligent traffic signal systems most frequently, followed by advanced traveler information systems, incident and emergency management, and pedestrian and bicycle safety applications (all cited by over 40% of arterial agencies planning to deploy). Other frequently selected applications are road weather, performance data collection, and safety applications (speed management, work zone warning, and transit safety).

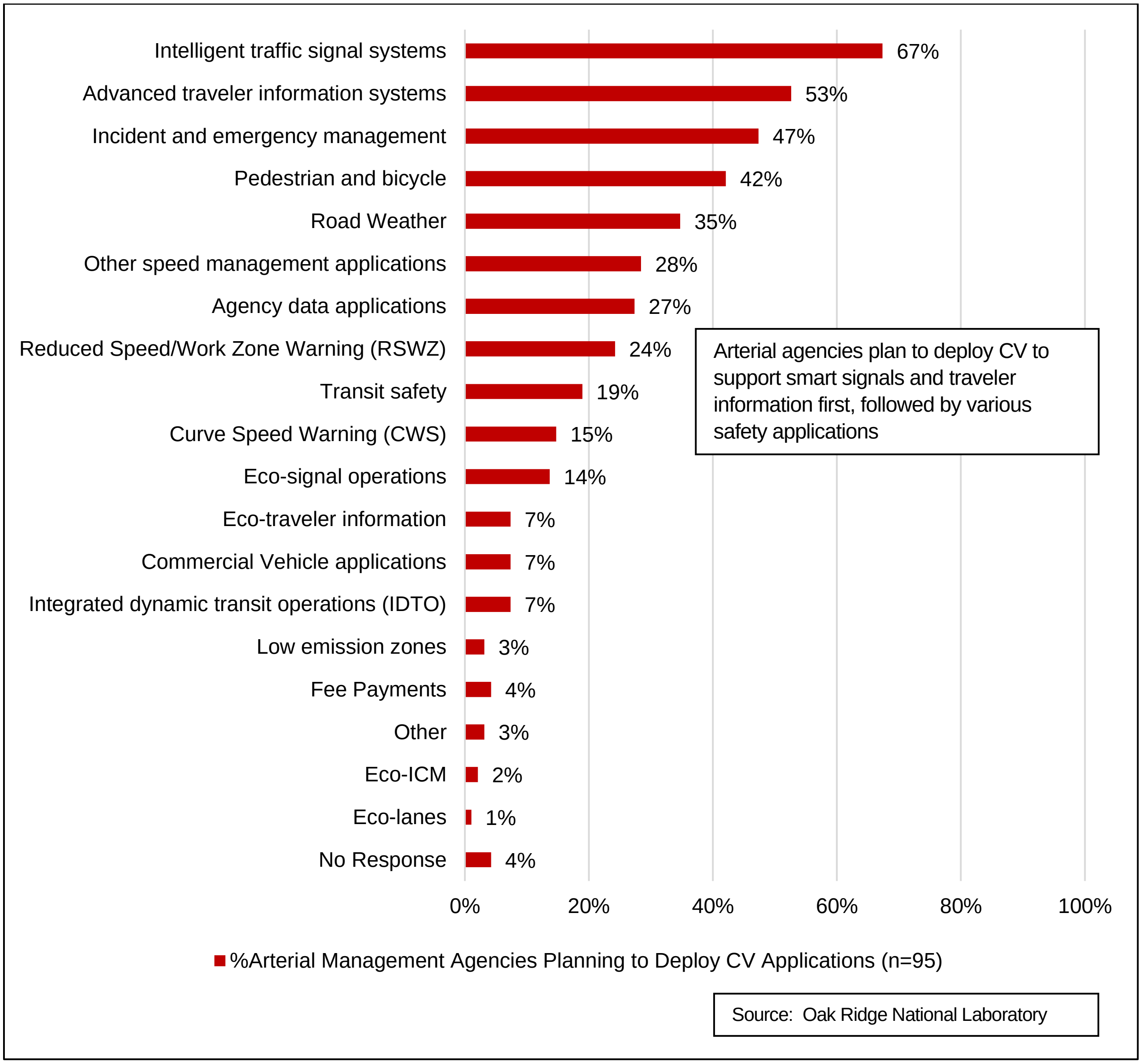


Figure 1-4. CV Applications Planned to be Deployed by Arterial Agencies

Future Transit CV Deployments

The transit agencies that plan to deploy CV applications reported multi-modal intelligent traffic signal systems most often, followed by fee payment, advanced traveler information systems, pedestrian in signalized crosswalk warning (PCW), and a variety of other safety systems.

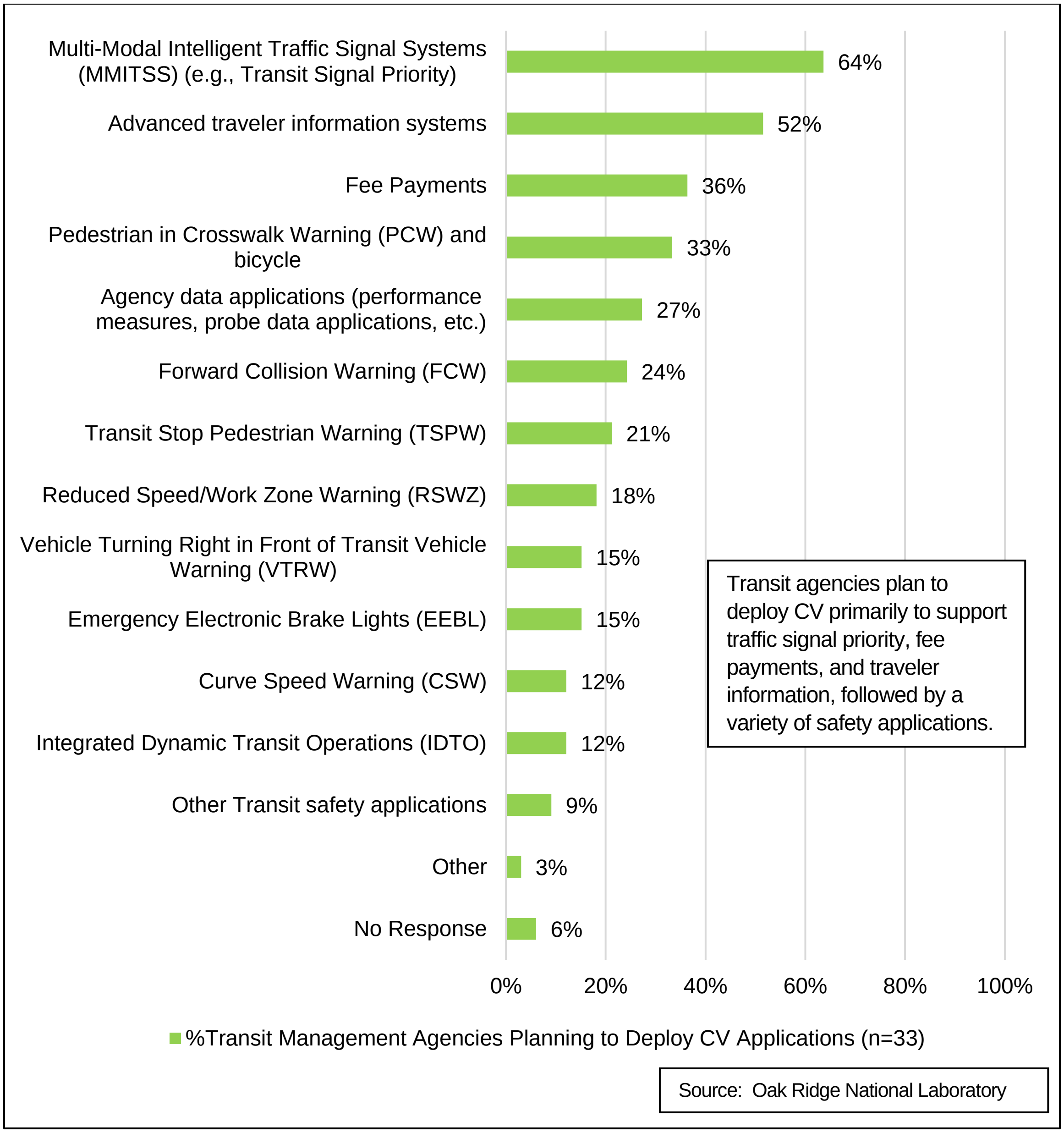


Figure 1-5. CV Applications Planned to be Deployed by Transit Agencies

Number of Planned CV Applications

In addition to the types of applications, the agencies were asked about the number of applications they plan to deploy and the timing of the deployments. Transportation agencies planning to deploy CV report that they often intend to deploy multiple CV applications. Figure 1-6 shows the number of different applications reported by those agencies planning to deploy CV technology. The data show that most arterial and transit agencies plan to deploy between 1 to 5 applications, freeway agencies differ, with 39% of the freeway agencies planning to deploy 6 or more.

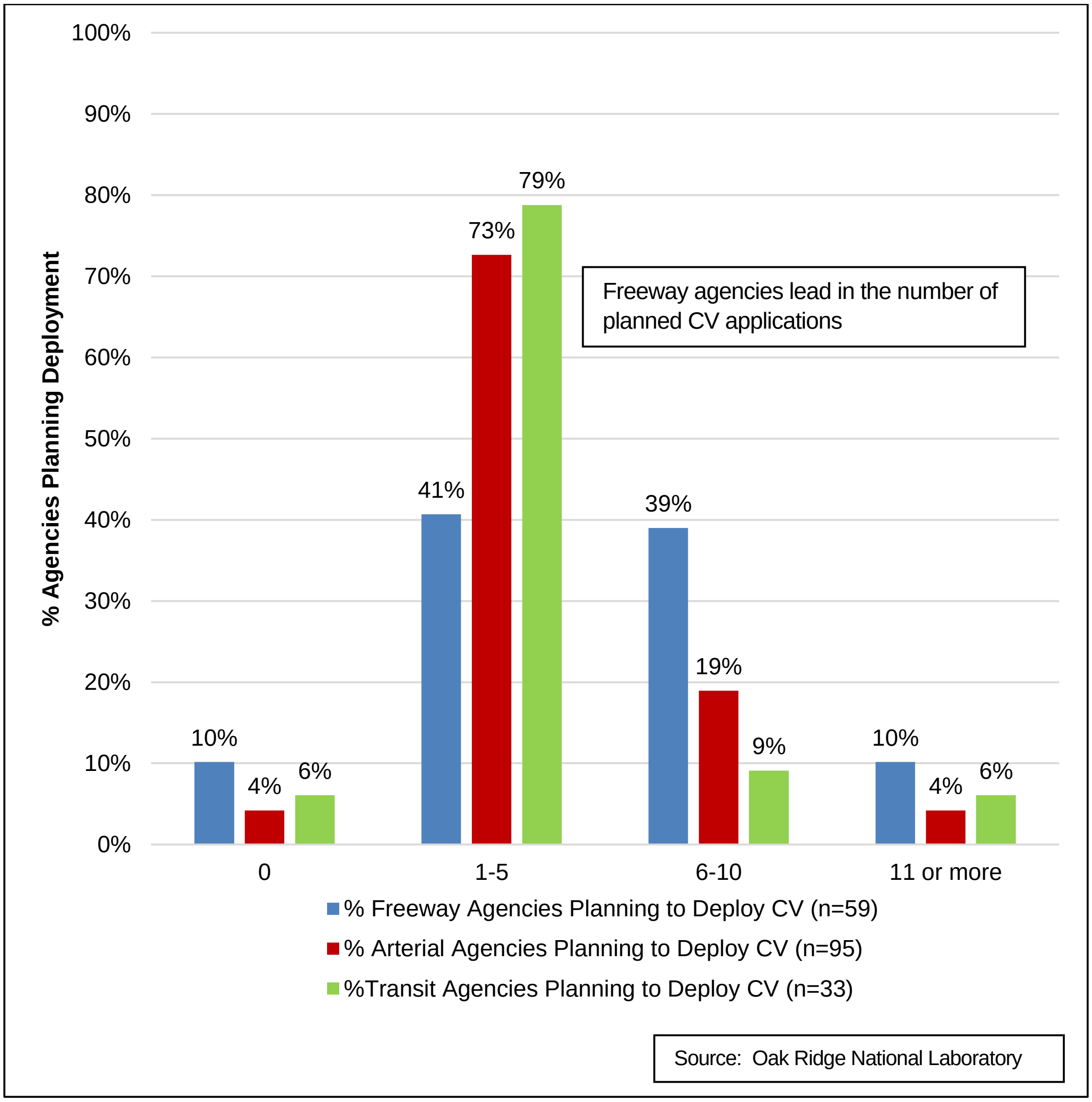


Figure 1-6. Number of Planned CV Applications by Type of Agency

Timing of Planned CV Deployments

Transportation agencies generally plan to deploy CV in the near term. As presented in Figure 1-7, the majority of transportation agencies planning to deploy CV applications intend to do so within the next three years. By the end of six years, nearly all agencies that plan to deploy CV applications will have done so.

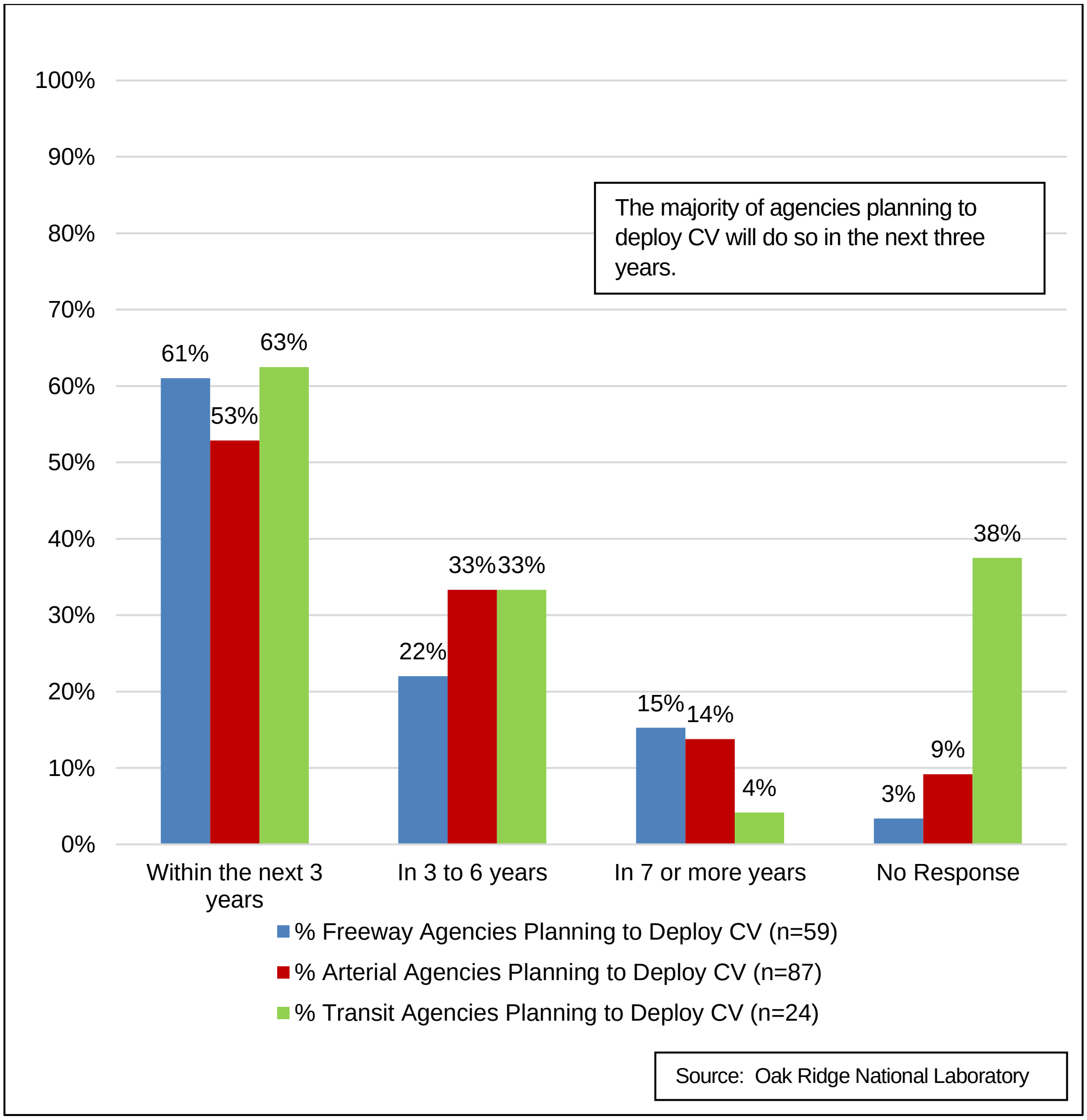


Figure 1-7. Planned Timing of CV Deployments by Agency Type

Issues Impacting Decisions to Invest in CV Applications

The previous section described agency plans to deploy CV; however, at this early stage of the CV program, there is a large body of agencies (35% of freeway, 60% of arterial, and 62% of transit) that do not currently plan to deploy CV. In this section, the focus shifts to these agencies to assess reasons they do not plan to deploy CV and determine the specific information and resources they would require to do so.

Reasons for Agencies Deciding Not to Deploy CV Applications

Agencies that do not plan to deploy CV applications were asked to specify the reasons and the results are summarized in Figure 1-8. The reasons for not deploying CV varied. Many agencies noted having other priorities, staffing shortfalls, institutional issues, and concern over cost. Each of these four issues was cited by a third to half of the responding agencies. Having other higher priorities and staffing limitations were most often cited by freeway and arterial agencies, while transit agencies cited cost most frequently.

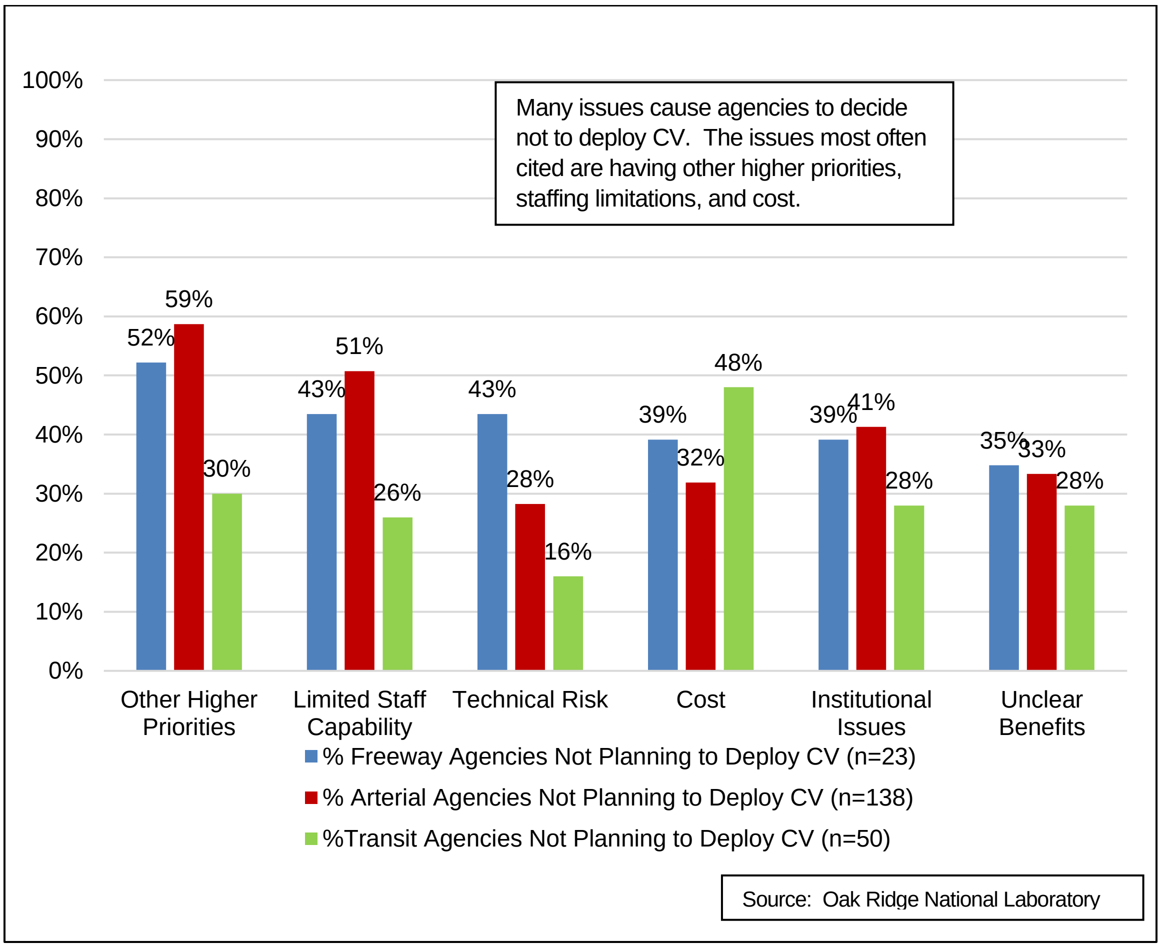


Figure 1-8. Reasons for Deciding Not to Deploy Connected Vehicle Technology by Agency Type

Types of Assistance Needed to Deploy CV Applications

Agencies were also asked to specify what actions, assistance, or support was needed to overcome barriers to deployment of CV applications. The results are shown for those agencies not planning to deploy CV in Figure 1-9. Although the different agency types had slightly different priorities, the results were generally consistent, with funding support most often cited. Following that, the agencies require information on how to procure CV technology, cost data, and benefit-cost data. To a lesser degree, agencies also require training, technical assistance, and guidance in making institutional agreements.

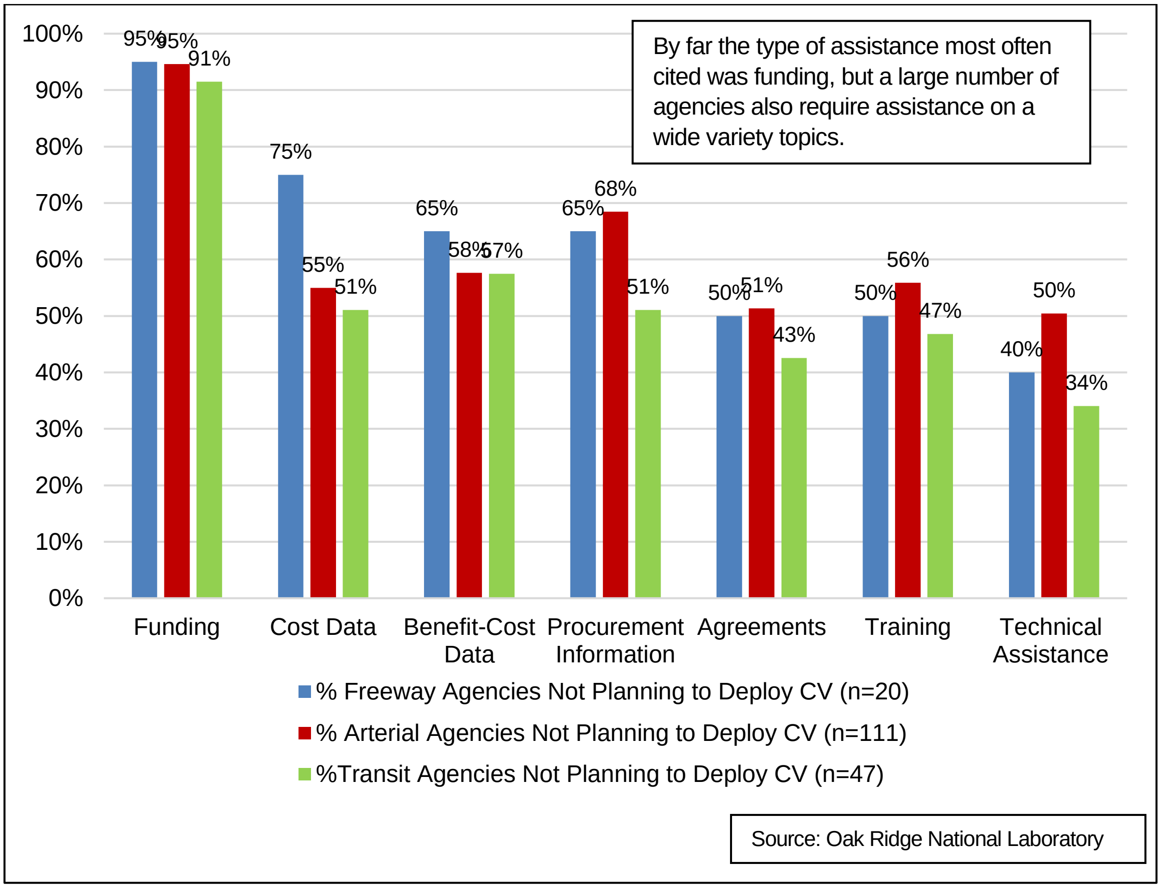


Figure 1-9. Types of Assistance or Resources Needed to Deploy CV by Agency Type

Readiness for Connected Vehicle Deployment

To assess readiness, a set of questions was asked covering six elements, four of which are specific actions agencies will have to complete to deploy CV and two that cover familiarity with resources developed to aid deployment. The elements include:

- Hiring a Chief Information Officer (CIO) or Chief Technical Officer (CTO);
- Obtaining a Federal Communication Commission (FCC) license to use a 5.0Ghz Frequency Spectrum (Dedicated Short-Range Communication);
- Inclusion of CV technologies and/or applications in agency planning documents;
- Adoption of CV applications and communication interfaces within the metropolitan area.
- Familiarity with the Connected Vehicle Reference Implementation Architecture (CVRIA);
- Familiarity with the Systems Engineering Tool – Intelligent Transportation (SET-IT);

Summary of Readiness Status for All Agencies

The results show that Freeway agencies lead arterial and transit in terms of readiness, as might be expected given that more of these agencies indicated plans to deploy CV technology. The only area where arterial and transit agencies have made significant progress is in hiring a CIO/CTO.

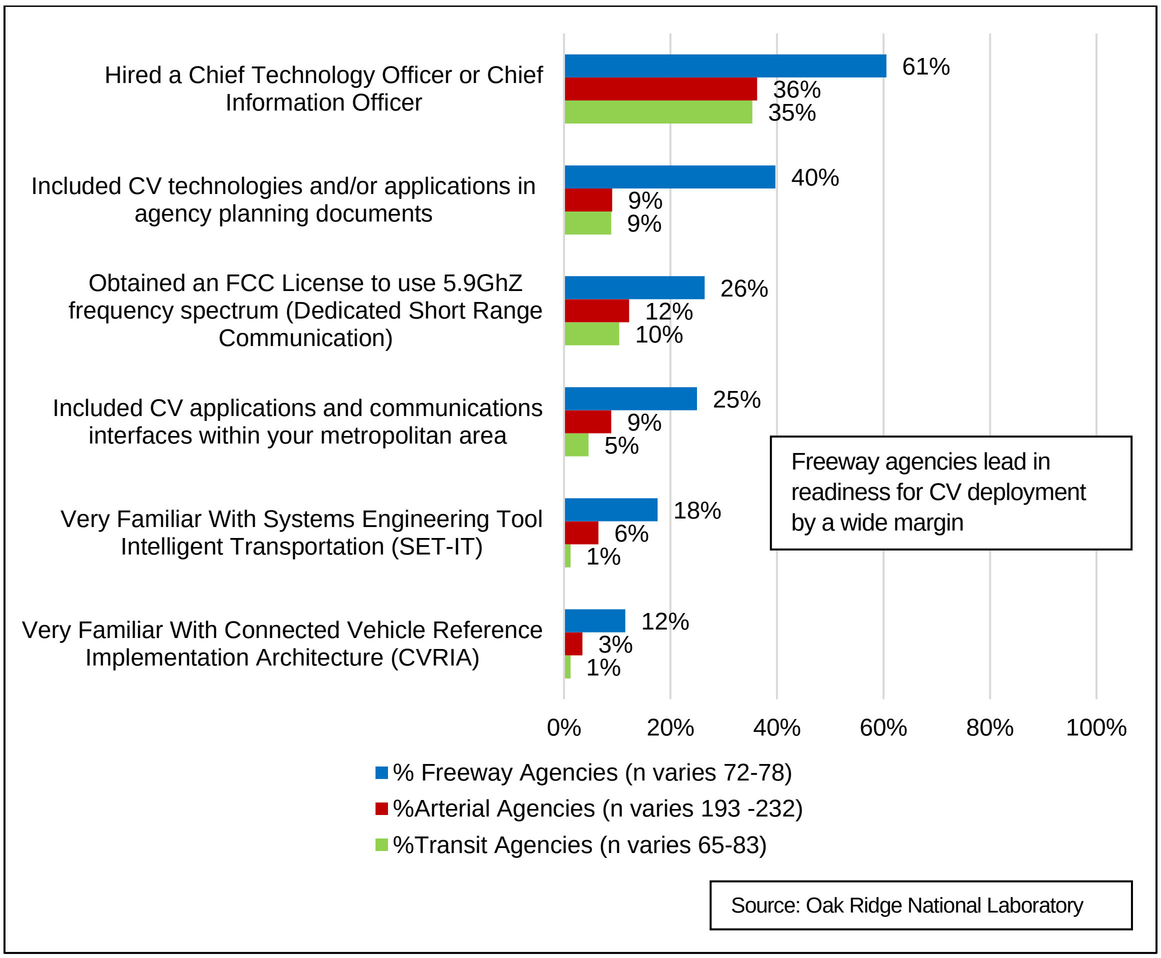


Figure 1-10. Summary: Actions Supporting CV Readiness by Agency Type

Comparison of Readiness for Freeway Agencies Planning and not Planning to Deploy CV

The next three charts cover the readiness for freeway, arterial, and transit agencies and compares results for agencies planning and not planning to deploy CV. Figure 1-11 shows the six readiness measures for freeway agencies. The data show an overall high level of readiness for agencies planning to deploy with a clear fall off for agencies not planning to deploy CV. This fall off of readiness is less problematic than for the other agency types as the freeway agencies not planning to deploy CV are a minority of the freeway agencies that were surveyed.

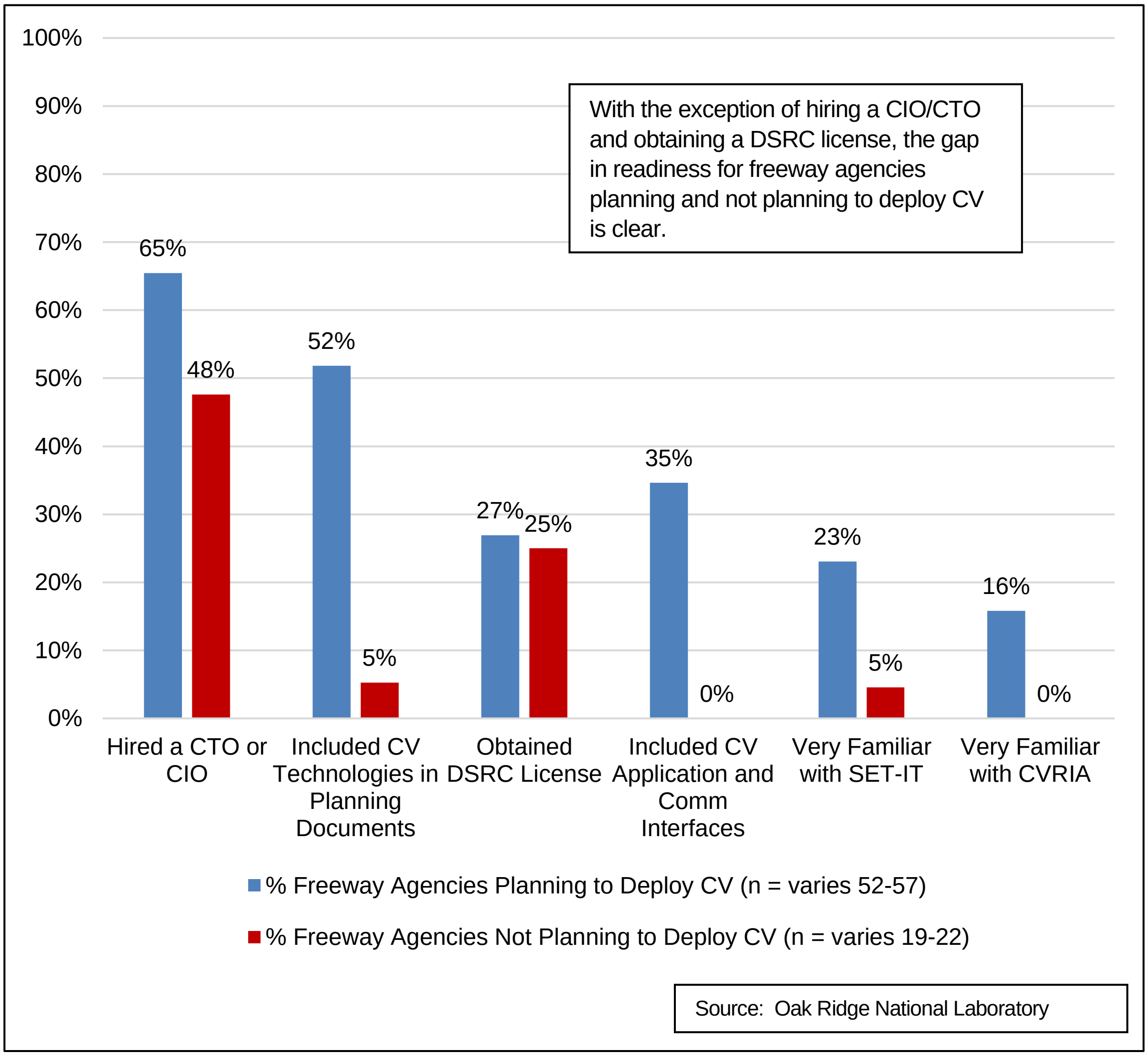


Figure 1-11. Readiness for Freeway Agencies Planning and not Planning to Deploy CV

Comparison of Readiness for Arterial Agencies Planning and not Planning to Deploy CV

Figure 1-12 shows the results for arterial agencies. The progress for arterial agencies is lower overall than freeway agencies and shows a clear distinction between agencies planning to deploy and not planning to deploy. Arterial agencies overall have a longer way to go than freeway agencies to achieve readiness for CV in light of the fact that fully three-fourths of the arterial agencies are not yet planning to deploy and have made little progress toward readiness for CV deployment.

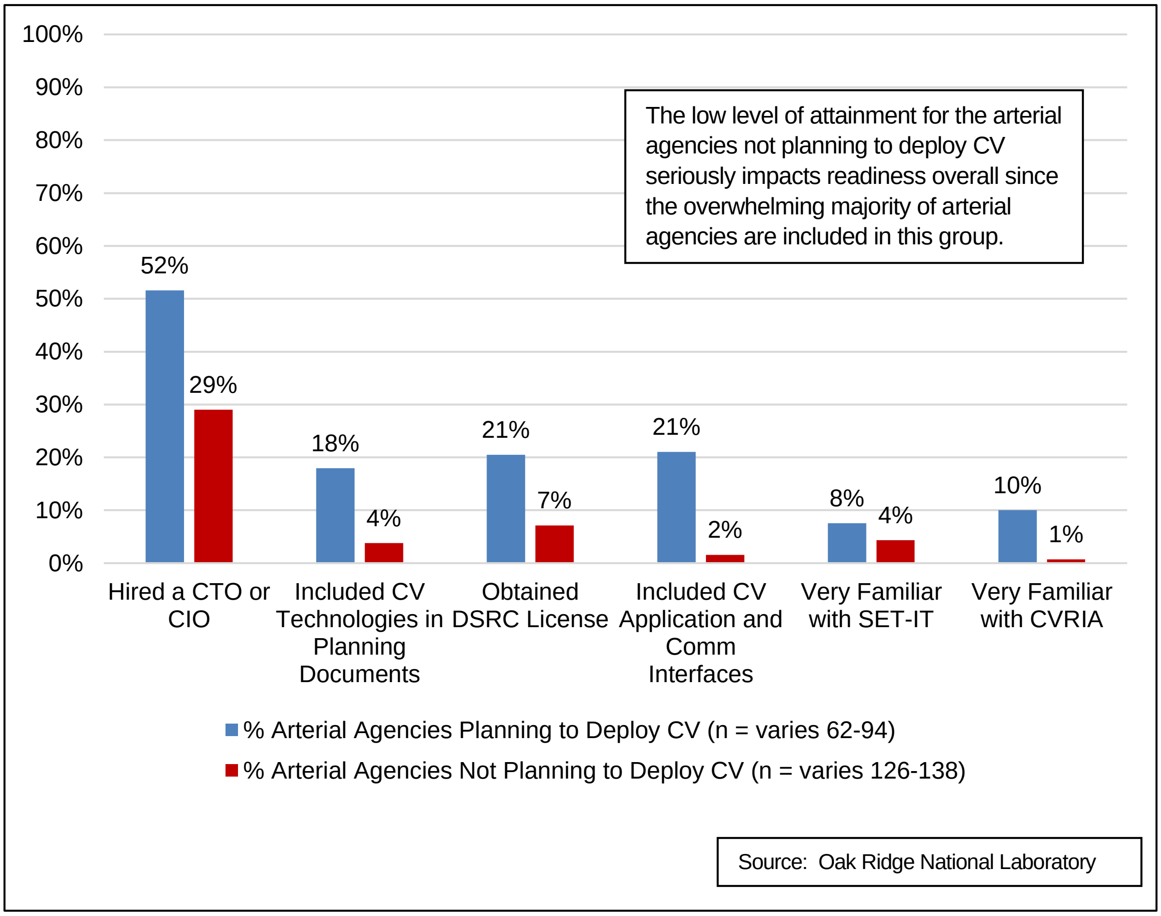


Figure 1-12. Readiness for Arterial Agencies Planning and not Planning to Deploy CV

Comparison of Readiness for Transit Agencies Planning and not Planning to Deploy CV

Figure 1-13 shows the readiness factors for Transit agencies. Transit agencies have made similar progress with the six readiness factors as arterial agencies but at a slightly lower extent (with the exception of hiring a CTO/CIO where transit leads arterial). As with arterial agencies, transit agencies also have a long way to go to be ready for CV deployment since more than 80% of the agencies are not planning to deploy and have made little progress with readiness for CV so far.

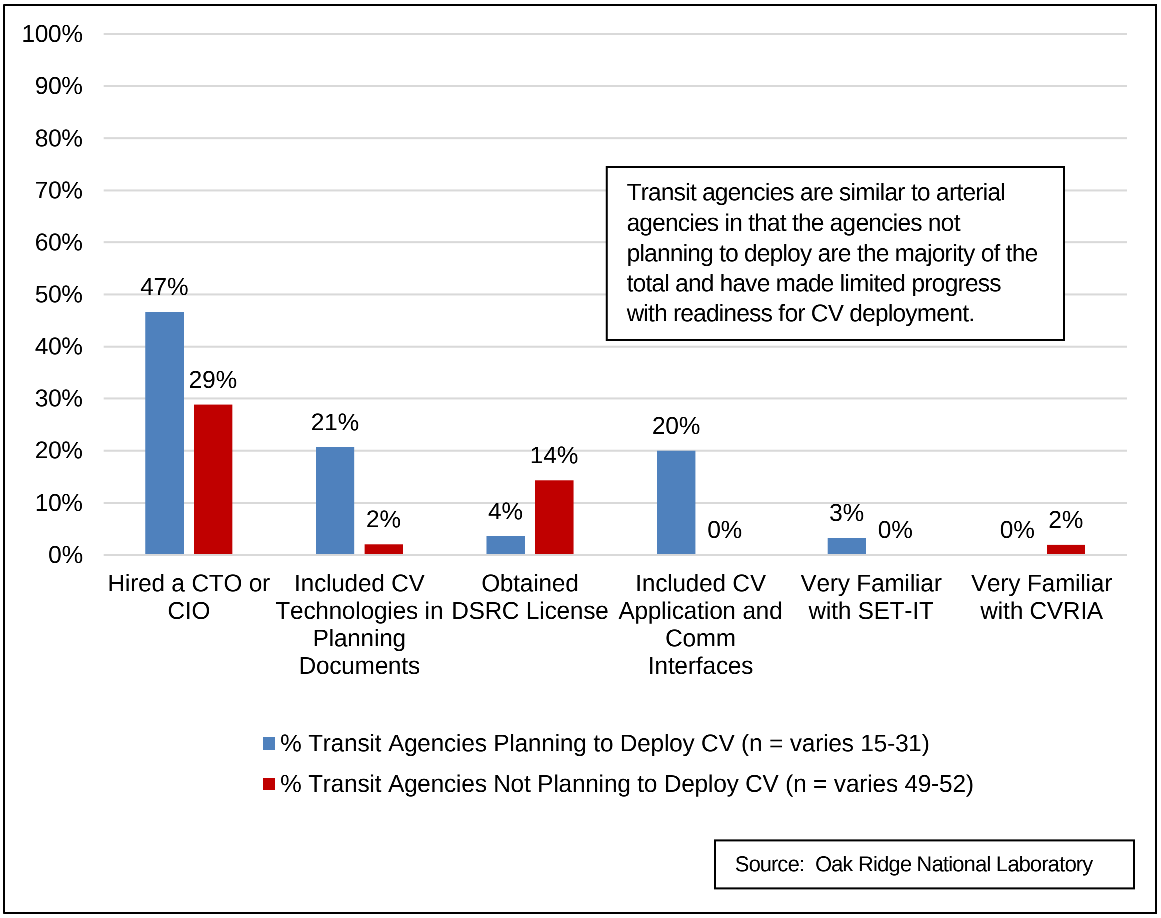


Figure 1-13. Readiness for Transit Agencies Planning and not Planning to Deploy CV

Familiarity with the CVRIA

The 2016 survey included questions to assess the depth of familiarity with the. Figure 1-14 summarizes the familiarity with the Connected Vehicle Reference Implementation Architecture (CVRIA) for the surveyed agencies. The CVRIA provides the basis for a common language definition for CV. The data show that familiarity with CVRIA is highest for freeway and arterial agencies planning to deploy CV with over 60% reporting at least some familiarity. However, that understanding is generally not very deep, with many of these agencies reporting being only slightly familiar. Familiarity with CVRIA for agencies not planning to deploy is significantly lower.

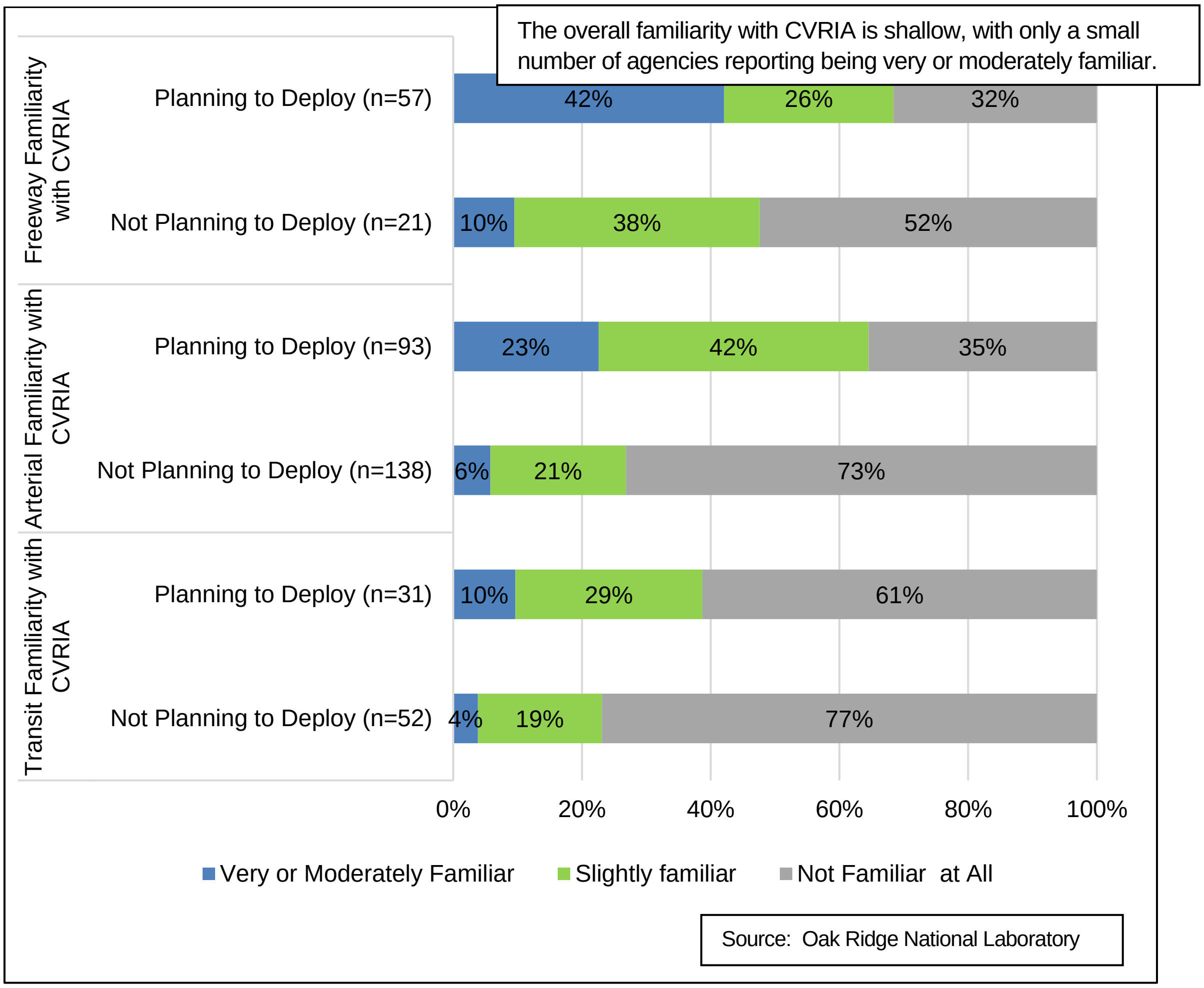


Figure 1-14. Familiarity with the Connected Vehicle Reference Implementation Architecture (CVRIA) by Plans to Deploy CV

Familiarity with SET-IT

The Systems Engineering Tool – Intelligent Transportation (SET-IT) is a single software tool that integrates drawing and database tools with the CVRIA enabling users to develop project architectures. Overall, the familiarity with SET-IT is low. Figure 1-15 shows that 44% of freeway, 32% of arterial and 16% of transit agencies planning to deploy CV report being very or moderately familiar with SET-IT. As with CVRIA, however, overall familiarity is low, with the majority of agencies report being only slightly familiar or not familiar at all.

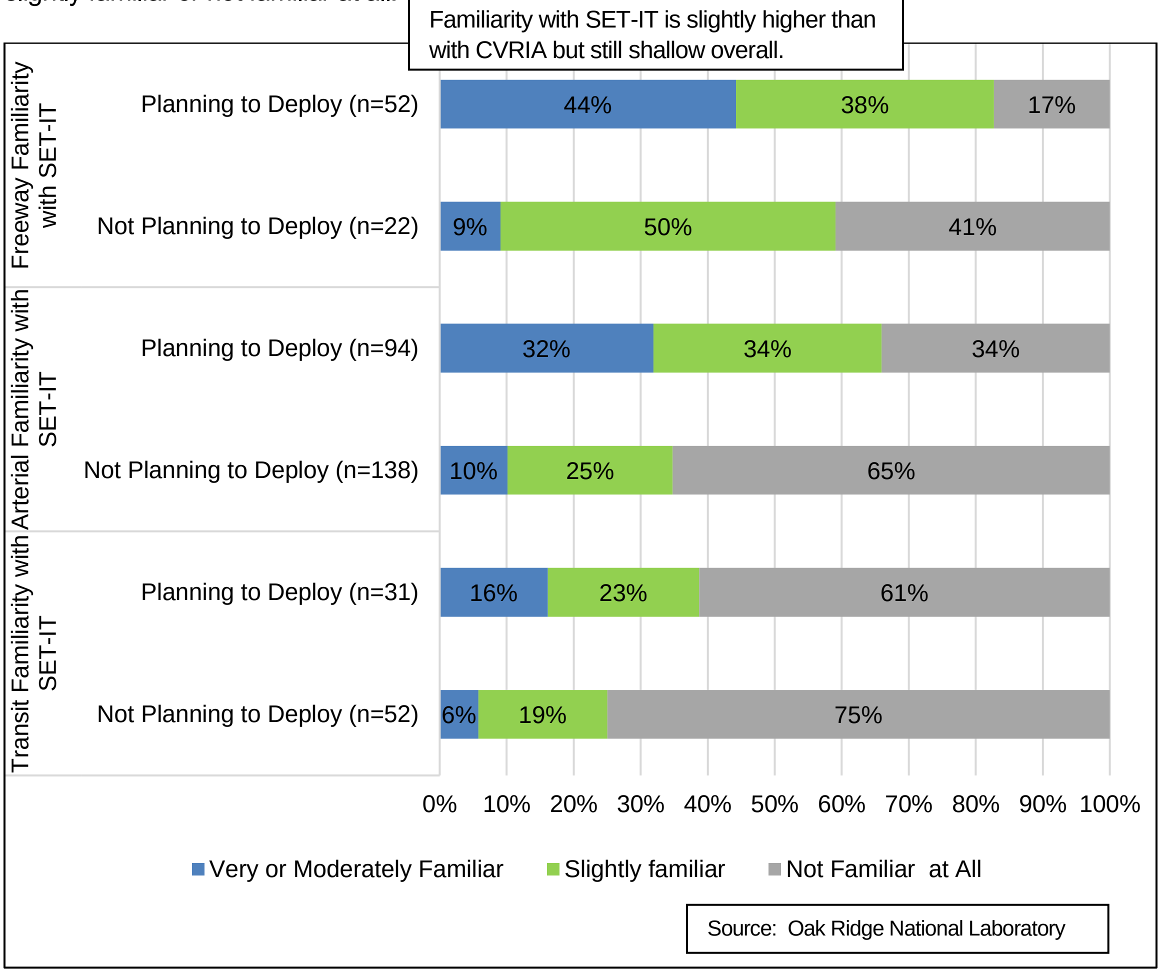


Figure 1-15. Familiarity with Systems Engineering Tool – Intelligent Transportation (SET-IT) by Plans to Deploy CV

CV Readiness Factors Achieved

Figure 1-16 shows the percentage of agencies achieving from zero to six of the readiness actions. The results clearly show the lead that freeway agencies have in readiness. Half of the arterial and transit agencies reporting have achieved zero actions compared to 20% of freeway agencies, while 22% of freeway agencies have achieved four readiness actions, compared to 7% for arterial agencies and only 3% for arterial agencies.

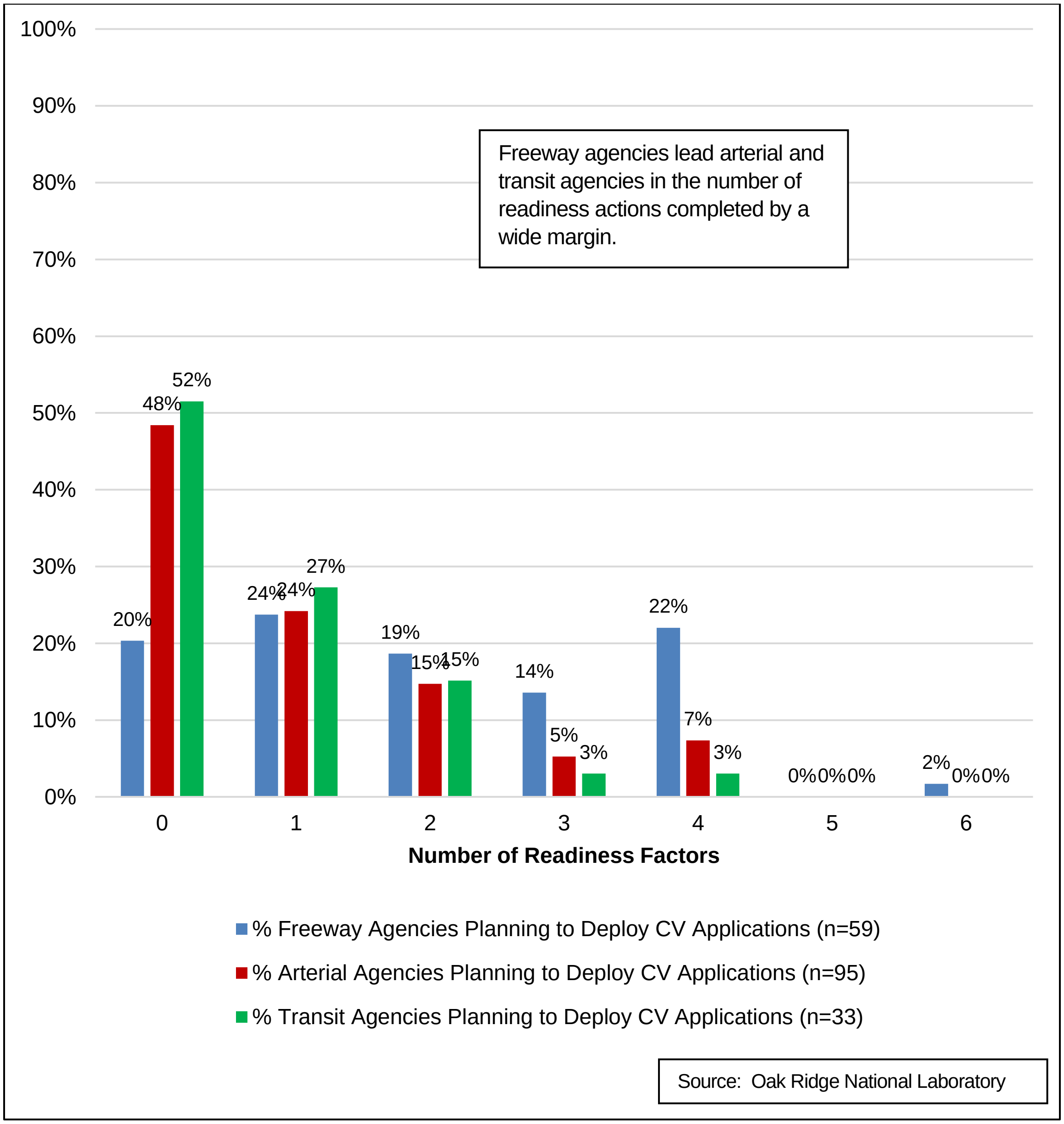


Figure 1-16. Number of Readiness Actions Completed by Agency Type

Communications

A connected vehicle infrastructure is tied together by high capacity wired and wireless communications. Figure 1-17 shows the extent that agencies have adopted different media. As expected, freeway agencies lead in the adoption of communications media, particularly fiber, cellular, microwave, and digital subscriber line. Arterial agencies have focused on fiber and cellular communications, as have transit agencies, which also have a significant investment in Wi-Fi.

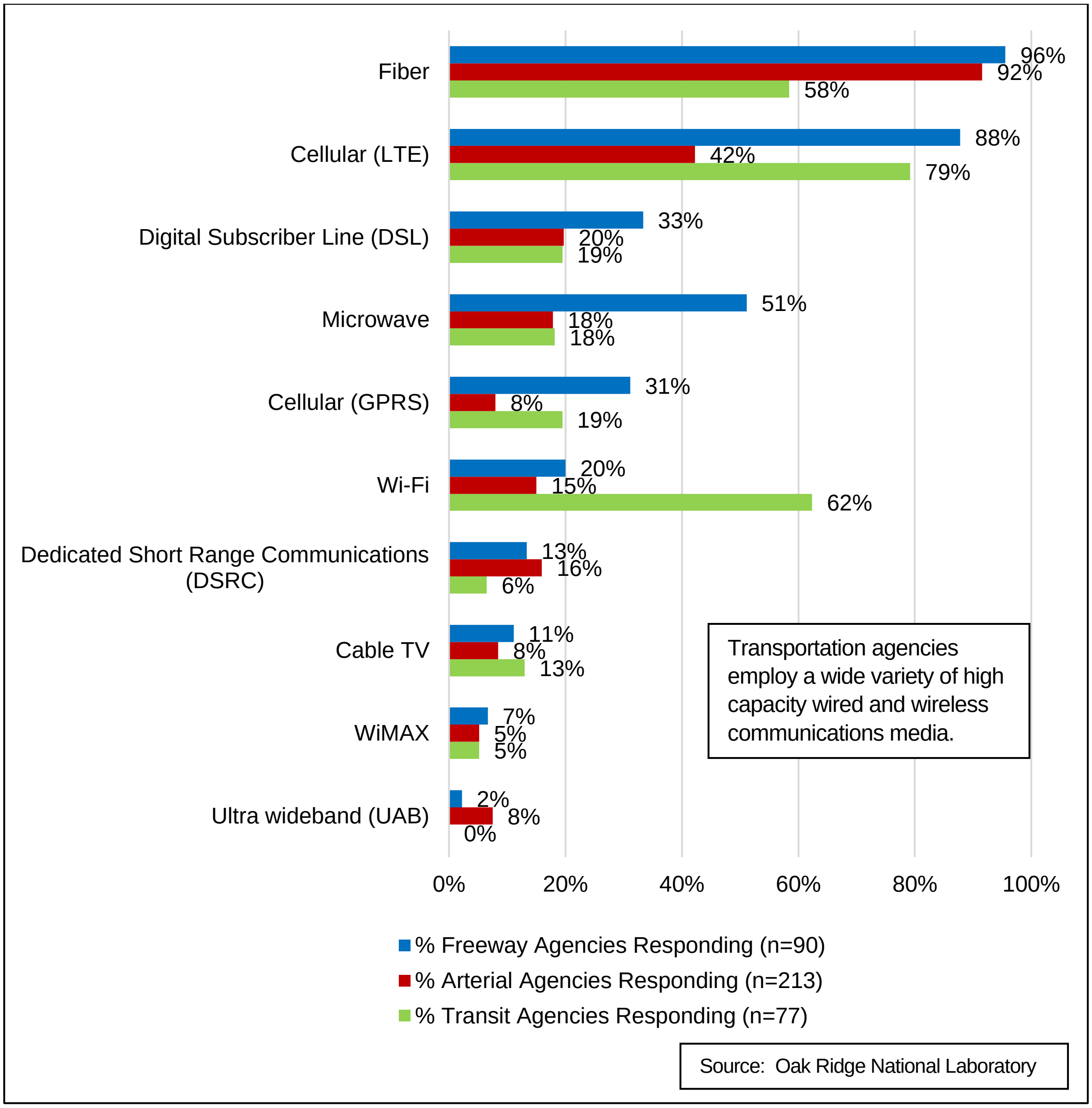


Figure 1-17. Adoption of Communication Media by Agency Type

Freeway and Arterial Agencies Having Devices with Backhaul Communications

The CV infrastructure involves constant communications to and from field devices. Experience with devices with backhaul communication capability serves as another measure of overall readiness to deploy CV. The survey questioned freeway and arterial agencies on this issue and the results are shown in Figure 1-18. Both agencies have extensive experience with backhaul communications.

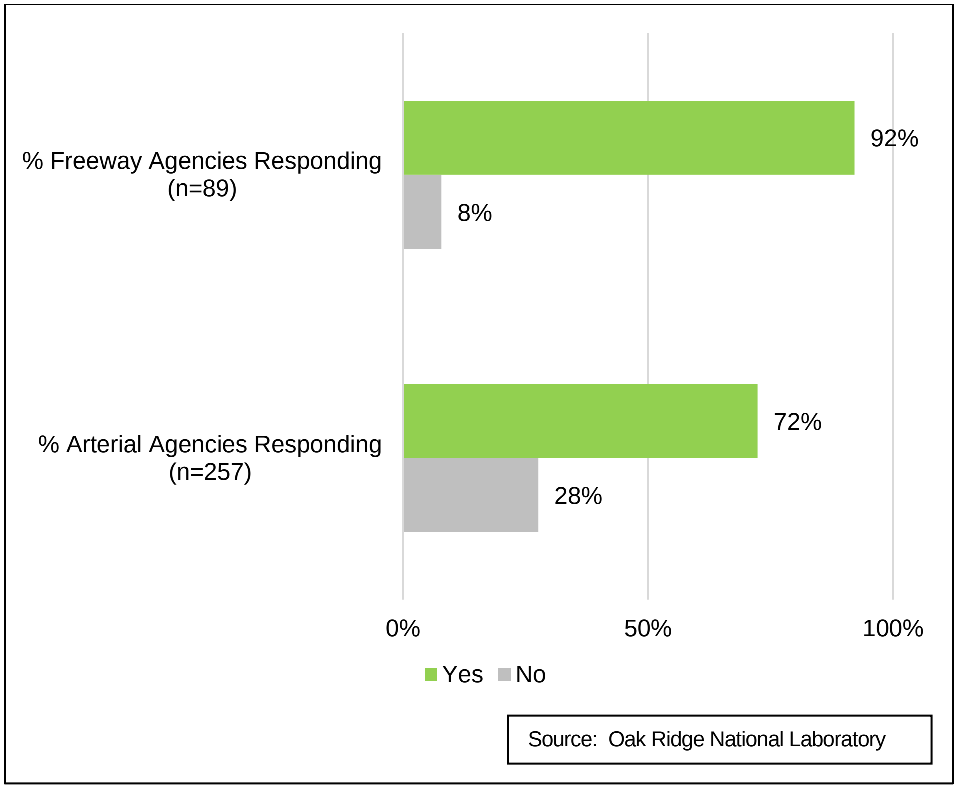
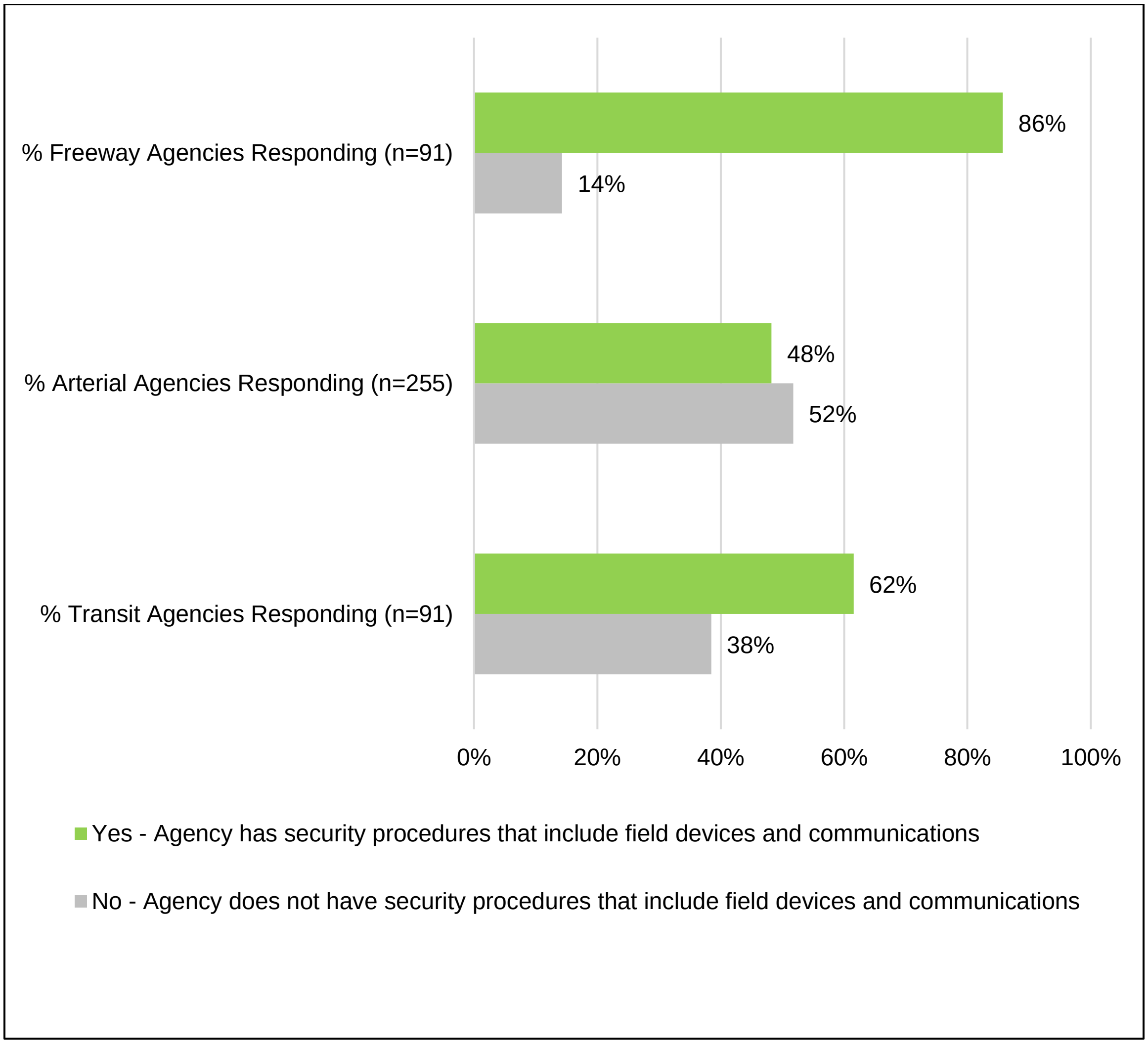


Figure 1-18. Freeway and Arterial Agencies Having Devices with Backhaul Communications

Agencies Having a Communications Security Policy with Scope that Includes Field Devices

Communications security is clearly a critical need for a CV infrastructure. All agencies were asked whether they had security policies and procedures for their field devices and other communications. The results are shown in



and it is clear that freeway agencies are approaching universal deployment, with transit agencies next and arterial agencies last with about half of agencies reporting they have security policies and procedures in place that include field devices.

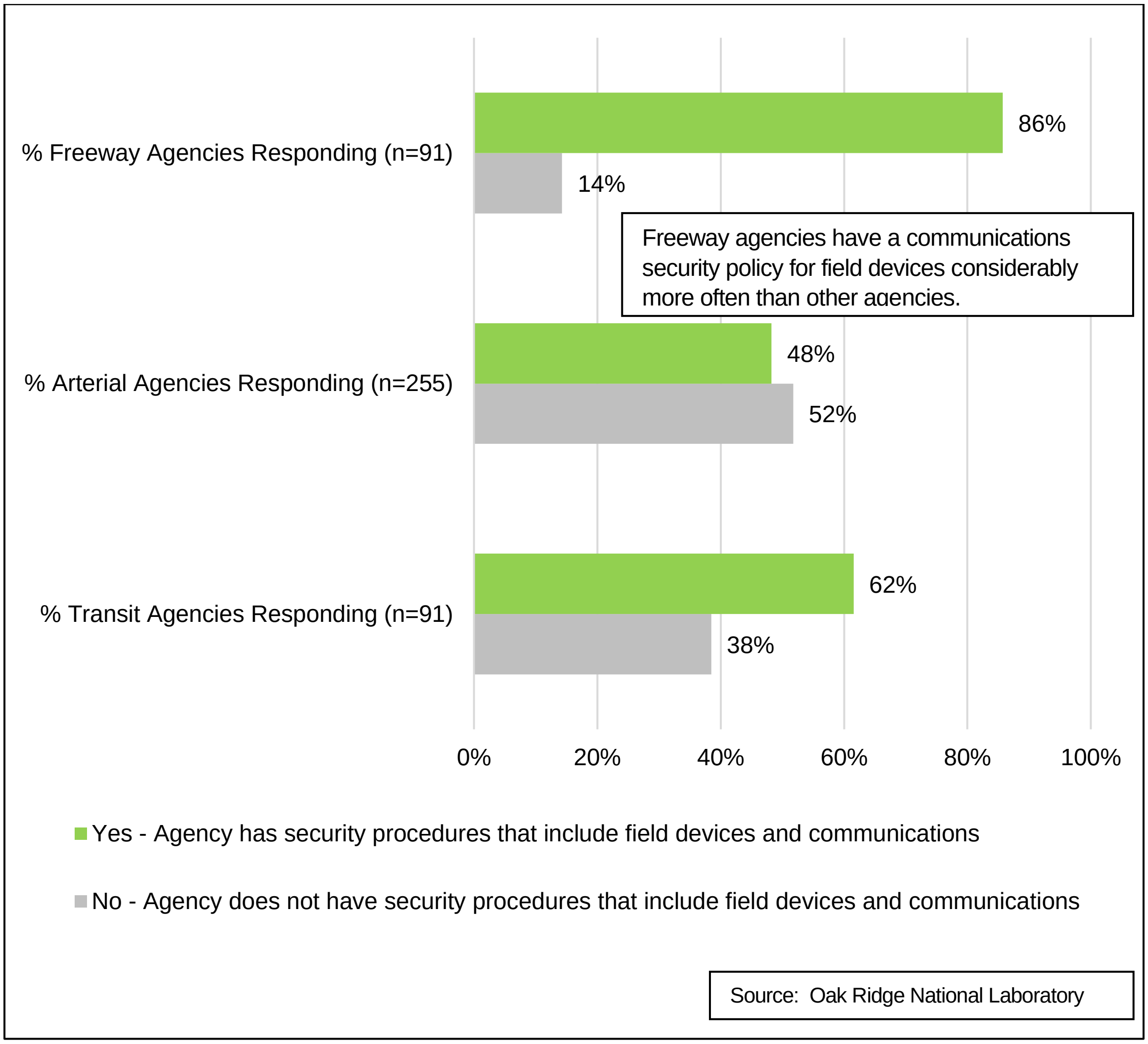


Figure 1-19 Agencies Having a Security Policy and Procedures with Scope that Includes Field Devices and Communications

Communications Security Policies That Cover Cyber Security

Cyber security is an important aspect of communications security and the survey included a question about whether the existing communications security policies specifically included cyber security. The results are shown in Figure 1-20 and 79% of freeway agencies report including cyber security, about twice as often as arterial and transit agencies do.

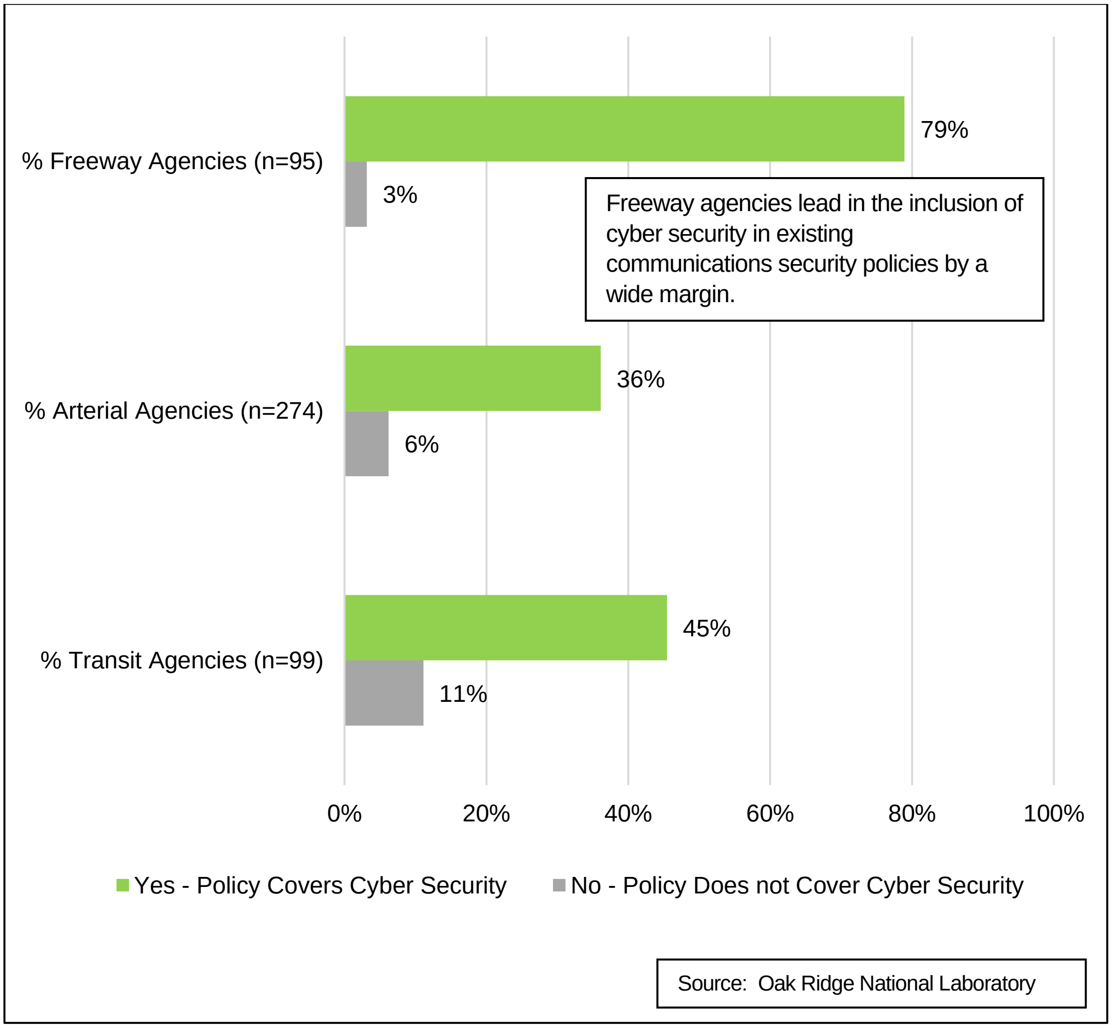


Figure 1-20. Security Policies That Cover Cyber Security

Agencies Having Discussions with Public and/or Private Partners about Partnership for CV Deployment and Operations

Figure 1-21 shows that agencies have begun discussions with other agencies concerning partnerships to coordinate CV deployment and operations. Most often these discussions are with both public and private sector partners, with a smaller portion working with public sector agencies only and private sector partners only.

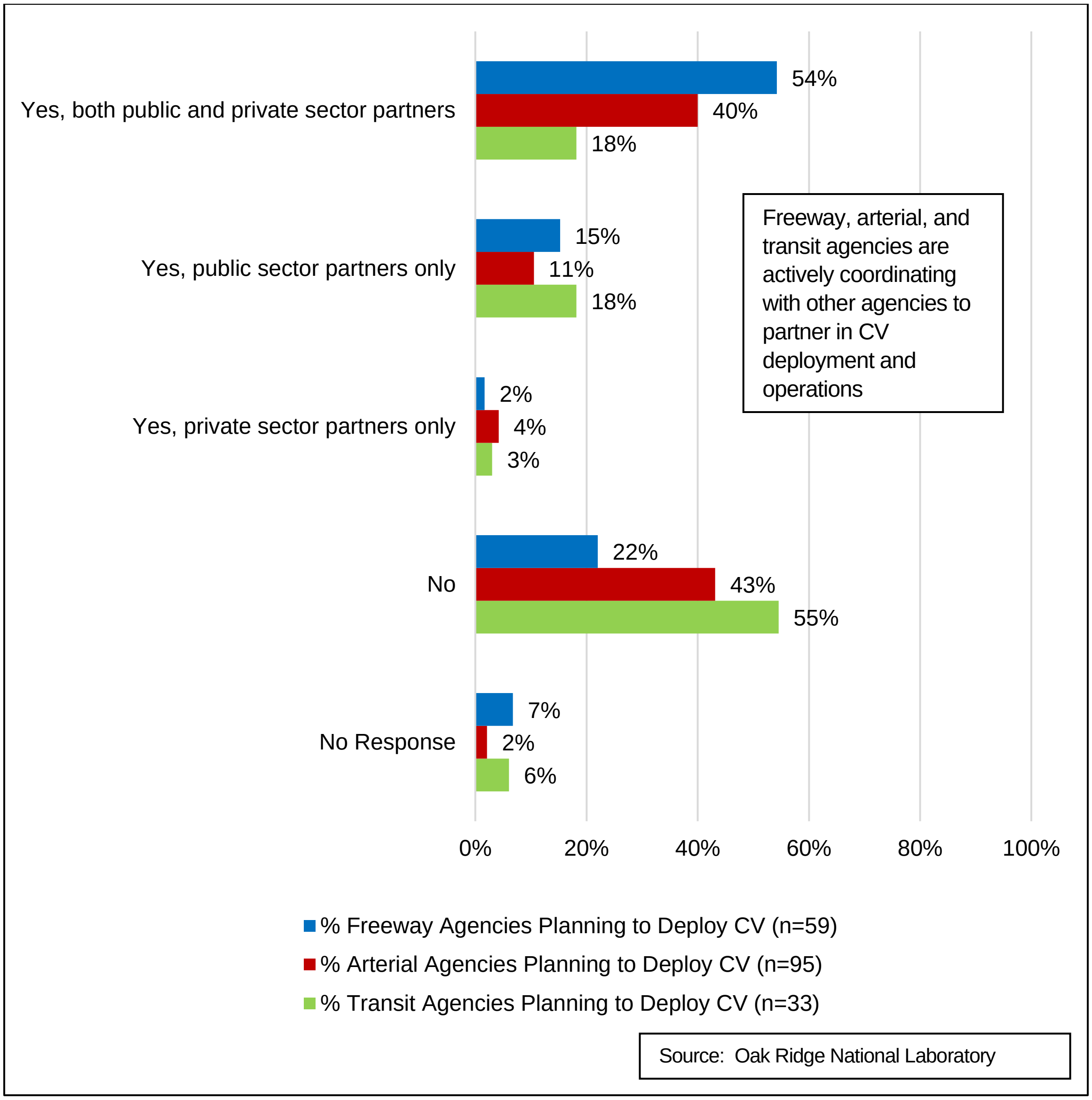


Figure 1-21. Interagency Partnerships with other Agencies for CV Deployment and Operations

Chapter 2 ITS Deployment Trends

As in previous surveys, the 2016 Intelligent Transportation System (ITS) deployment tracking survey continued to gather a consistent set of data elements designed to track deployment trends for key ITS technologies in major cities. In this chapter deployment data are presented in two varieties: *coverage,* measuring how much has been deployed, expressed as the percentage of signalized intersections, miles of road or vehicles equipped; and *adoption,* which establishes whether or not a particular technology has been deployed, expressed as the percentage of agencies that report having deployed the technology. Coverage and adoption data are shown for different years to explore trends and, where appropriate, data for freeway and arterial agencies are shown together for comparison. The coverage data are based on a set of deployment indicators developed early in the project and tracked in every survey. This chapter groups the data for the different agency types covered in the survey: freeway management, arterial management, incident management, and transit management.

Freeway Management

Error! Reference source not found. shows the coverage trends for key surveillance ITS technologies deployed on freeways. The data show that the ITS technologies supporting real-time data collection on freeways experienced an increase in coverage from the 2013 and this growth is consistent with long term trends. There has been a substantial increase in the capability of agencies to visually monitor travel conditions through the use of closed circuit television (CCTV) with coverage increasing from 15% of freeway miles in 2000 to 68% in 2016. The percent of freeway miles under electronic surveillance has also experienced continuous and rapid growth, expanding from 22% in 2000 to 72% in 2016.

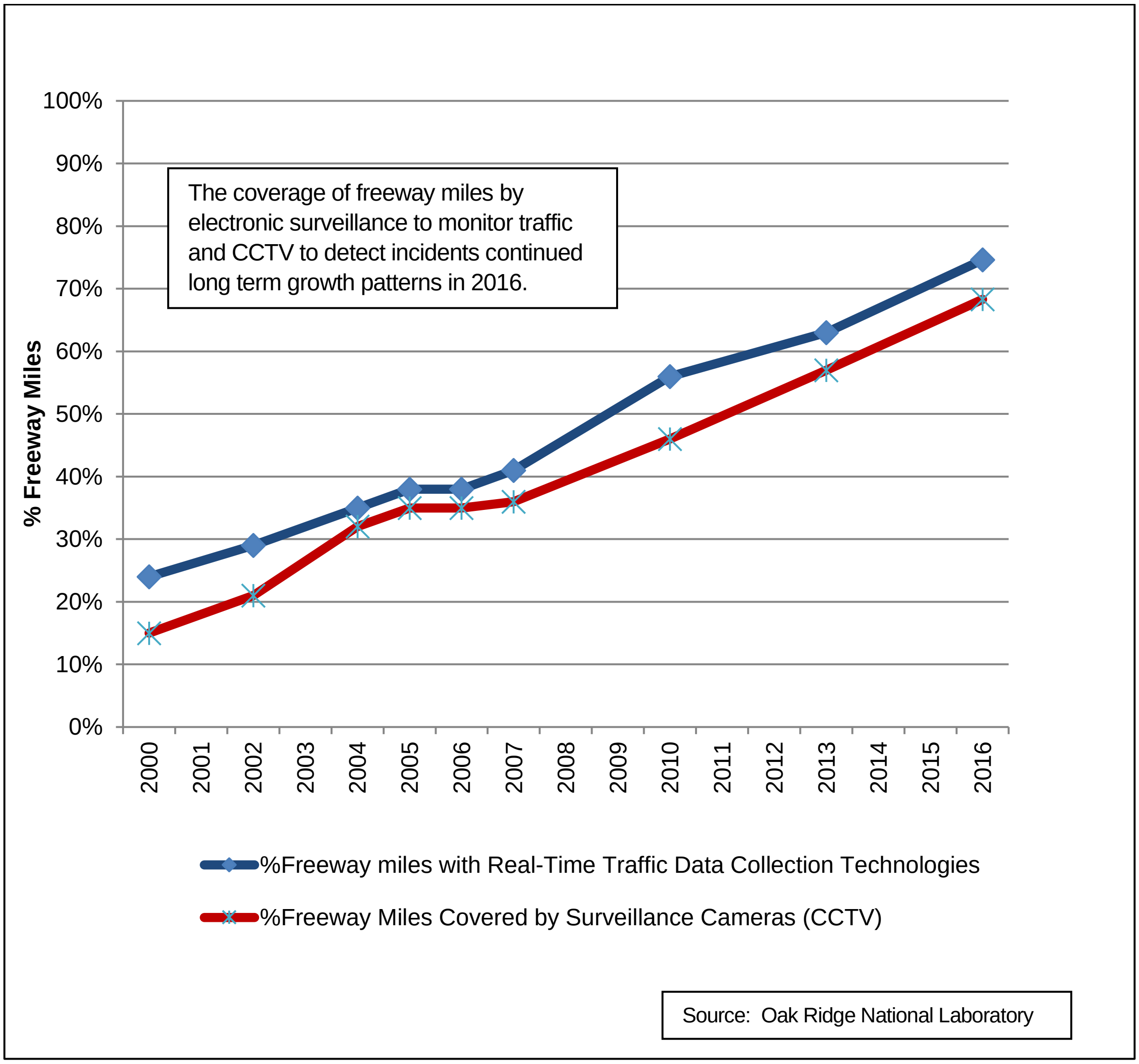


Figure 2-1. Freeway Management Deployment Trends, 2000 – 2016

Figure 2-2 shows the trends in the adoption of key ITS technologies by freeway agencies, comparing the data for 2010, 2013, and 2016. Adoption of CCTV and DMS expanded in lockstep over this period becoming essentially universal by 2016. Adoption of highway advisory radio (HAR) has leveled off and begun to decline in 2016. The data on adoption of sensor technologies show a movement away from loop stations to other alternatives. The percentage of freeway agencies using radar has increased from 54% of agencies in 2010 to 62%% in 2013 but stalled at that level in 2016 and appears to have reached its peak in adoption. One of the causes of the lack of growth in use of radar is clearly the rapid increase in the use of probe readers more than doubling in six years to 52% of freeway agencies. During that time, adoption of loop stations has flattened out to cover about a third of freeway agencies. The increase in use of probe readers appears to be due mainly to one type of probe reader, Bluetooth, the adoption of which ballooned from 4% of freeway agencies in 2010 to 33% just six years later.

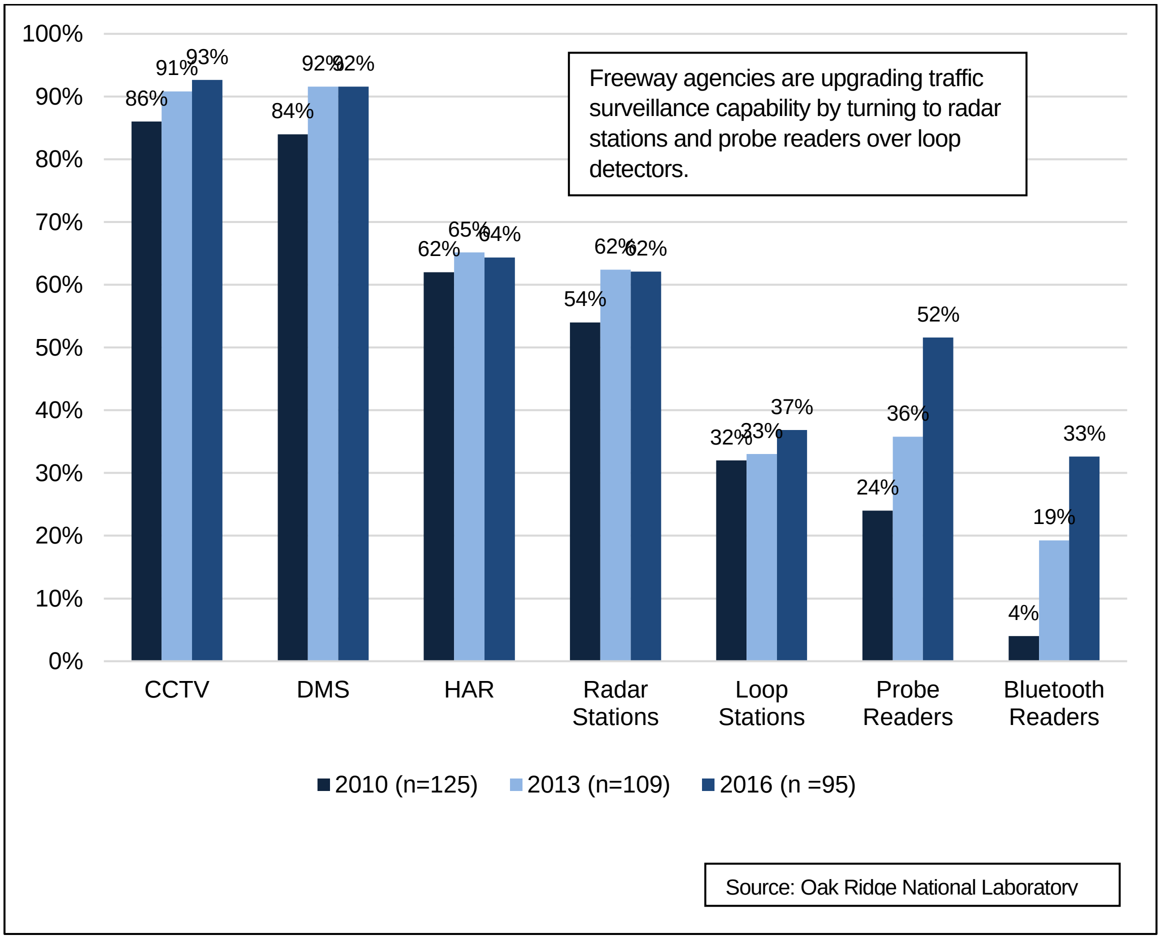


Figure 2-2. Technologies Adopted by Freeway Agencies, 2010, 2013 and 2016

Arterial Management

Arterial management deployment trends are summarized in Figure 2-3. Since 2000, the percentage of signalized intersections covered by electronic surveillance has continued to expand strongly. Coverage of other technologies on arterials has grown more slowly. The coverage of signalized intersections equipped with emergency vehicle preemption increased from 25% to 29% between 2013 and 2016. The coverage of HAR and signalized intersections with transit priority both remained static between 2013 and 2016 at 4%.

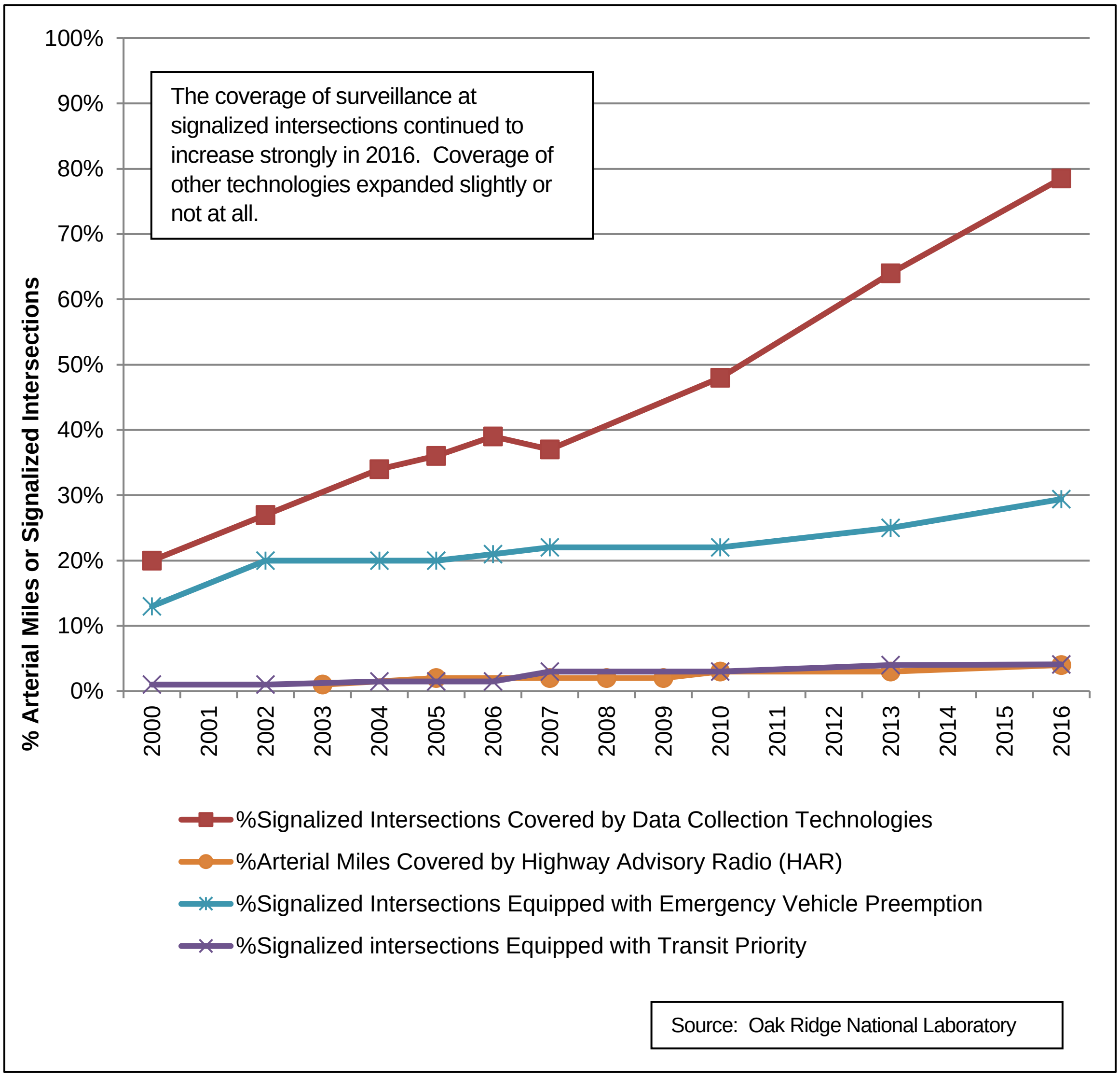


Figure 2-3. Arterial Management Deployment Trends, 2000 – 2016

The trends for adoption of ITS technologies by arterial agencies are shown in Figure 2-4. For most technology, adoption continued to expand in 2016. The adoption of in-pavement loop stations by arterial agencies has become virtually universal in 2016. Video Imaging Detectors (VIDS) adoption follows a similar trend and has increased from 58% of arterial agencies in 2010 to 78% in 2016. The use of CCTV by arterial agencies has more than doubled from 2013 to 55% in 2016. Adoption of Bluetooth readers jumped from only 2% of arterial agencies in 2010 to 20% of arterial agencies in 2016, and that of radar stations from 13% of arterial agencies to 39% in the same interval. The adoption of traffic adaptive signals is increasing, doubling between 2010 and 2013, to 23% of arterial agencies in 2016. Some trends were flat or negative--adoption of parking management systems has shown essentially no change and adoption of red light running cameras was significantly lower in 2016. Adoption of DMS is also flat at about a quarter of the agencies.

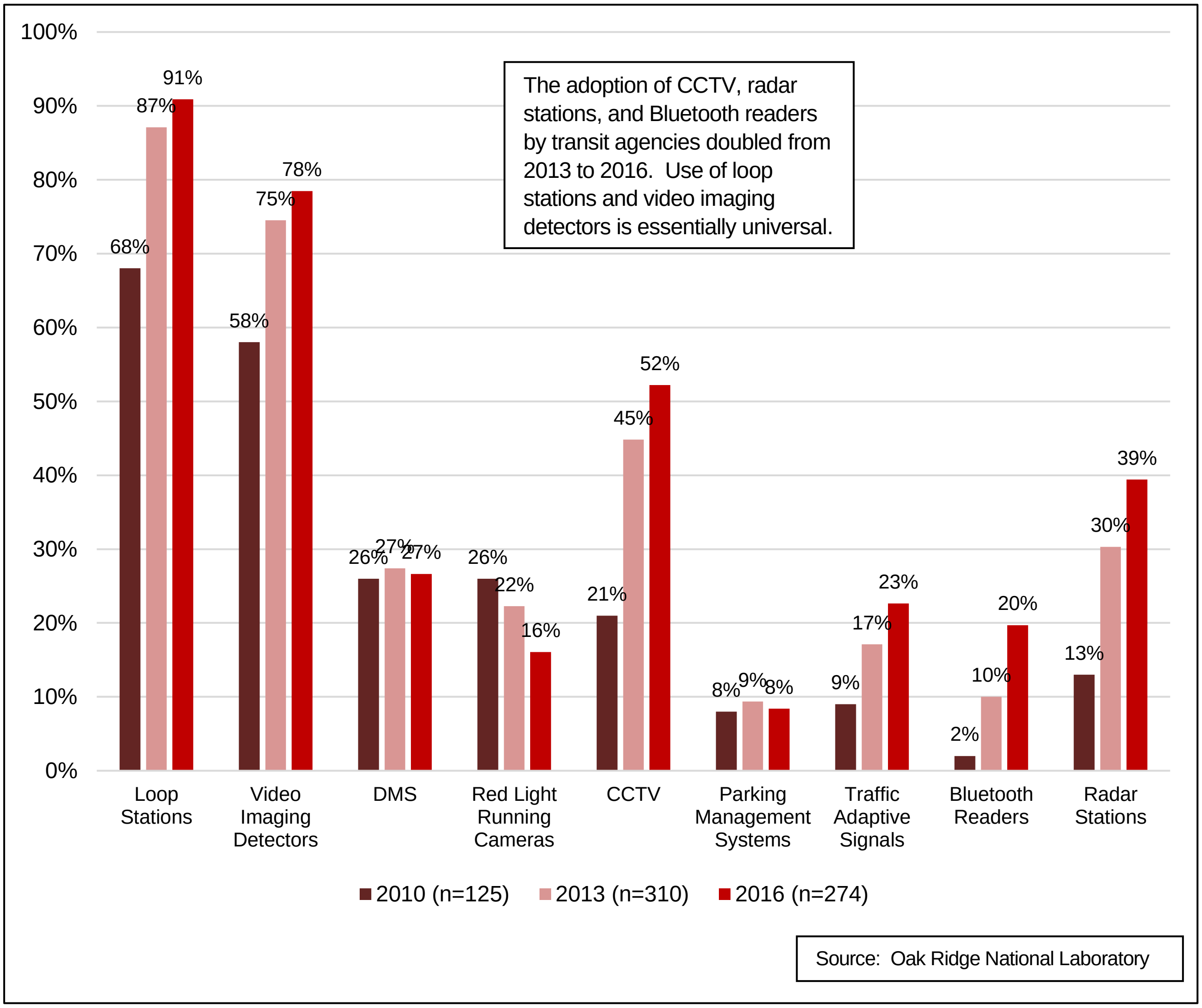


Figure 2-4. Technologies Adopted by Arterial Agencies, 2010, 2013 and 2016

Incident Management

Coverage data on incident management technologies for freeway and arterial agencies are summarized in Figure 2-5, covering data from 2000 to 2016. Over that time, the coverage of freeway miles by service patrols increased gradually from 40% of freeway miles in 2000 to 57% in 2016. CCTV coverage has increased rapidly, growing from 16% of freeway centerline miles in 2000 to 68% by 2016. The use of computer algorithms to detect incidents on freeways is not growing and apparently has been displaced by alternate methods.

For arterials, the most dynamic indicator is the coverage of CCTV cameras, which had steady but gradual growth from 2000 to 2010 but has accelerated to the point that coverage is just under 20% of arterial miles in 2016. Since the percentage of arterial agencies that employ CCTV has remained basically static, as shown in figure 2-4 above, it appears that agencies that already have CCTV coverage are expanding it. The use of service patrols on arterials also experienced an uptick in coverage to 16% in 2016.

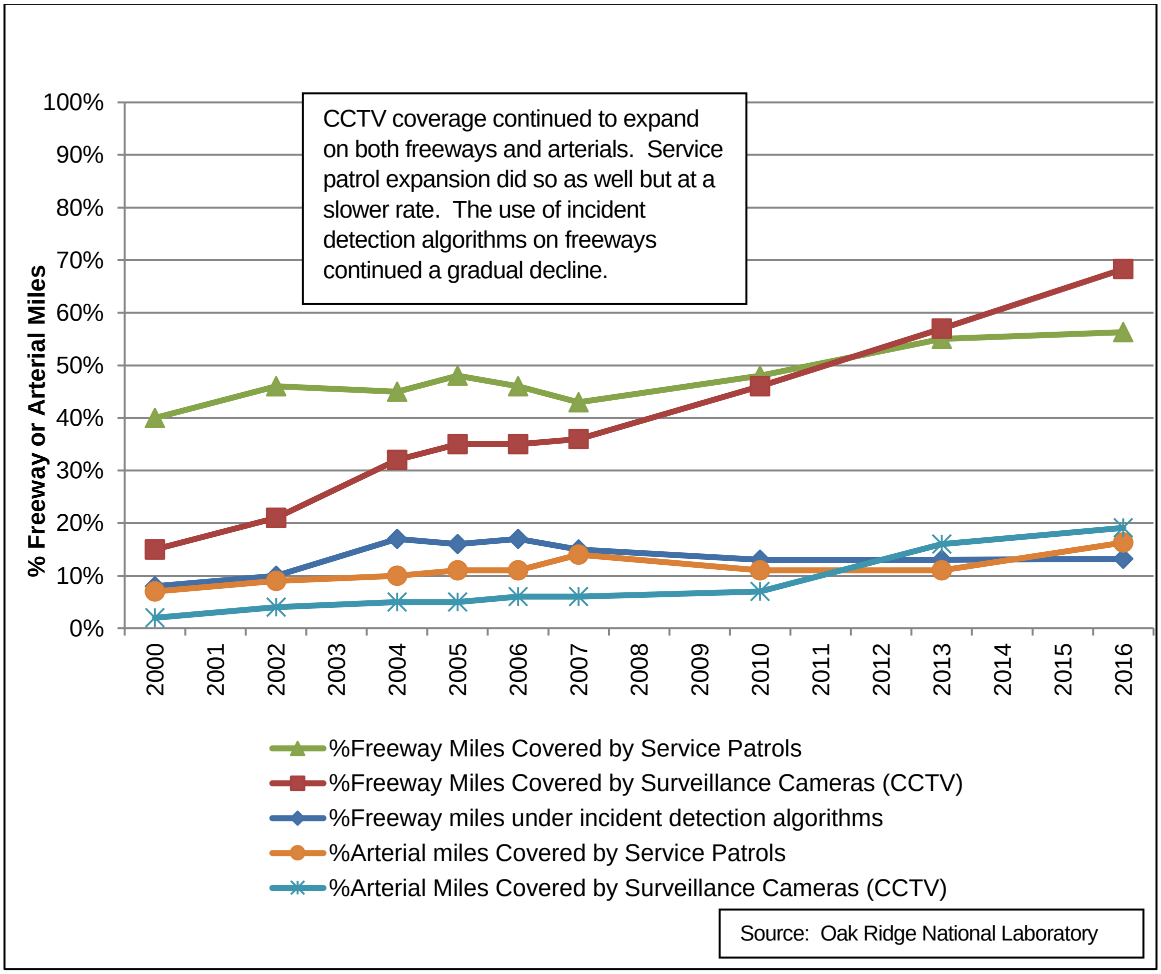


Figure 2-5. Freeway Incident Management Deployment Indicators, 2000 – 2016

Transit Management

Transit management deployment trends are summarized in Figure 2-6. Since 2000, there has been a significant increase in the deployment of several transit technologies. The percentage of fixed route buses equipped with automatic vehicle location (AVL) increased from 66% in 2010 to 86% in 2013 and by 2016 is universal with 98% of buses equipped. In addition, the demand responsive vehicles operating under computer aided dispatch (CAD) increased from 88% of vehicles in 2010 to become virtually universal by 2013 and remains so in 2016. Finally, the proportion of fixed route buses equipped with electronic real-time monitoring system components may be leveling off after increasing from 35% in 2010 to 48% in 2013, but only slightly more in 2016 to 50% of the fleet equipped.

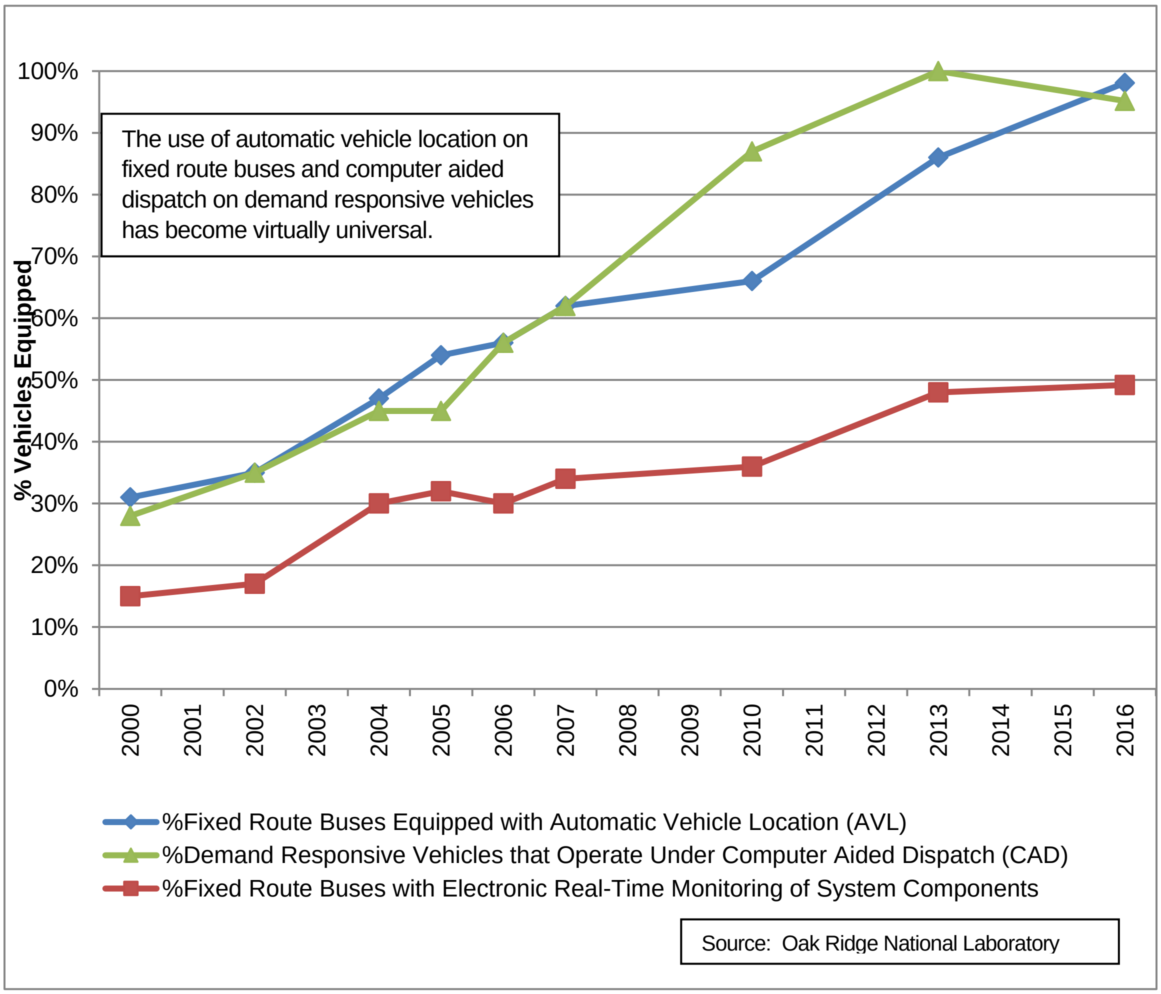


Figure 2-6. Transit Management Deployment Indicators, 2000 – 2016

The adoption of ITS technology by transit agencies experienced rapid advance between 2013 and 2016. Figure 2-7 shows that transit agencies greatly increased the adoption of AVL and electronic fare payment technologies in 2016. The proportion of agencies deploying AVL on fixed route bus increased from 54% of transit agencies in 2010 to 76% by 2016. The use of electronic fare payment systems also increased significantly. The percentage of agencies deploying magnetic strip readers on fixed route buses increased from 40% in 2010 to 57% by 2016. Similarly, adoption of smart card readers increased from 24% of agencies in 2010 42%in 2016. Adoption of traffic signal priority systems on fixed route buses showed no growth in 2016.

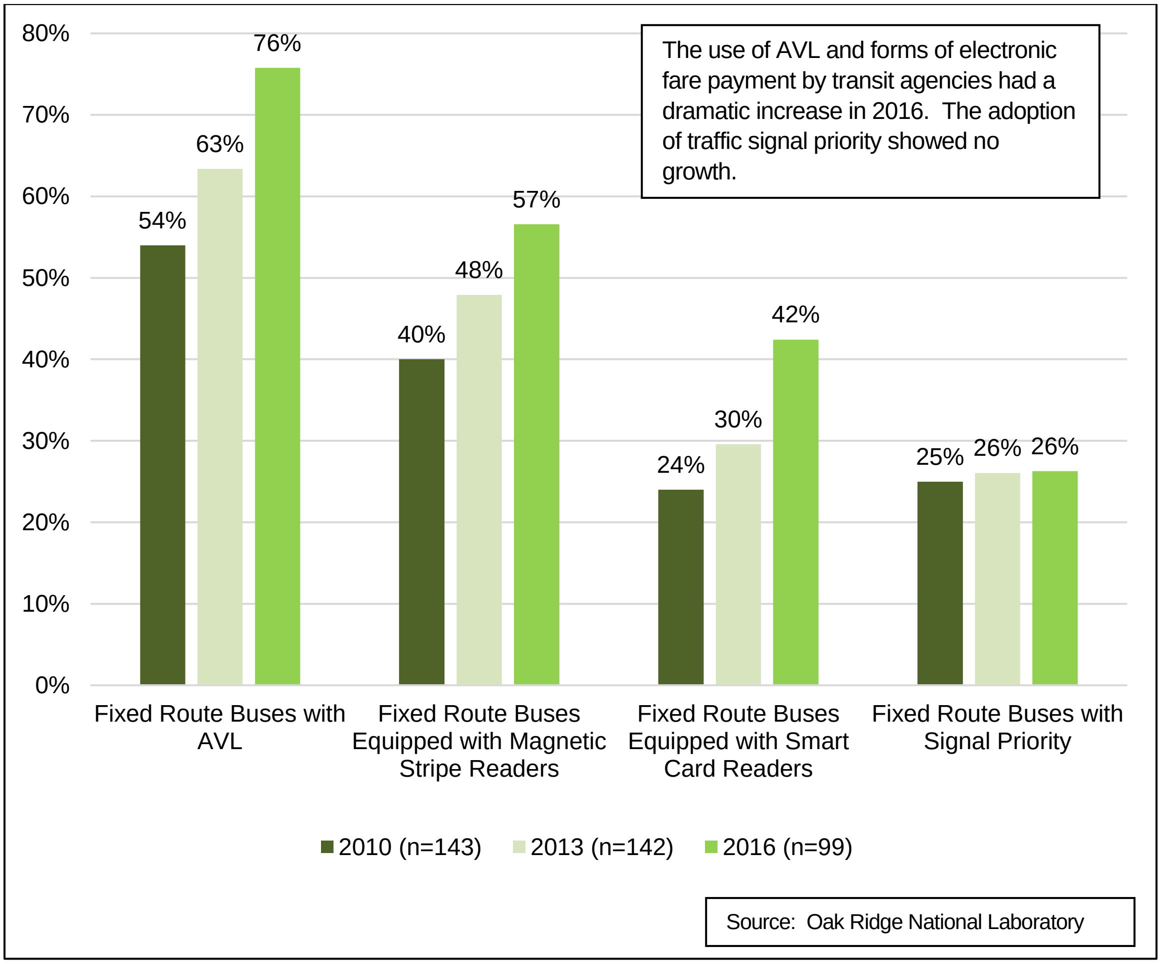


Figure 2-7. Technologies Deployed on Fixed Route Buses, 2010, 2013 and 2016

Future ITS Deployment Planning

Agencies were asked about their plans to invest in new ITS technology or to expand current ITS coverage during the period 2016 – 2019. Figure 2-8 shows that over 80% of freeway agencies and more than two-thirds of arterial and transit agencies plan to deploy ITS technology in that period and.

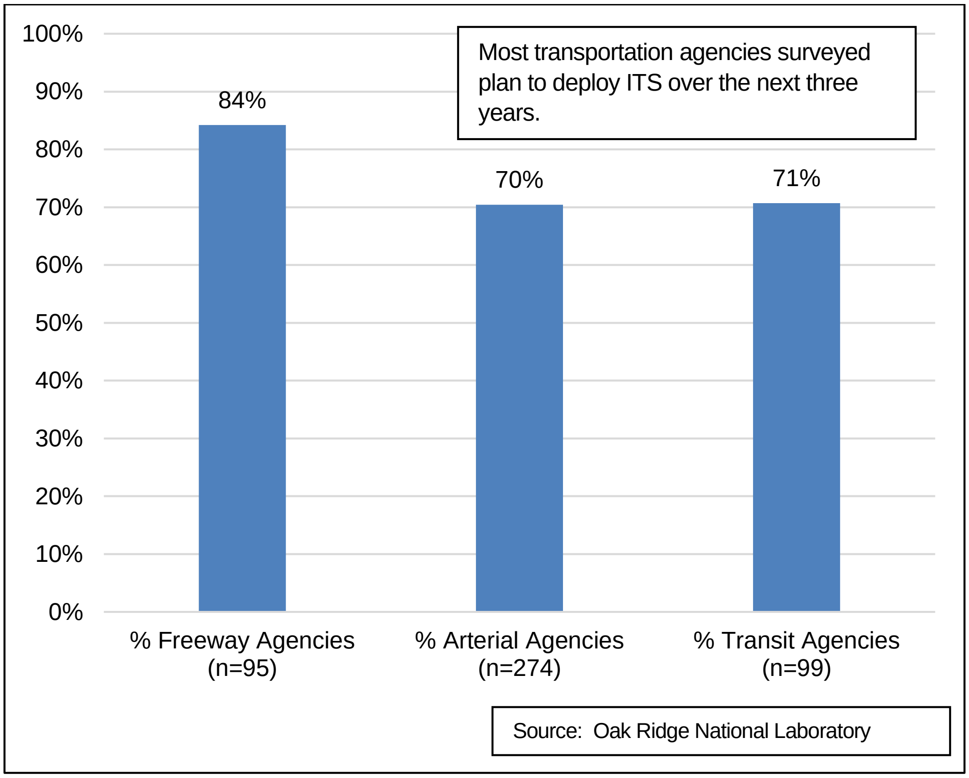


Figure 2-8. Agencies Planning Future ITS Deployments 2016 – 2019

Plans for New and Expanded ITS Deployments

The agencies that reported plans to deploy ITS technologies in the future were asked to characterize these planned deployments as either investments in new technologies or expansion of existing ITS deployments. Figure 2-9 shows that freeway and transit agencies have an equal commitment to new and expanded deployment. Arterial agencies planning to deploy favor expanding existing deployments over new technologies.

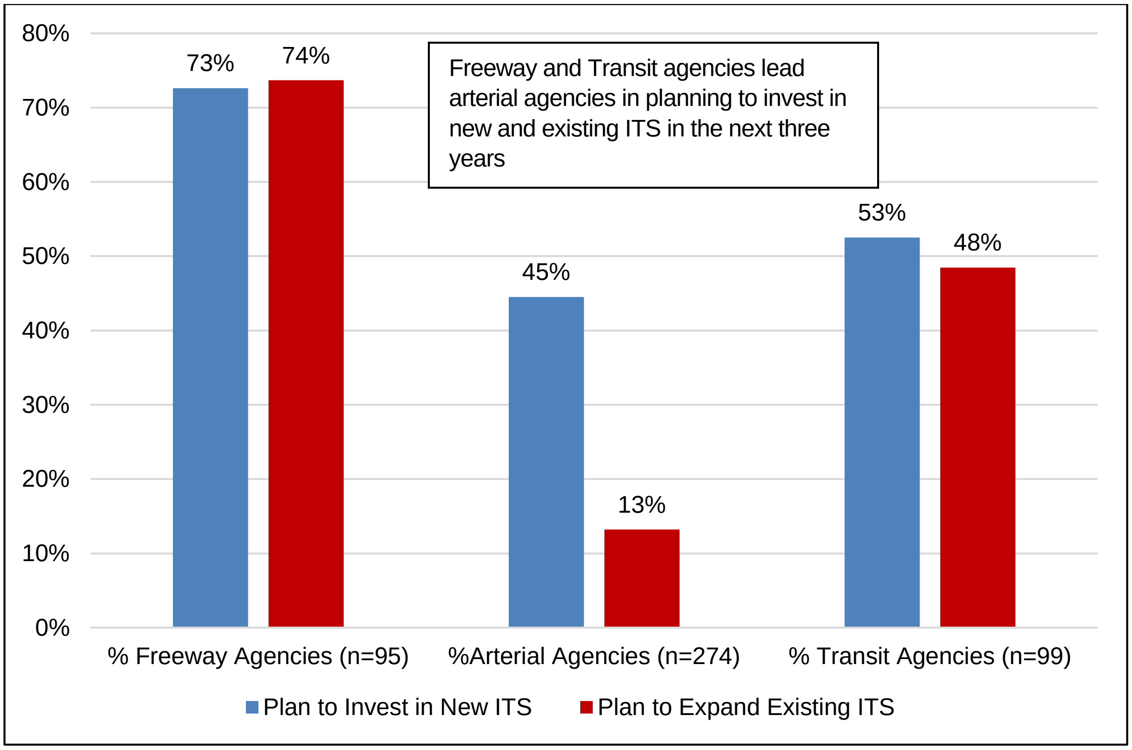


Figure 2-9. Types of Future ITS Deployments Planned 2016 - 2019

Planned Deployments of Specific ITS Technologies

The agencies that reported having plans to invest in ITS technologies were asked to enter the particular technologies to be purchased. This section summarizes comments from freeway, arterial, and transit agencies. Not all agencies that could have provided comments chose to do so, and as a result, the number of agencies included is less than the number indicating plans to make future investments. While the sample sizes are relatively small, the results provide a picture of the relative importance of specific technologies to the different agency types when considering future deployment.

Figure 2-10. Planned Future Deployments for Freeway Agencies 2016 – 2019

shows the planned deployments for freeway agencies. Cameras and DMS were listed most often by freeway agencies as planned future deployments. CV technology was next in frequency, which is a major change from 2013 when CV technologies were barely mentioned. Next in importance are detectors, road weather information system (RWIS), and variable speed limits. These results indicate that in the next three years, freeway agencies are focusing on expanding their ability to collect and disseminate real-time traffic data to support new traffic management strategies.

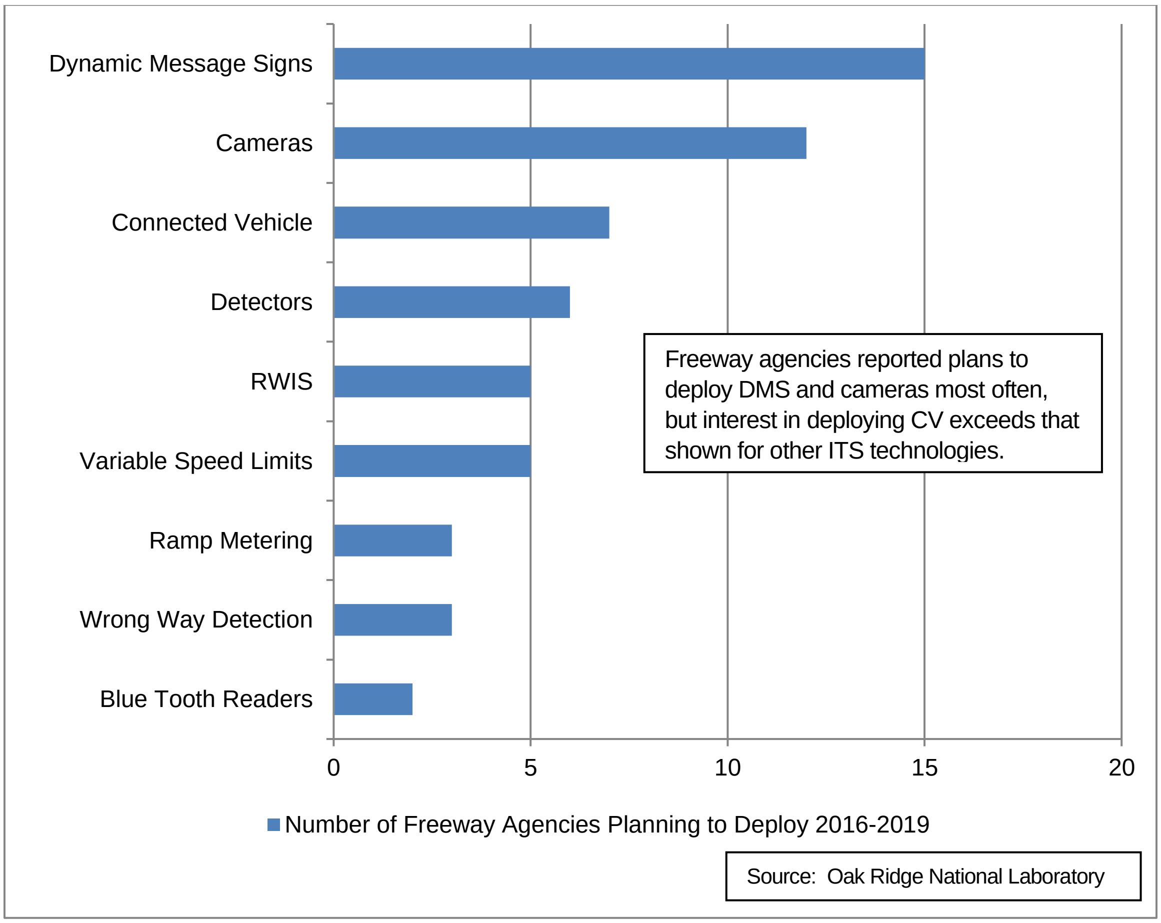


Figure 2-10. Planned Future Deployments for Freeway Agencies 2016 – 2019

Figure 2-11 shows the specific deployment plans for arterial agencies. The technologies most often cited are cameras, traffic adaptive signals, and DMS, with connected vehicle applications fairly high on the list. Perhaps related, there is strong interest in improving data transmission through deployment of fiber optic cabling and wireless communication. Interest in deployment of truck parking, signal controller upgrades, and travel time detection all may indicate a growing commitment to deploying sophisticated technology allowing arterial agencies to expand their capabilities into new areas.

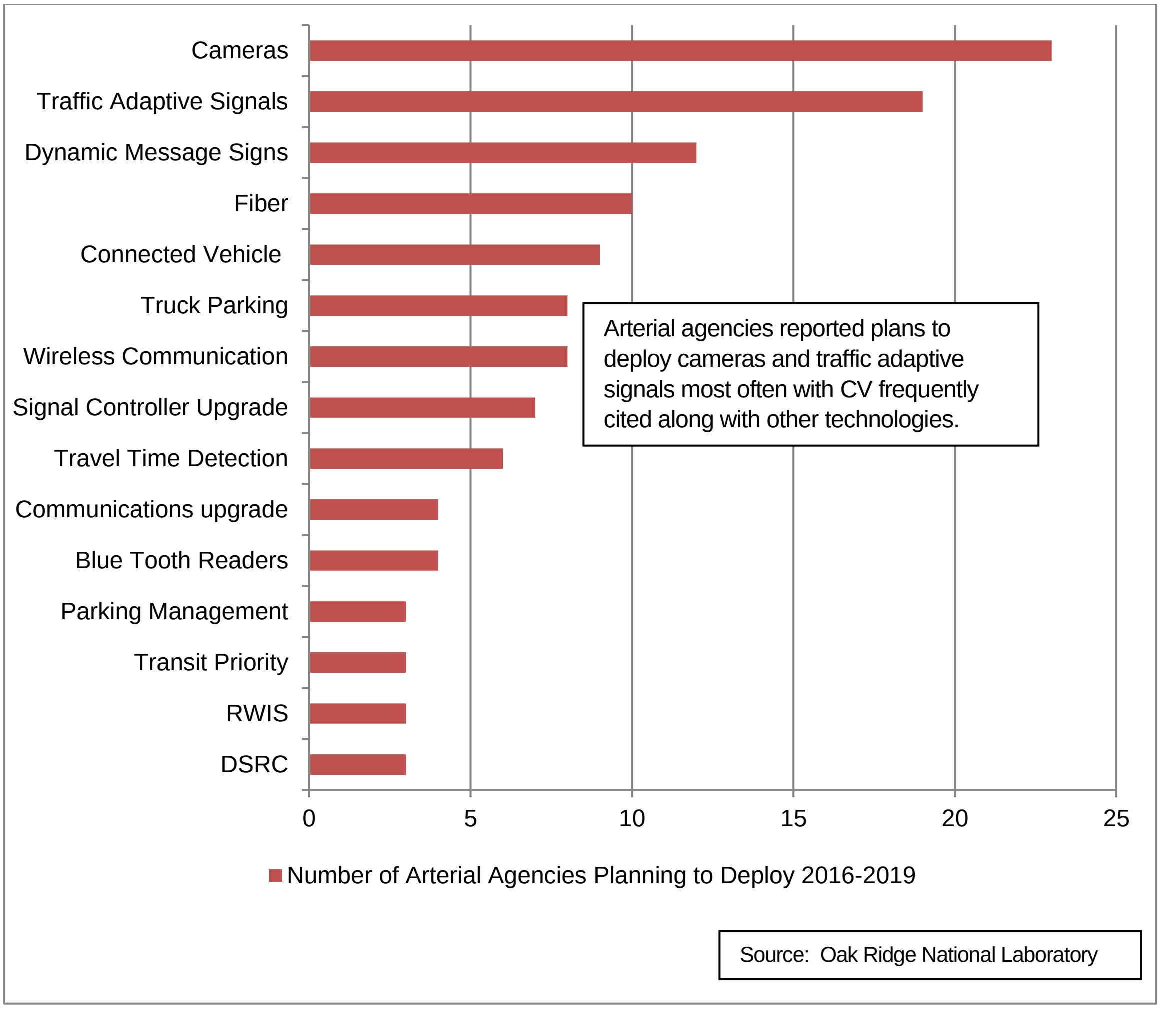


Figure 2-11. Planned Future Deployments for Arterial Agencies 2016 – 2019

Figure 2-12 shows the plans for future deployments by transit agencies over the next three years. The most frequently mentioned technologies are all directly related to improving service to transit passengers: traffic signal priority, AVL, Automatic Passenger Counters, and electronic fare collection. The use of AVL will allow agencies to implement real time bus arrival service and, with CAD, the use of improved dynamic scheduling capability. Some agencies are also planning on deploying sophisticated technology to improve safety in the form of video analytics threat detection and automated collision avoidance systems.

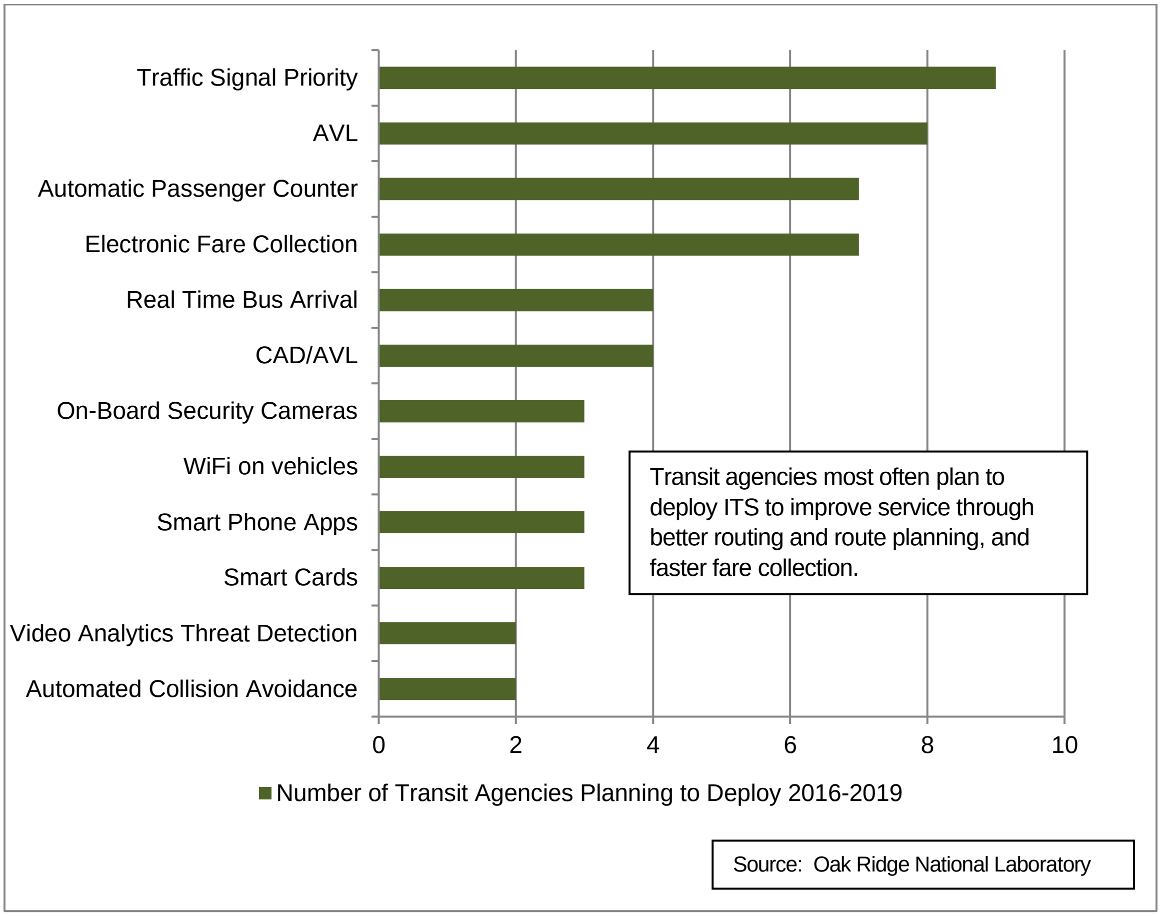


Figure 2-12. Planned Future Deployments for Transit Agencies 2016 – 2019

Chapter 3 ITS Applications

ITS technology is used to support a variety of operations and management applications. Over time, the deployment tracking survey expanded from a focus on individual technologies to include the new capabilities for traffic mangers enabled by using technology to integrate operations and support additional applications. The section on management and operations strategies covers specific strategies for traffic management enabled by deployment of ITS. Data collection and dissemination looks at advancements in collection and sharing of data. Operations performance management explores how ITS technology can track a wide range of performance measures that, along with archived data, can support a program of continuous improvement. Other new management strategies that are enabled by the capability provided by ITS include integrated corridor management as well as joint planning for operations. ITS also improves traffic management and safety through safety and enforcement systems and real-time weather monitoring. Finally, the emergence of sophisticated ITS technologies has created the need for improved methods to track maintenance status and take actions to correct malfunctioning devices. Chapter 3 will cover survey results for the following applications:

- Management and Operations Applications
- Data Collection and Dissemination
- Operations Performance Management
- Safety, Enforcement, and Work Zone Systems
- Road Weather Systems
- Integrated Corridor Management (ICM)
- Joint Planning for Operations
- Maintenance of ITS Technology

Management and Operations Applications

ITS technology enables a rich variety of strategies to execute and integrate transportation management within a metropolitan area.

Ramp Metering

The deployment of ITS technology has supported increasing capability for ramp metering deployments, moving from simple time of day timing schemes to dynamic timing in which timing is adjusted in accordance with traffic conditions. As shown in Figure 3-1, about two-thirds of the agencies employ simple time of day changes for some of their metering sites. However, the use of dynamic timing is very widespread. The most frequently cited dynamic timing scheme is one in which traffic conditions are monitored in the area of the ramp and traffic is metered onto the freeway to achieve the best combination of throughput and safety. A more sophisticated method, also widely employed by agencies with ramp metering, integrates multiple metering sites along a corridor to provide the best control for the corridor as a whole. Another integrated strategy is to coordinate metering with nearby arterial signal timing to manage queues that form on the ramp, employed by 29% of the agencies with ramp metering.

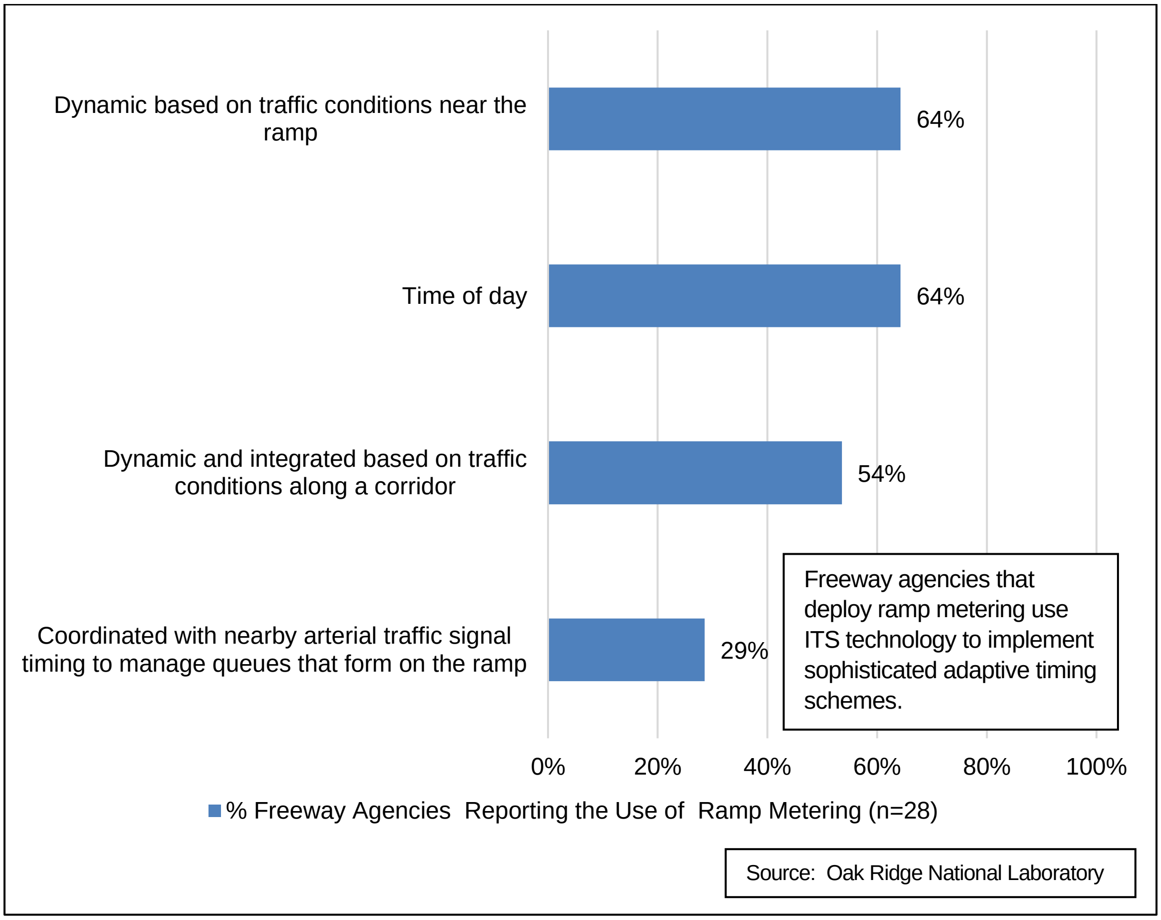


Figure 3-1. Ramp Metering Control Strategies

Freeway Managed Lanes

About a quarter of the freeway agencies employ managed lanes. The extent of deployment of various managed lane strategies by freeway agencies is shown in Figure 3-2, with the percentages based on the number of agencies that reported using managed lanes. The most common strategy is the use of High Occupancy Vehicle (HOV) lanes, in which access is restricted to vehicles with multiple passengers. Next in frequency is the employment of High Occupancy Toll (HOT) lanes, in which high occupancy vehicles can operate at no cost or a reduced toll, while other vehicles pay a toll varied based on demand. Reversible flow lanes are also employed by freeway agencies. A small number of freeway agencies open and close lanes for various reasons and employ truck only lanes.

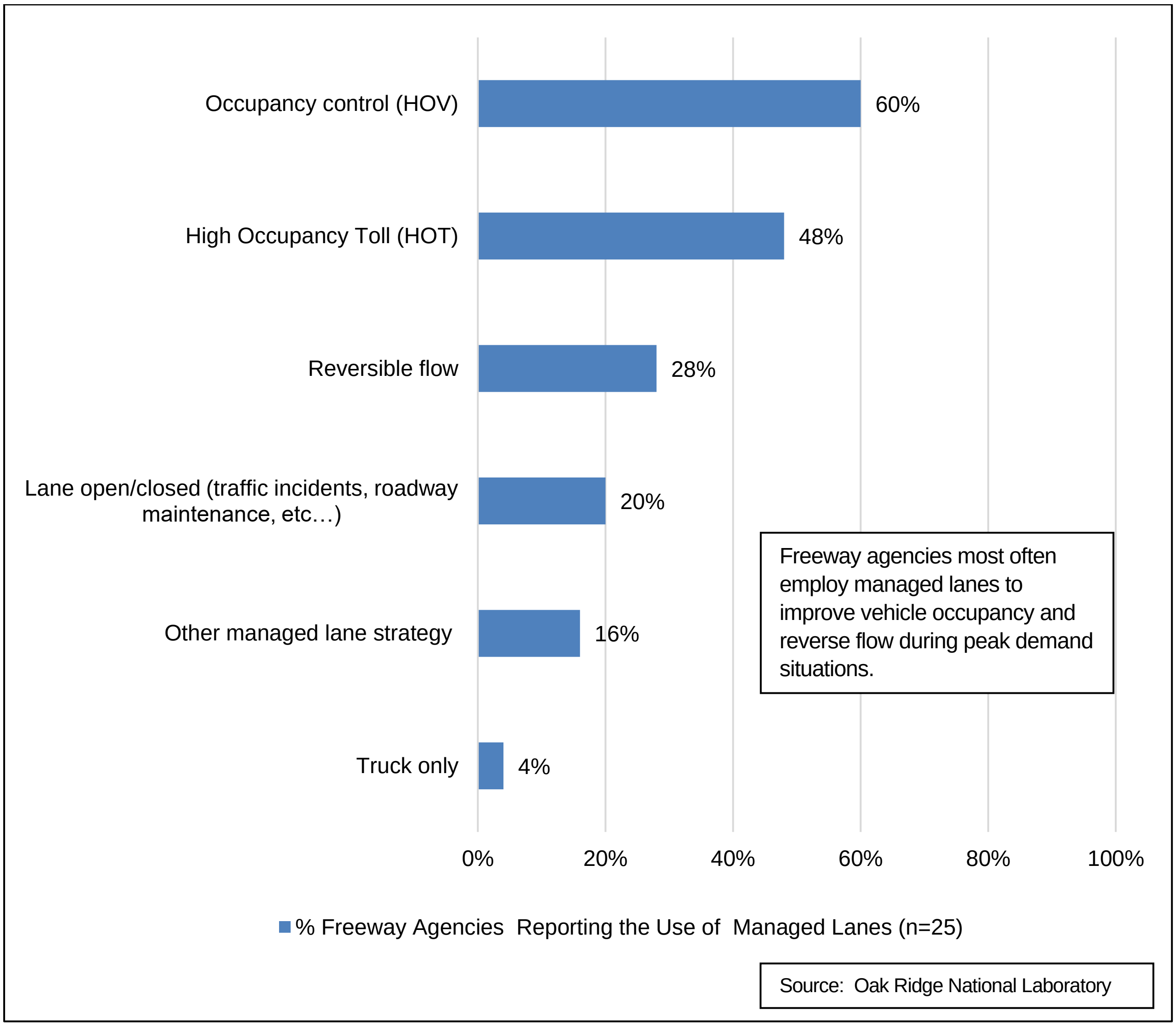


Figure 3-2. Strategies of Freeway Agencies Operating Managed Lanes

Arterial Traffic Signal Control Strategies

Many arterial agencies employ traffic signal control strategies that provide preemption or priority for different types of vehicles. Figure 3-3 shows that the strategy most often cited is signal preemption for emergency vehicles. Next in frequency is signal control near a highway-rail intersection in which the signal timing is preempted to allow the clearing of a vehicle queue that extends across an active highway-rail grade crossing. Signal priority for transit vehicles has also been implemented, but less widely, and a small number of agencies allow signal priority for trucks.

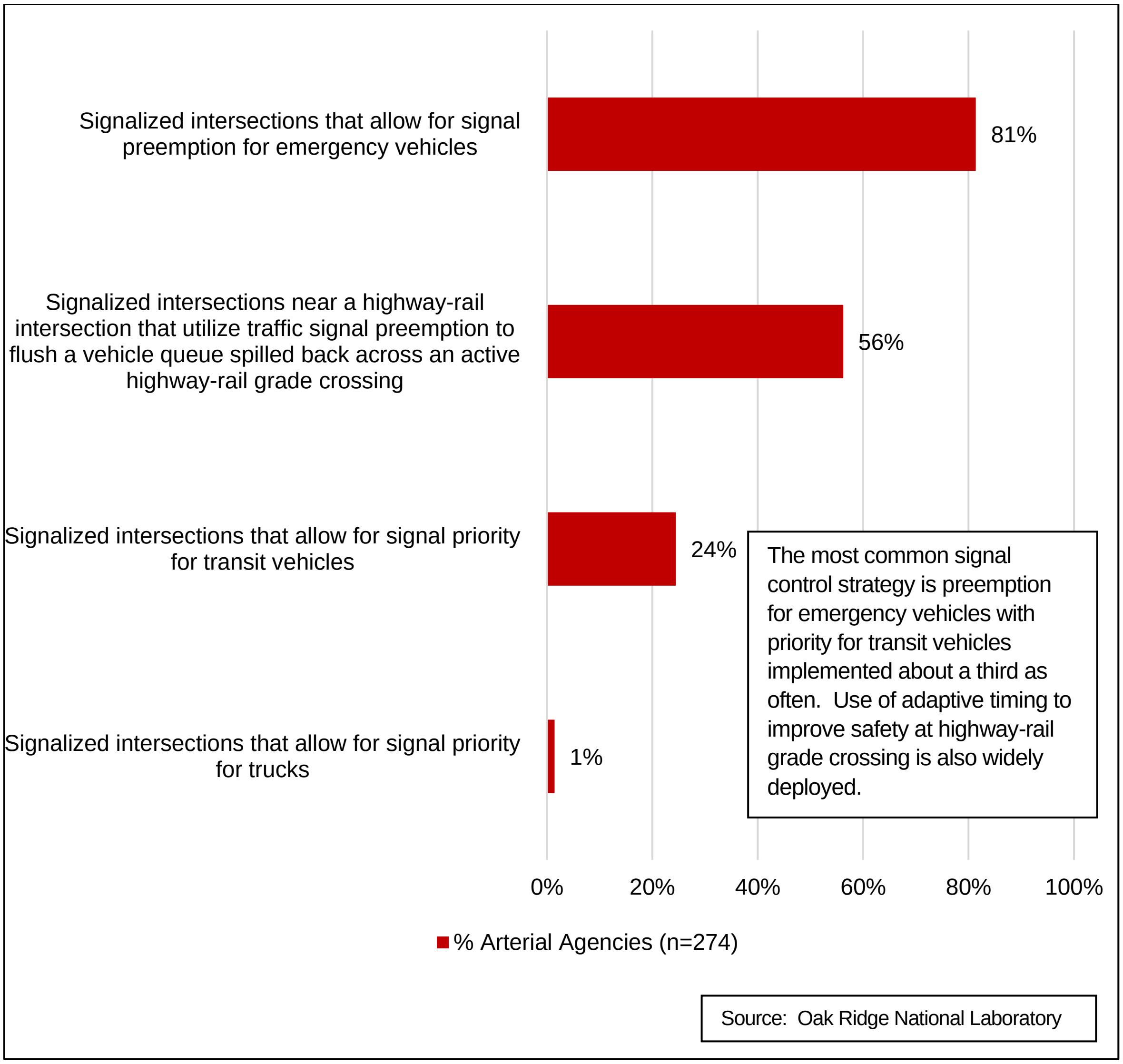


Figure 3-3. Use of Traffic Signal Control Strategies by Arterial Agencies

Arterial Parking Management

Adoption of parking management by arterial agencies is currently at an early stage, with all strategies reported by less than 10% of arterial agencies. Figure 3-4 shows that 9% of arterial agencies reported that they monitor the availability of parking and disseminate the information to drivers. Some agencies allow travelers to reserve a parking space to ensure availability. Arterial agencies also employ a parking pricing strategy (typically peak period surcharges) to manage congestion. Arterial agencies form public-private partnership to monitor the availability of parking and, in some instances a private entity alone is responsible for monitoring parking availability.

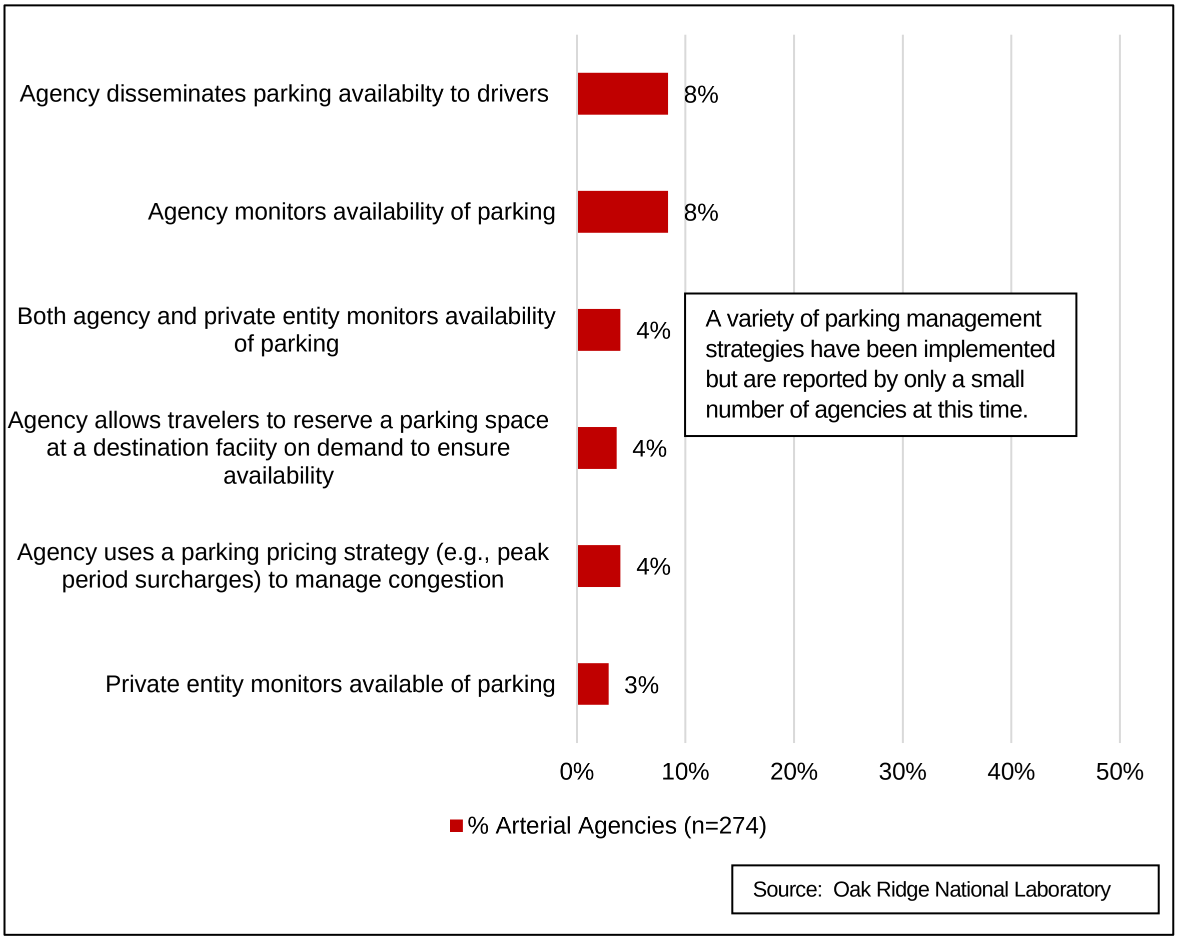


Figure 3-4. Parking Management Strategies

Transit Interface with Traffic Signal Control

Figure 3-5 shows the extent of adoption of traffic signal priority and preemption strategies by transit agencies. About a quarter of transit agencies support signal priority for fixed route buses. A much smaller number of agencies support preemption for fixed route buses as well as priority or preemption for light rail vehicles. Traffic signal preemption and priority can only operate with vehicles that are appropriately equipped.

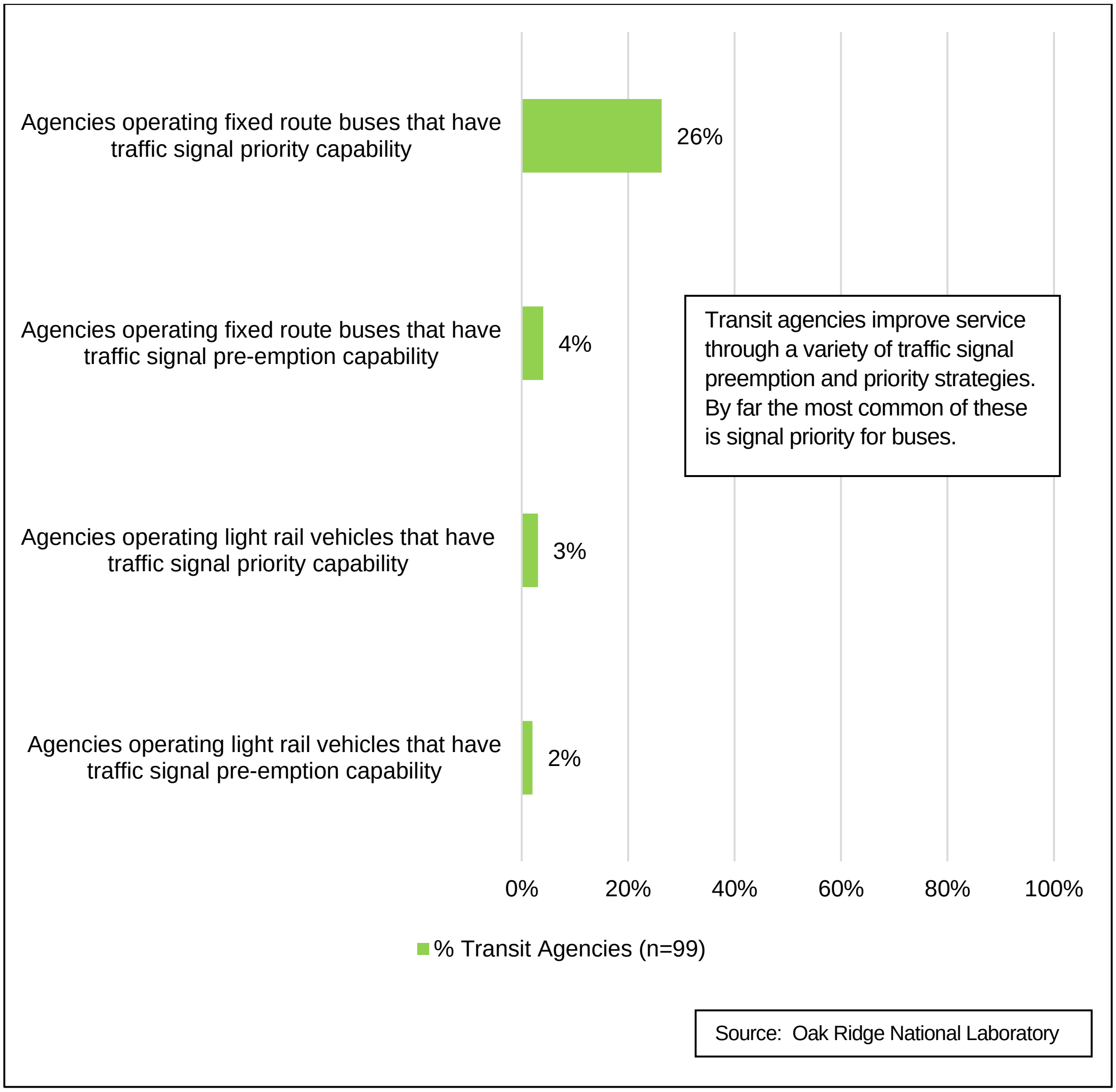


Figure 3-5. Transit Agencies Supporting Traffic Signal Priority or Preemption

Transit Service Improvement Strategies

Figure 3-6 shows the adoption of a number of transit management strategies that are made possible through the use of ITS technology. The most widely employed strategy, reported by just under half of the transit agencies, is connection protection in which of data on passenger schedules and vehicle location are used to improve service by holding vehicles when needed to allow the transfer of passengers between vehicles or transit systems. Transit agencies also use technology (vehicle location and dispatching systems) to support flexible routing and scheduling and to flexibly assign buses to meet real-time variations of demand on sections of the network. A small number of agencies coordinate with other agencies within a corridor to reduce fares as needed to encourage the use of transit to reduce traffic volume in periods of high congestion.

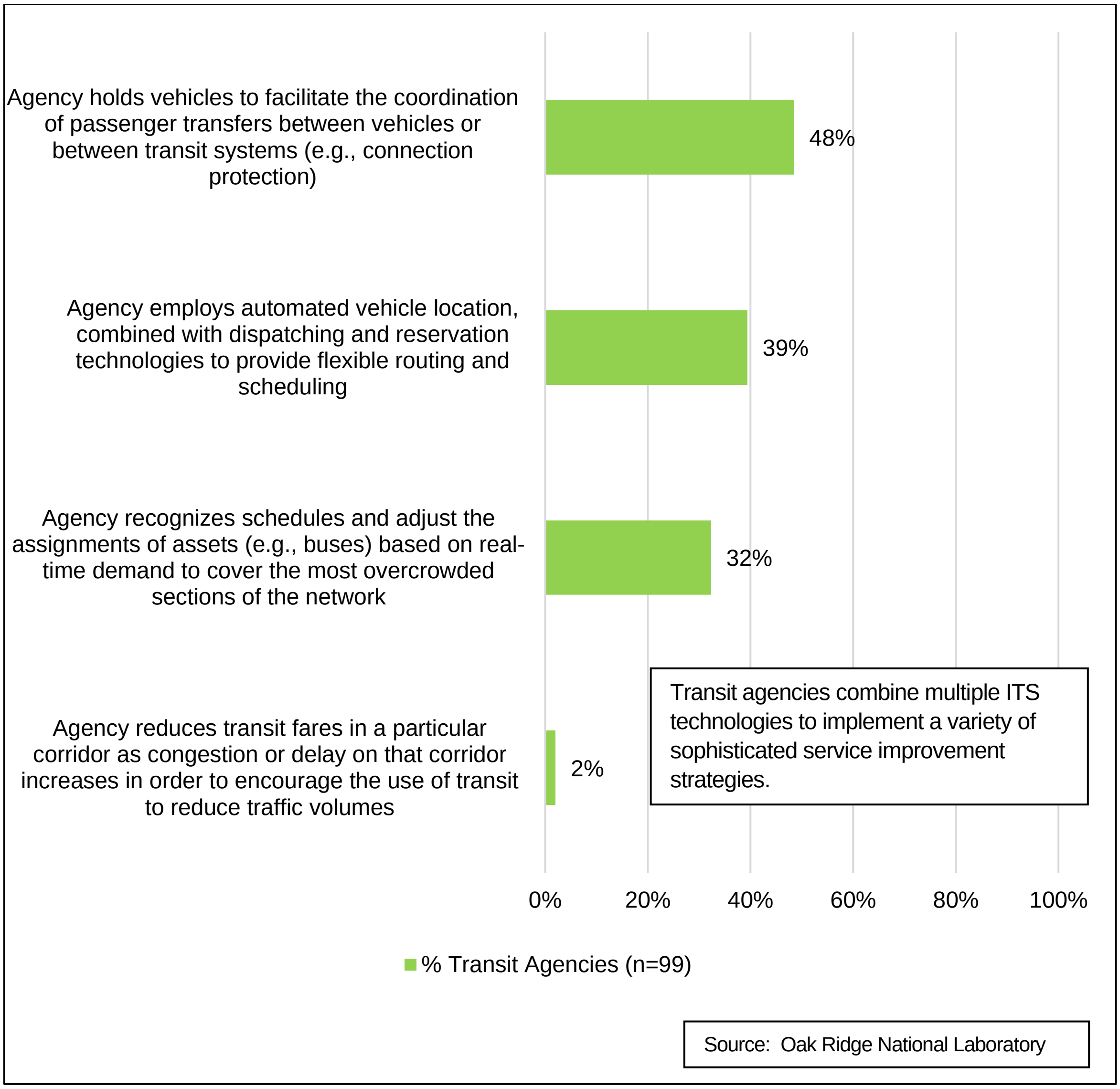


Figure 3-6. Transit Management Strategies

Transit Support for People with Disabilities

Transit agencies employ a variety of sophisticated technologies to support transport of people with disabilities as shown in Figure 3-7 Most widely adopted is the use of automated audio and visual announcements, reported by half of transit agencies. Next in frequency of adoption is the use of audio and Braille capable fare vending machines. Other technically advanced systems, typically deployed by 10% or more of the reporting agencies, include: interactive voice response and speech interface, and a navigation app for global positioning system (GPS) equipped phones to help travelers find their way within a station, some including audio-tactile tools.

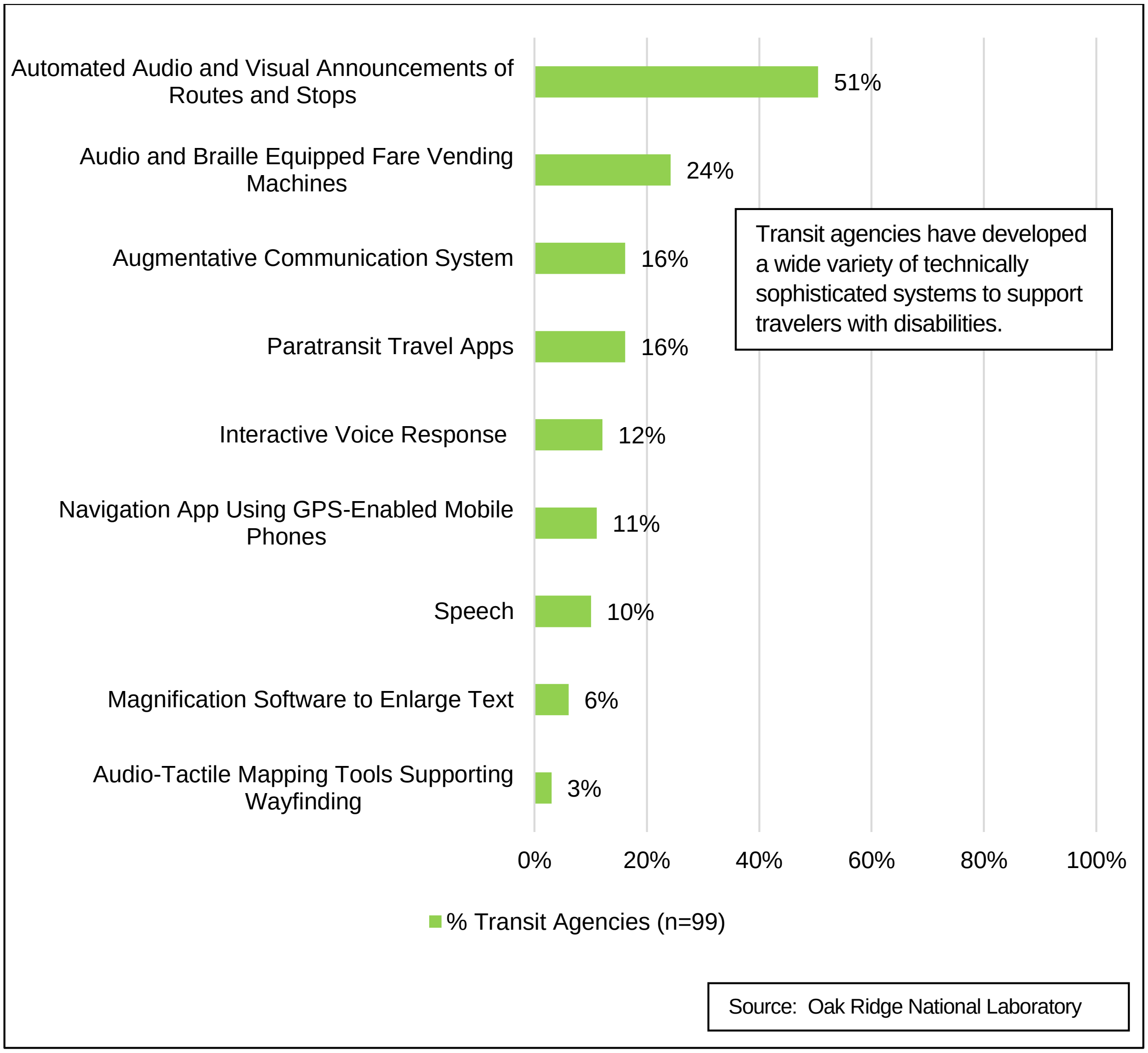


Figure 3-7. Technologies to Support Transport of People with Disabilities

Transit Electronic Fare Payment.

The adoption of electronic fare payment systems at transit facilities and vehicles in the form of smart cards and magnetic stripe readers has become widespread. Figure 3-8 breaks out the percentage of transit agencies reporting the use of electronic fare payment in transit vehicles and facilities. The data show that two-thirds of transit agencies report the use of either smart cards or magnetic stripe readers at fixed route buses, heavy or rapid rail stations, and light rail stations. Less than a tenth of transit agencies report the use of electronic fare payment on paratransit vehicles or at bus stations.

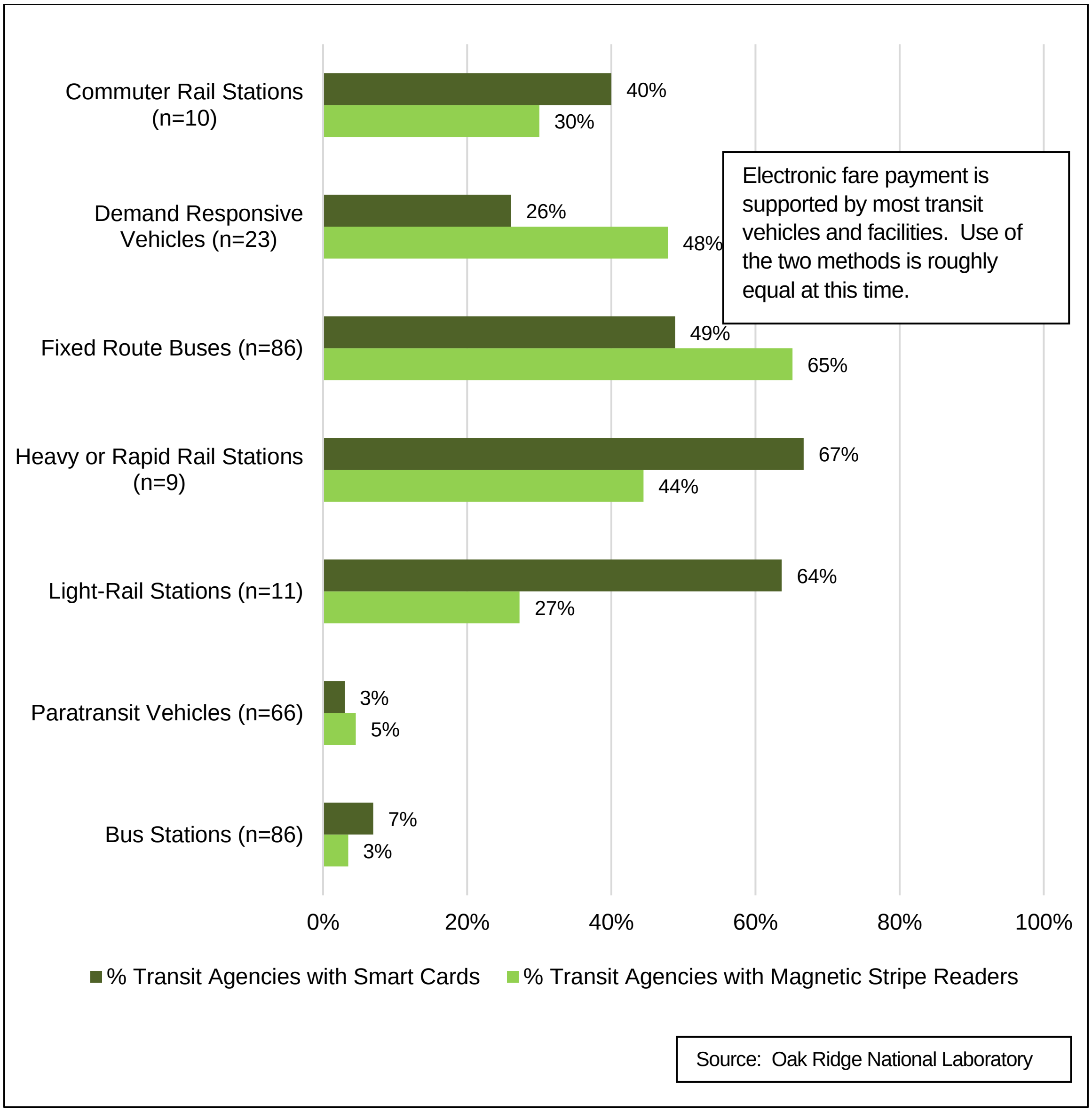


Figure 3-8. Fare Media Used by Transit Agencies

Freeway and Arterial Decision Support Systems

Freeway and arterial agencies frequently employ decision support systems to assist in a variety of tasks, as shown in Figure 3-9. As with most technologies, freeway agencies have the highest usage but arterial agencies report a significant level of adoption as well. Most common is the use of decision support systems in support of incident management and road weather management. About one quarter of freeway and arterial agencies use decision support for emergency management. Also supported by decision support systems are roadside device maintenance, evacuation management, and adaptive ramp metering.

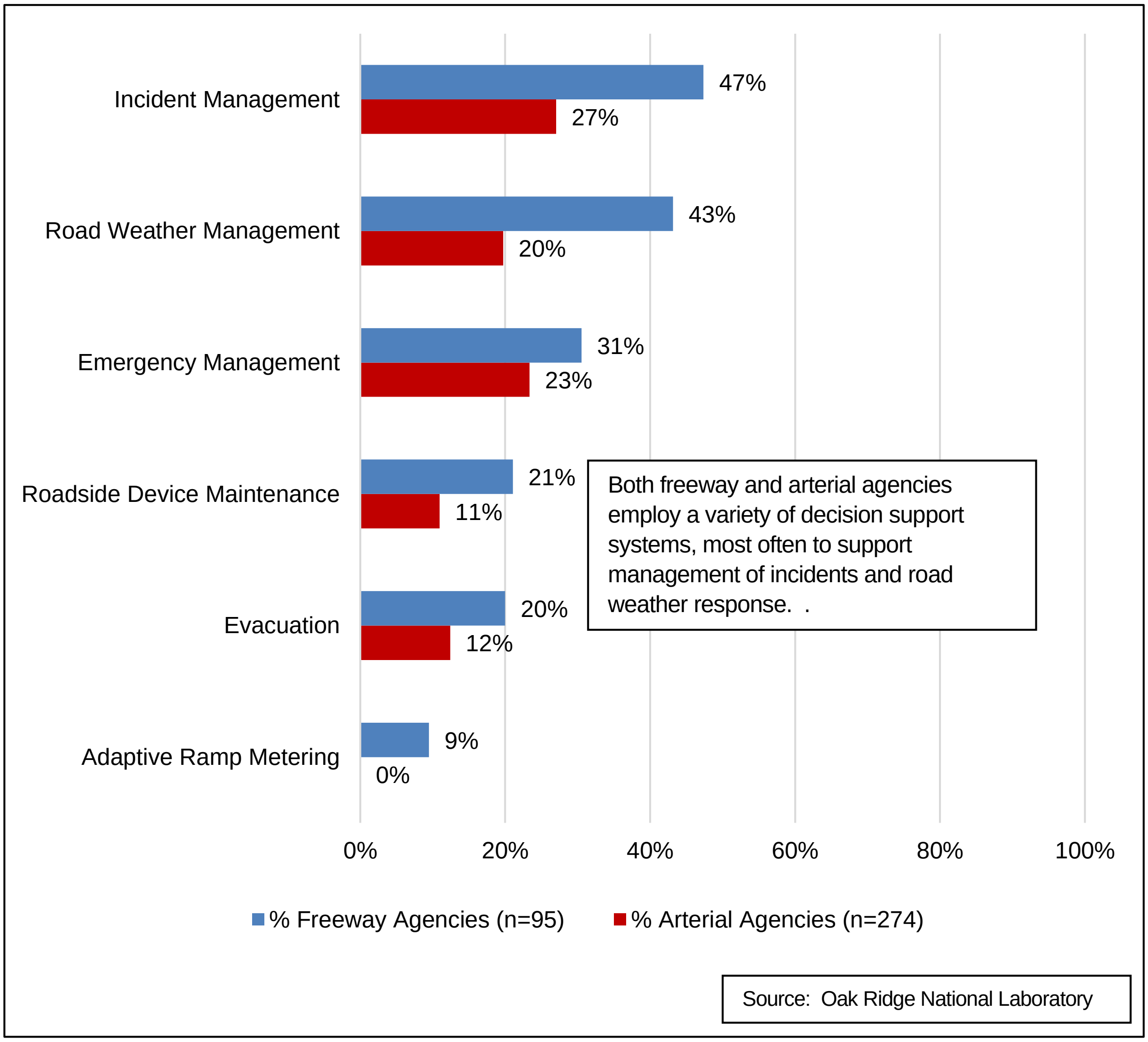


Figure 3-9. Types of Decision Support System Deployed

Data Collection and Dissemination

Transportation agencies are using a variety of sophisticated ITS technologies to collect and distribute information.

Probe Readers

The use of probe readers by freeway and arterial agencies was widely reported in 2016. As Figure 3-10 shows, Bluetooth readers are the most commonly employed type of probe reader by both freeway and arterial agencies, and is reported about twice as often as the next most popular type, cellular phone readers. Adoption of other types of probe readers is reported, but almost exclusively by freeway agencies.

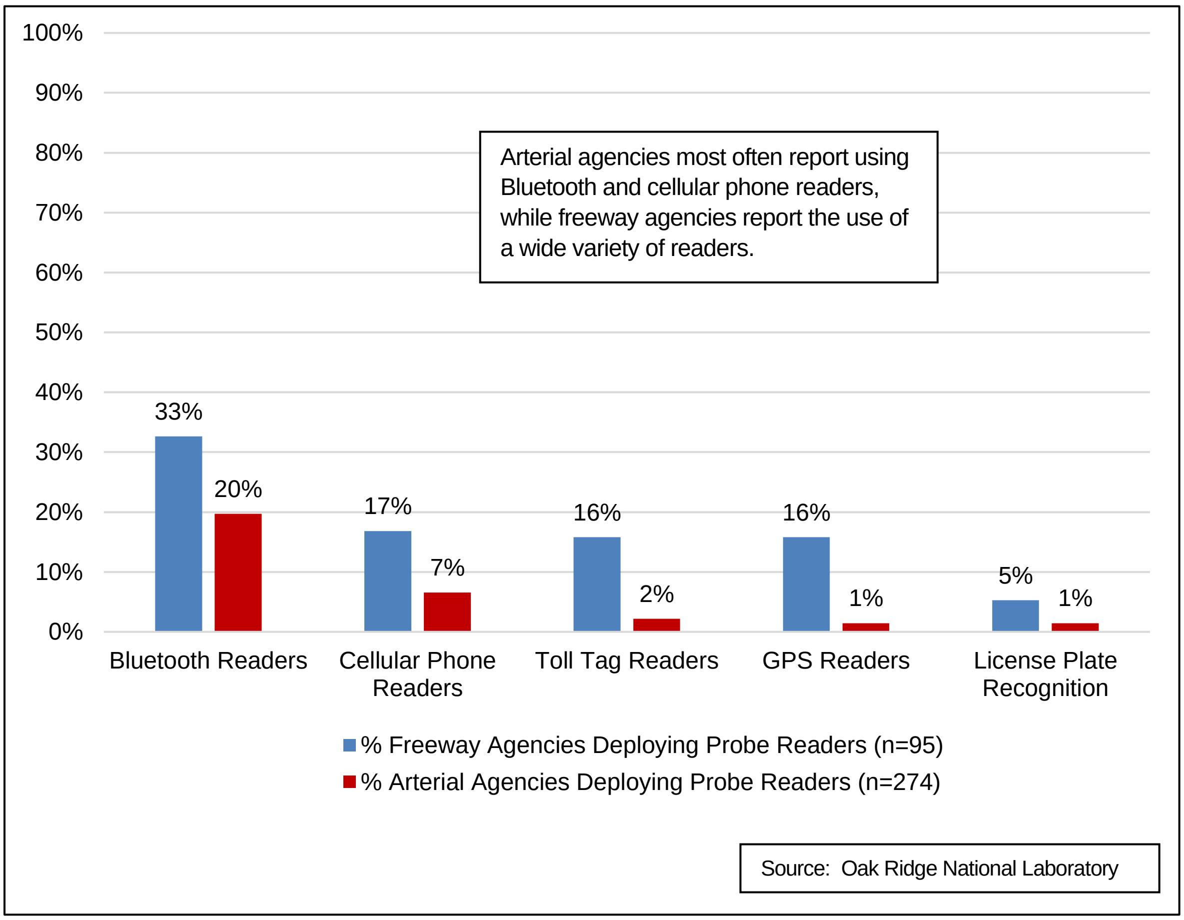


Figure 3-10. Types of Probe Readers Adopted by Freeway and Arterial Agencies

Crowdsourced Data

Transportation agencies are supplementing data gathered from field devices such as cameras and sensors with data collected from the travelers themselves using social media. Currently freeway agencies use crowdsourced data about four times as often as arterial agencies. As shown in Figure 3-11, the most commonly used is Waze, followed closely by commercial providers (e.g., Inrix and HERE). Google maps traffic is also used by freeway and arterial agencies. Cellular phone calls and custom created smartphone apps are also in use, almost exclusively by freeway agencies.

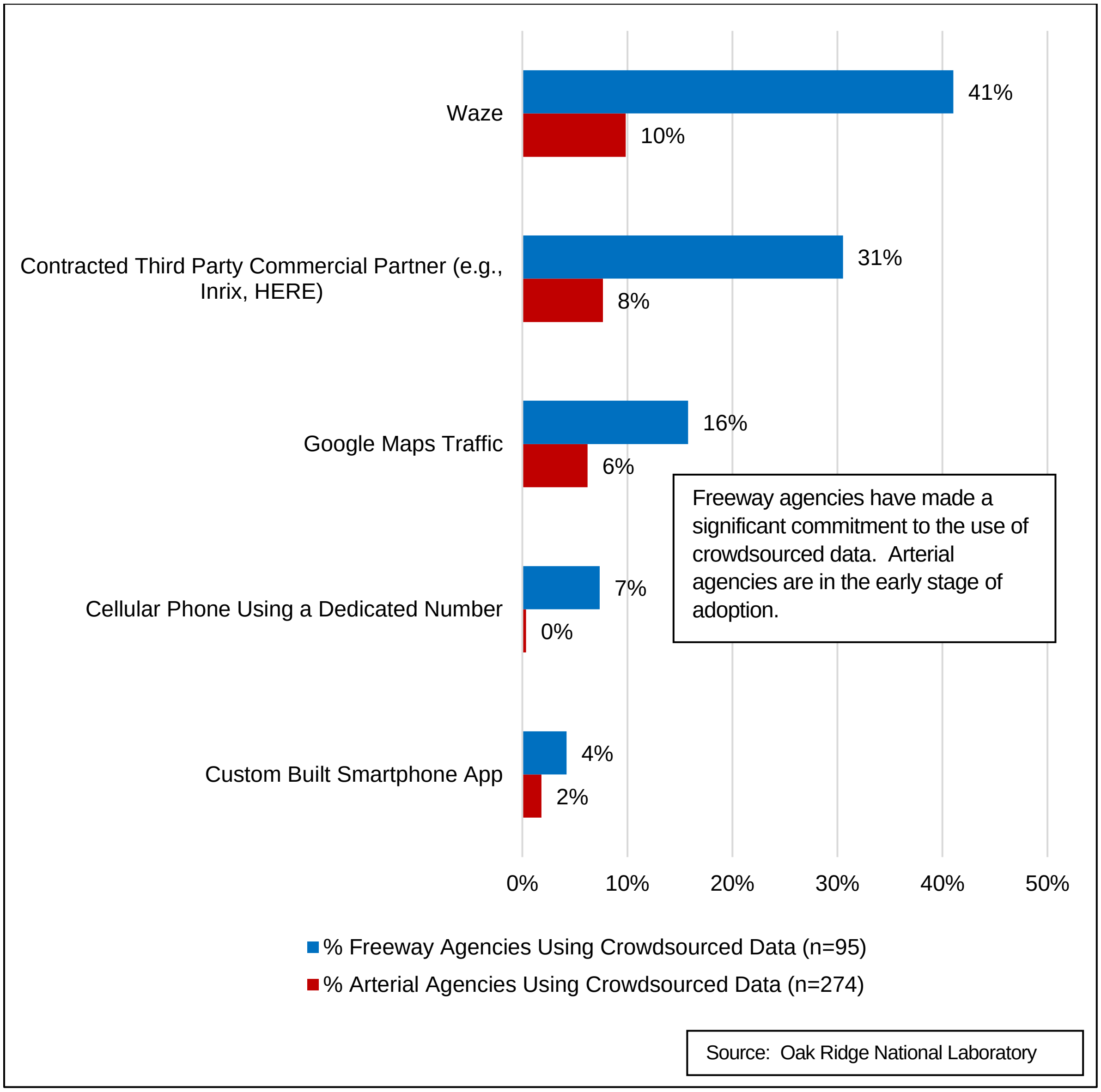


Figure 3-11. Methods Used to Gather Crowdsourced Data

Media Used to Distribute Traveler Information

The use of social media to distribute information to travelers has expanded rapidly. Four of the top six methods of data distribution in use are social media as shown in Figure 3-12. Freeway agencies lead the way in the variety of media used, with 70% or more reporting the use of one or more of six media types. Twitter is the medium most frequently reported in use by freeway agencies, followed by DMS, website, email, 511, and Facebook. Arterial and transit agencies most often use a website to distribute information. Twitter, email, Facebook, DMS, and 511 are the remaining major media employed by arterial agencies. The most important media for transit agencies following use of a website are email, DMS in station, mobile phone app, Twitter, and custom-built smartphone app.

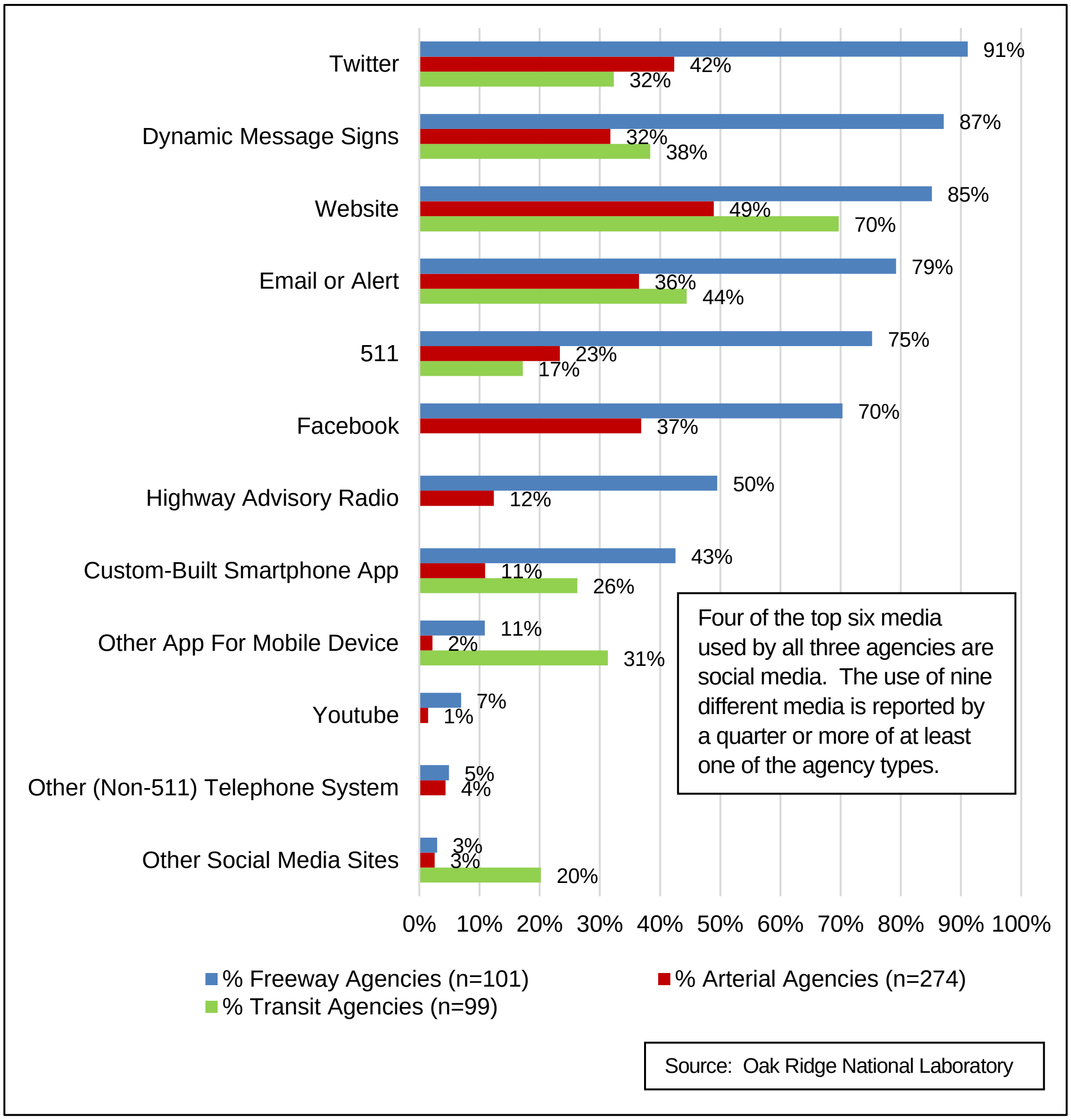


Figure 3-12. Methods Used to Distribute Traveler Information by Freeway, Arterial and Transit Agencies

Operations Performance Management

The deployment of ITS technologies greatly enhances the ability of agencies to employ a performance management approach to improve operations.

Performance Management

Figure 3-13 shows that both freeway and arterial agencies collect and use performance data, with freeway agencies doing so more frequently than arterial agencies. Three-fourths of freeway agencies are collecting operational data and more than half of freeway agencies establish performance targets in order to diagnose and overcome specific issues impacting quality of service.

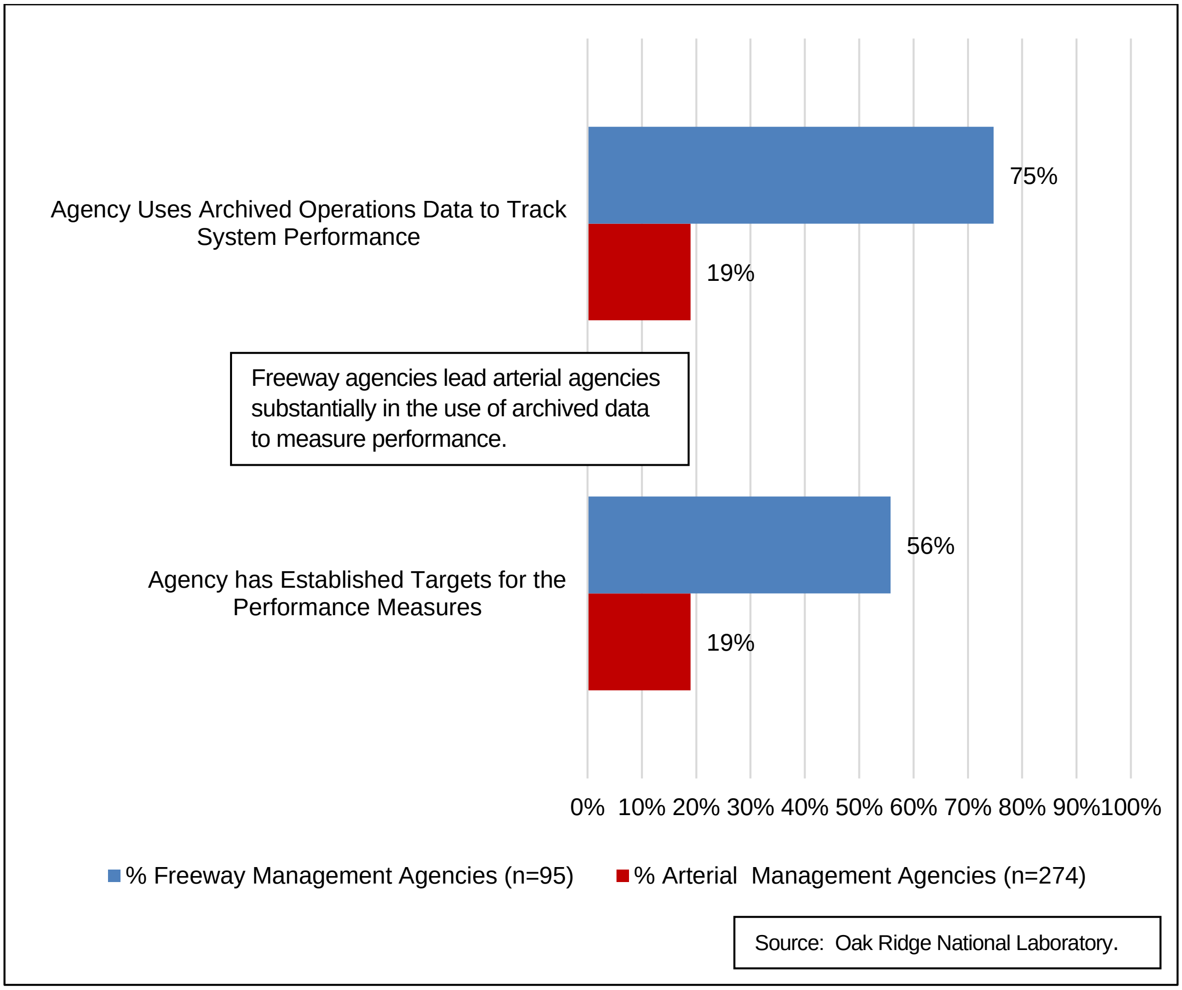


Figure 3-13. System Performance Management by Freeway and Arterial Agencies

Freeway and Arterial Performance Measures

As shown in Figure 3-14 freeway and arterial agencies employ a variety of measures to track performance and improve service. Freeway agencies lead in the use of performance measures but generally not by much; as in most cases arterial agencies report the use of specific measures about two-thirds as often. Travel time, average speed, travel time reliability, and vehicles per hour are most widely used. The use of three particular performance measures, delay per incident, vehicles per lane per mile, and frequency of severe congestion, differs from other measures in being almost exclusively reported by freeway agencies.

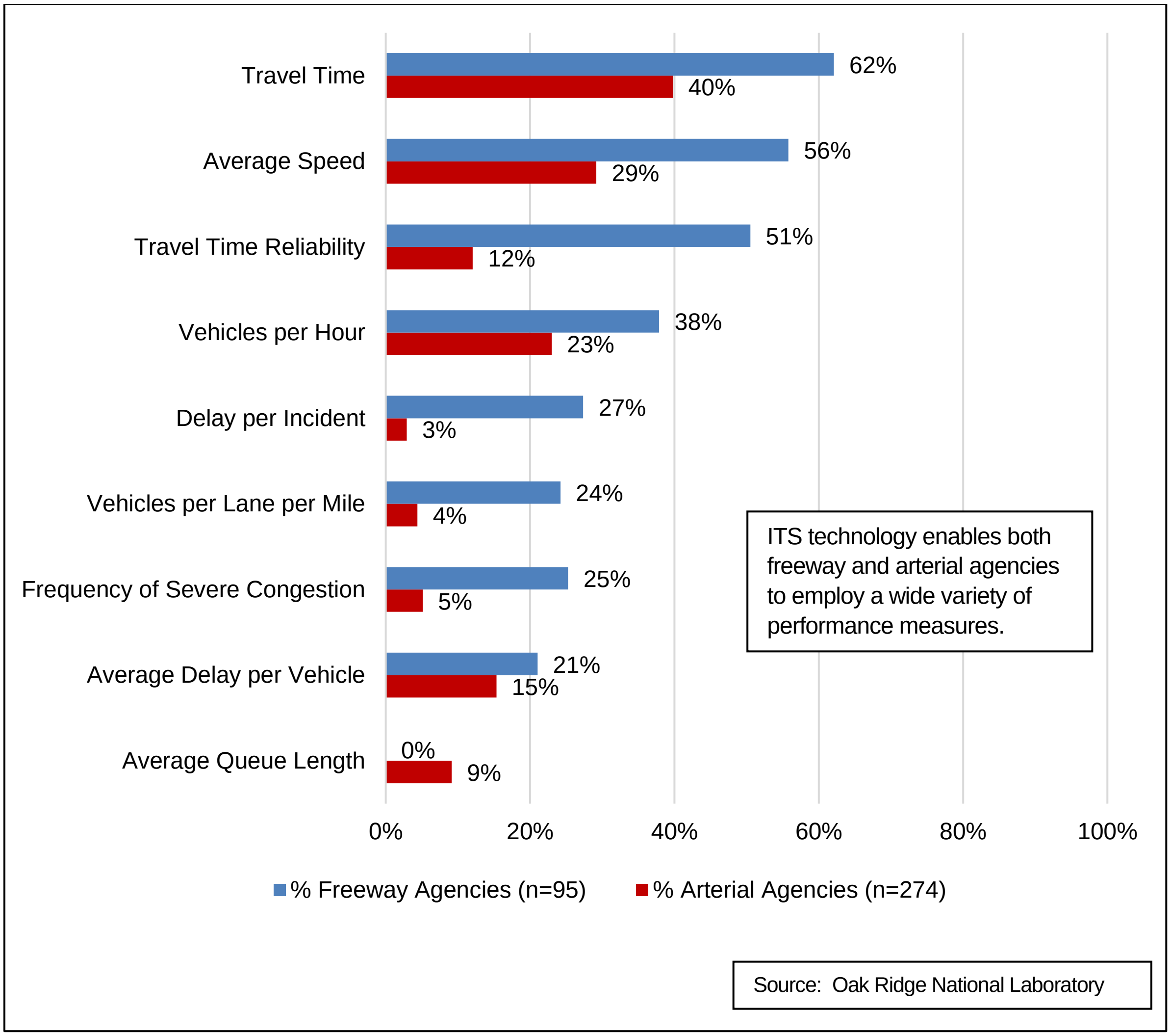


Figure 3-14. Performance Measures Used by Freeway and Arterial Agencies

Transit Performance Measures

Figure 3-15 shows that transit agencies report an extensive and growing use of a variety of performance measures. The most often reported are vehicle time and location, as well as passenger counts, incidents, vehicle diagnostics, and vehicle monitoring status, all reported by 30% or more of transit agencies. The use of performance measures increased significantly in the three years from the last survey and shows a primary focus on vehicle reliability and schedule adherence.

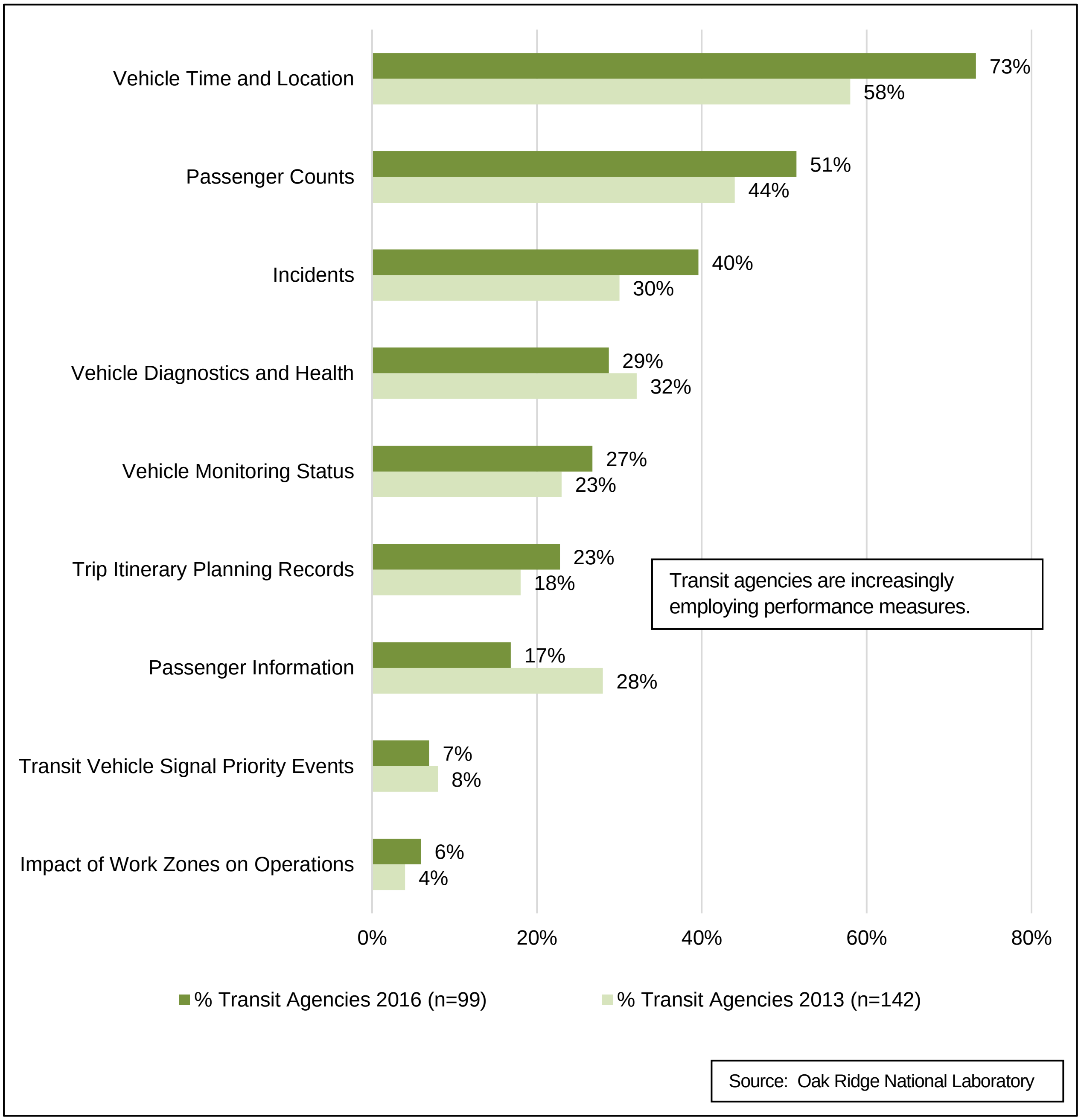


Figure 3-15. Performance Measures Used by Transit Agencies

Functions Supported by Archived Data

Figure 3-16 shows that freeway and arterial agencies use archived data to support a variety of functions, with freeway agencies doing so two to four times as often as arterial agencies. The most often cited use for freeway agencies is operations planning and analysis followed by work zone planning and analysis, and capital planning, all reported by half or more of the freeway agencies. Arterial agencies also cite operations planning and analysis most often, followed by use for real-time operations, and capital planning and analysis.

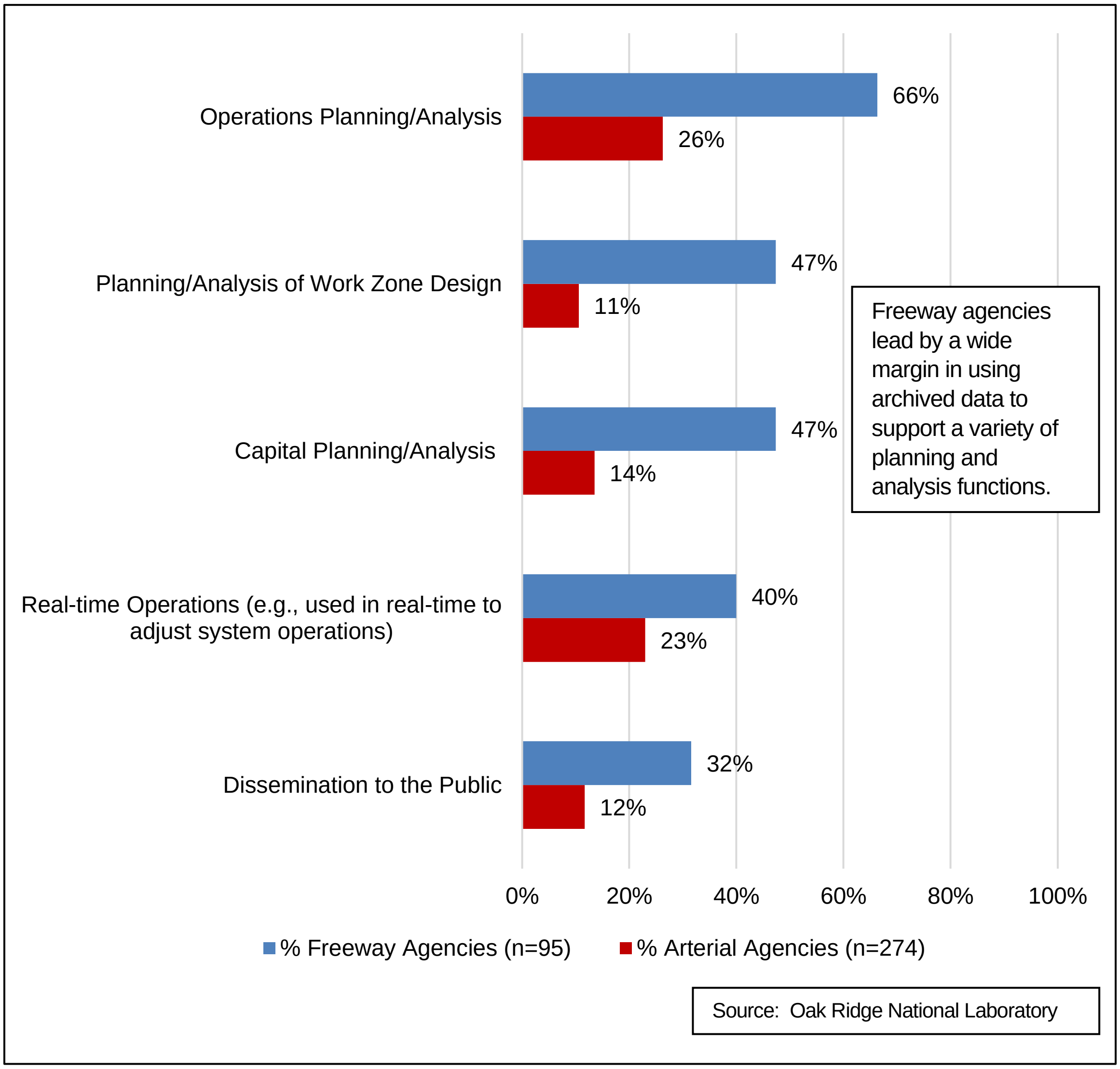


Figure 3-16. Uses for Archived Data by Freeway and Arterial Agencies

Safety, Enforcement, and Work Zone Systems

Transportation agencies use ITS technologies, in some cases quite advanced, to make travel through and around work zones safer and more efficient. Outside work zones, ITS technology is used to detect a variety of hazards and provide warnings to travelers.

Work Zone Safety Systems

Figure 3-17 shows that freeway and arterial agencies are using technology to improve safety at work zones and that freeway agencies lead in doing so by a wide margin. The use of portable CCTV, travel time systems, and queue detection are most often reported, with deployment of portable traffic monitoring devices, variable speed limits, dynamic lane merge, and route guidance around work zones also widely reported, but less frequently.

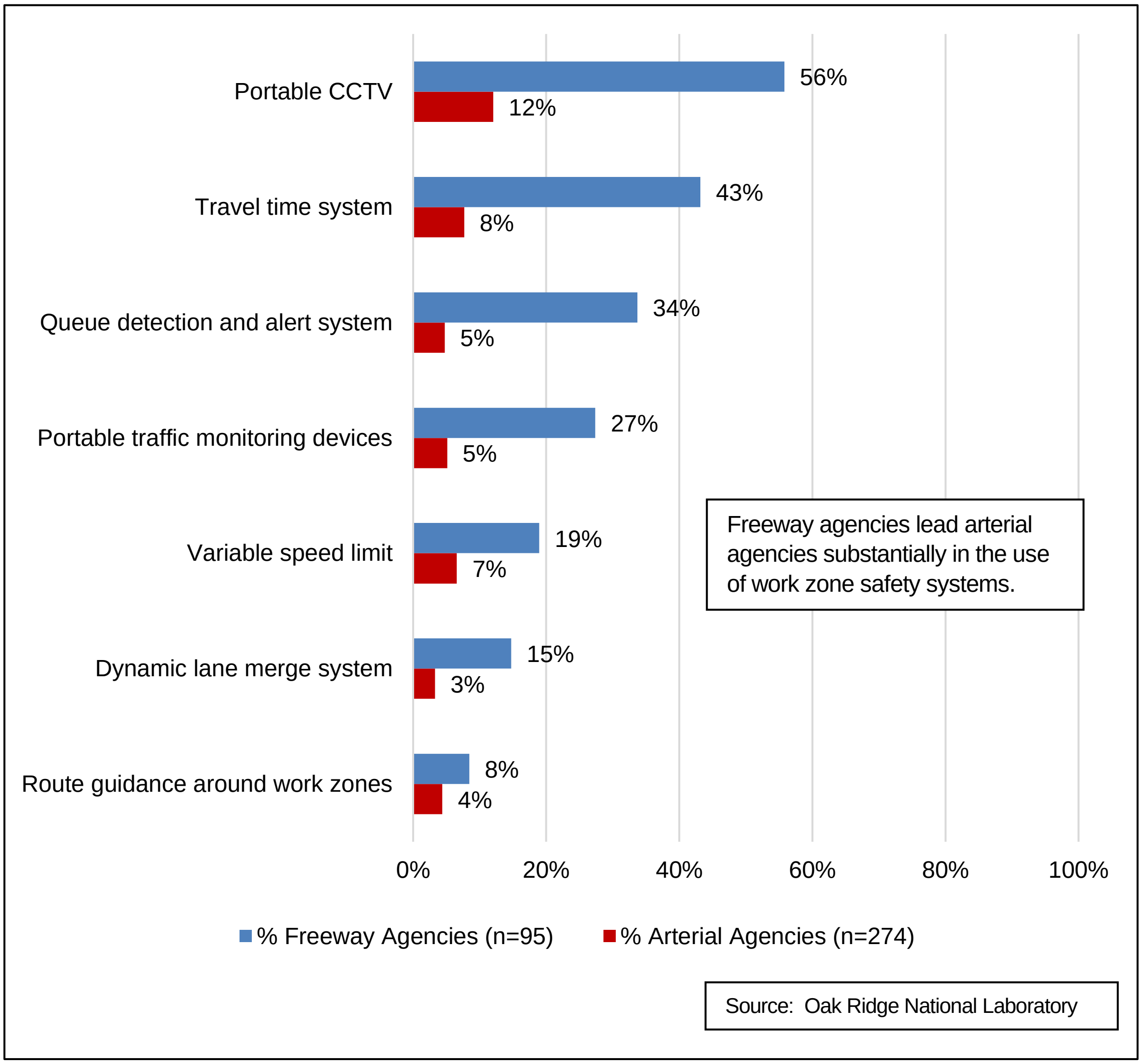


Figure 3-17. Technologies Deployed at Work Zones by Freeways and Arterial Agencies

Surveillance at Transit Facilities

Transit agencies enhance safety through the use of audio or video surveillance at facilities. Figure 3-18 shows that surveillance of bus stations and multi-modal stations or transfer centers is reported most frequently, with surveillance at rail stations, bus stops, and ferry boat landings reported about half as often.

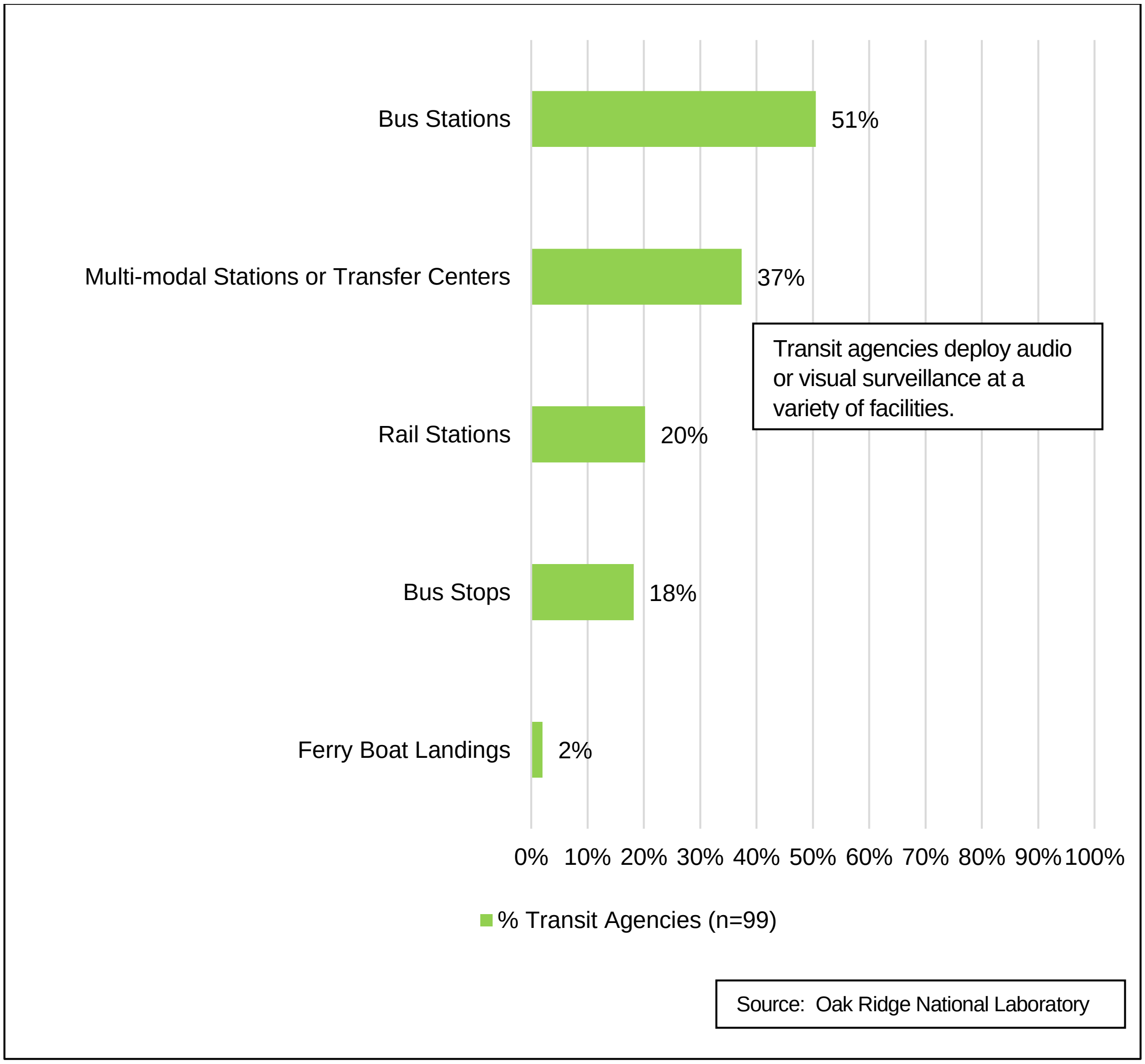


Figure 3-18. Deployment of Surveillance Systems at Transit Facilities

Transit Vehicle Surveillance

Transit agencies deploy audio/visual surveillance systems extensively on vehicles. Figure 3-19 shows that the use of in-vehicle surveillance is most often reported for fixed route buses and light rail, followed by paratransit and light rail about two thirds as often. Surveillance is also reported on demand responsive vehicles but significantly less frequently.

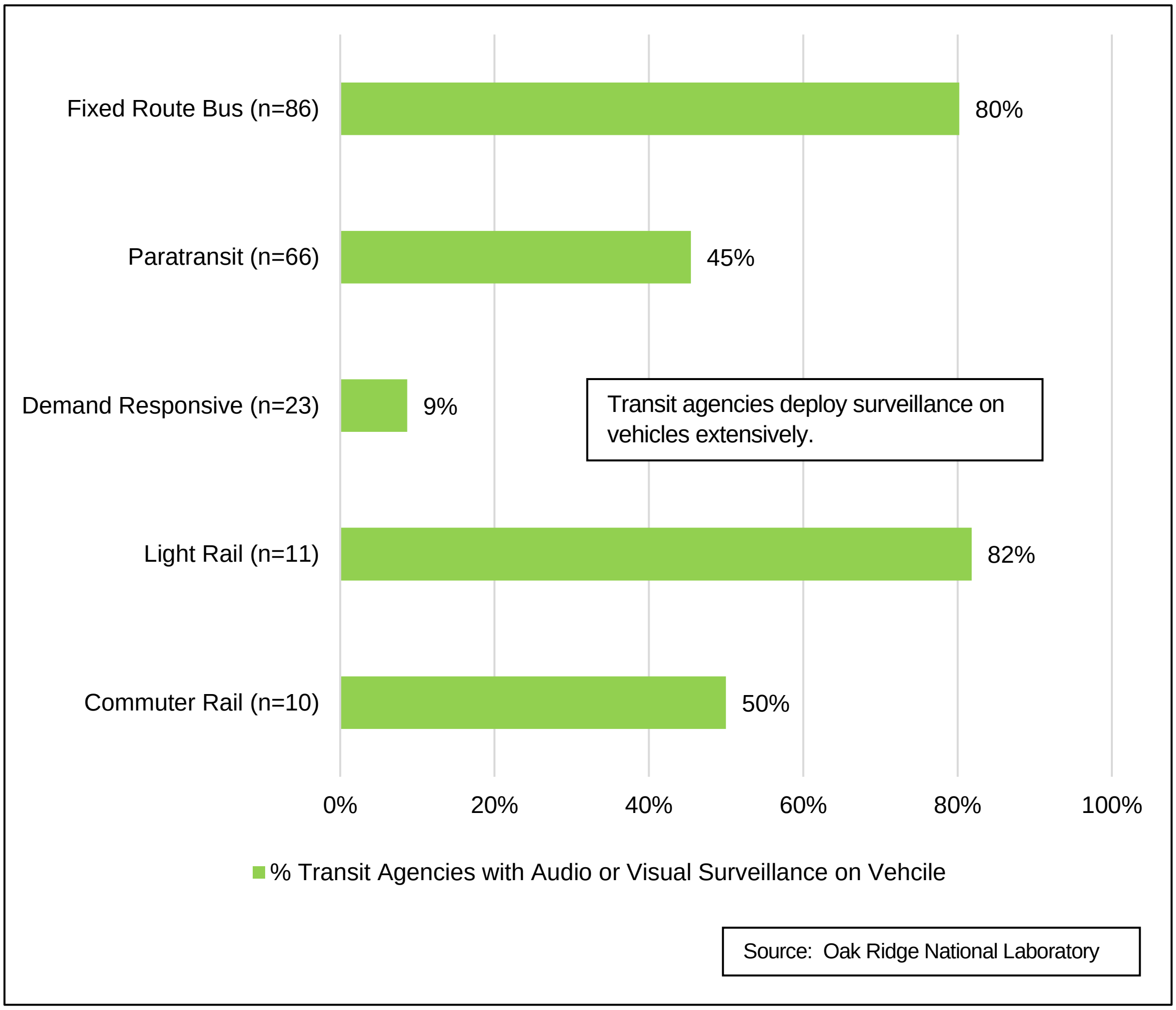


Figure 3-19. Transit Vehicles Equipped with Audio/Video Surveillance to Enhance Security

Freeway and Arterial Safety Systems

Freeway and arterial agencies deploy a variety of sophisticated safety systems that typically employ multiple components to detect and assess threats and provide warnings as shown in Figure 3-20. Over height warning and queue warning systems are most often reported, both deployed by just under 40% of freeway agencies and nearly 10% of arterial agencies. Use of a dynamic curve warning system and variable speed limits is reported by a quarter of freeway and a tenth of arterial agencies. Speed harmonization systems are also in use by both agencies, but less frequently.

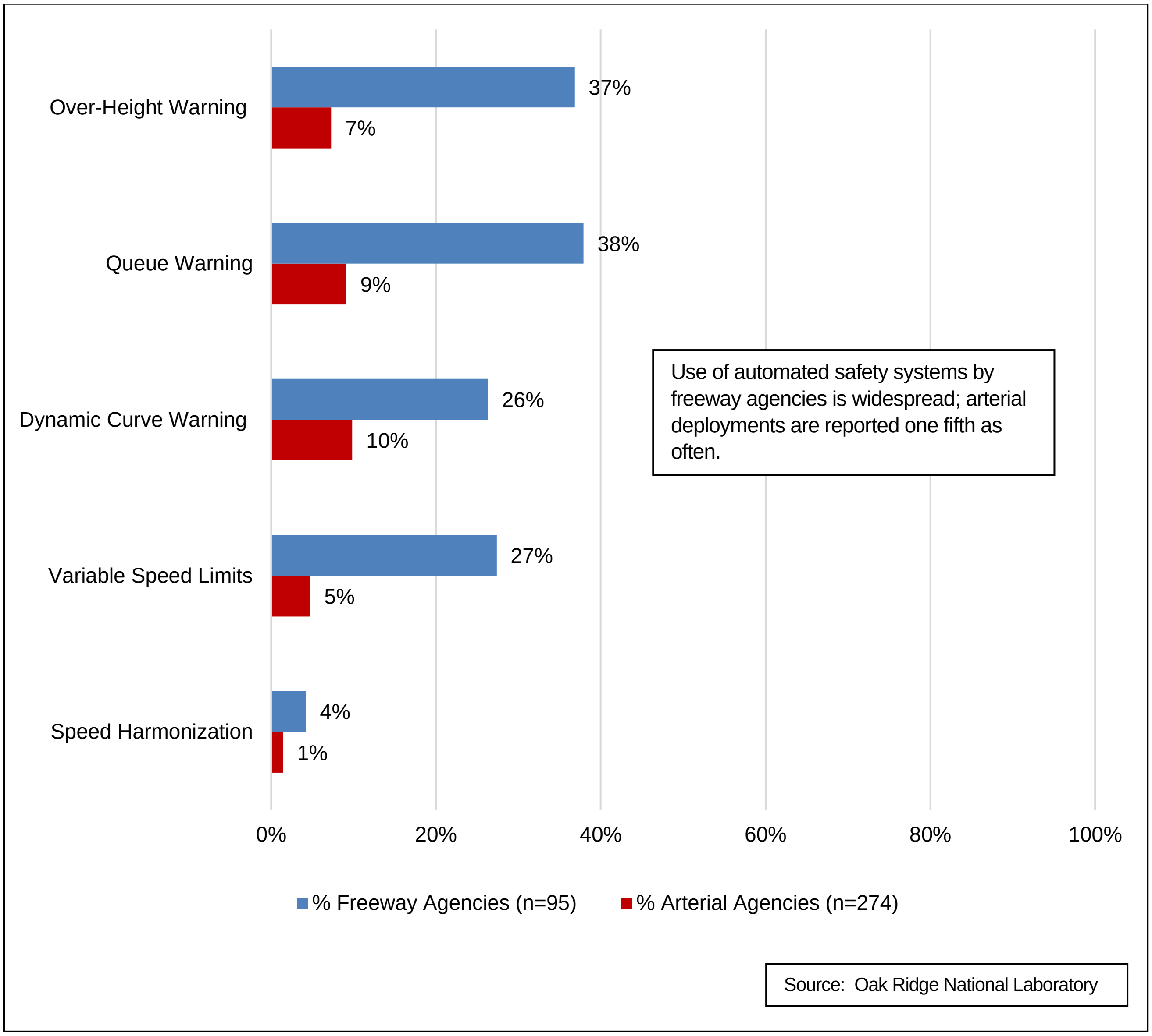


Figure 3-20. Deployment of Safety Systems by Freeway and Arterial Agencies

Automated Enforcement Technologies

Automated enforcement systems are similar to safety systems in that they rely on the integration of multiple systems to detect violations and identify the violators. These systems are in use by both freeway and arterial agencies and are in their initial stage of deployment. As shown in Figure 3-21, these systems most often rely on cameras, license plate recognition and toll tag readers to detect and identify violators, with the use of cameras reported most often by a wide margin.

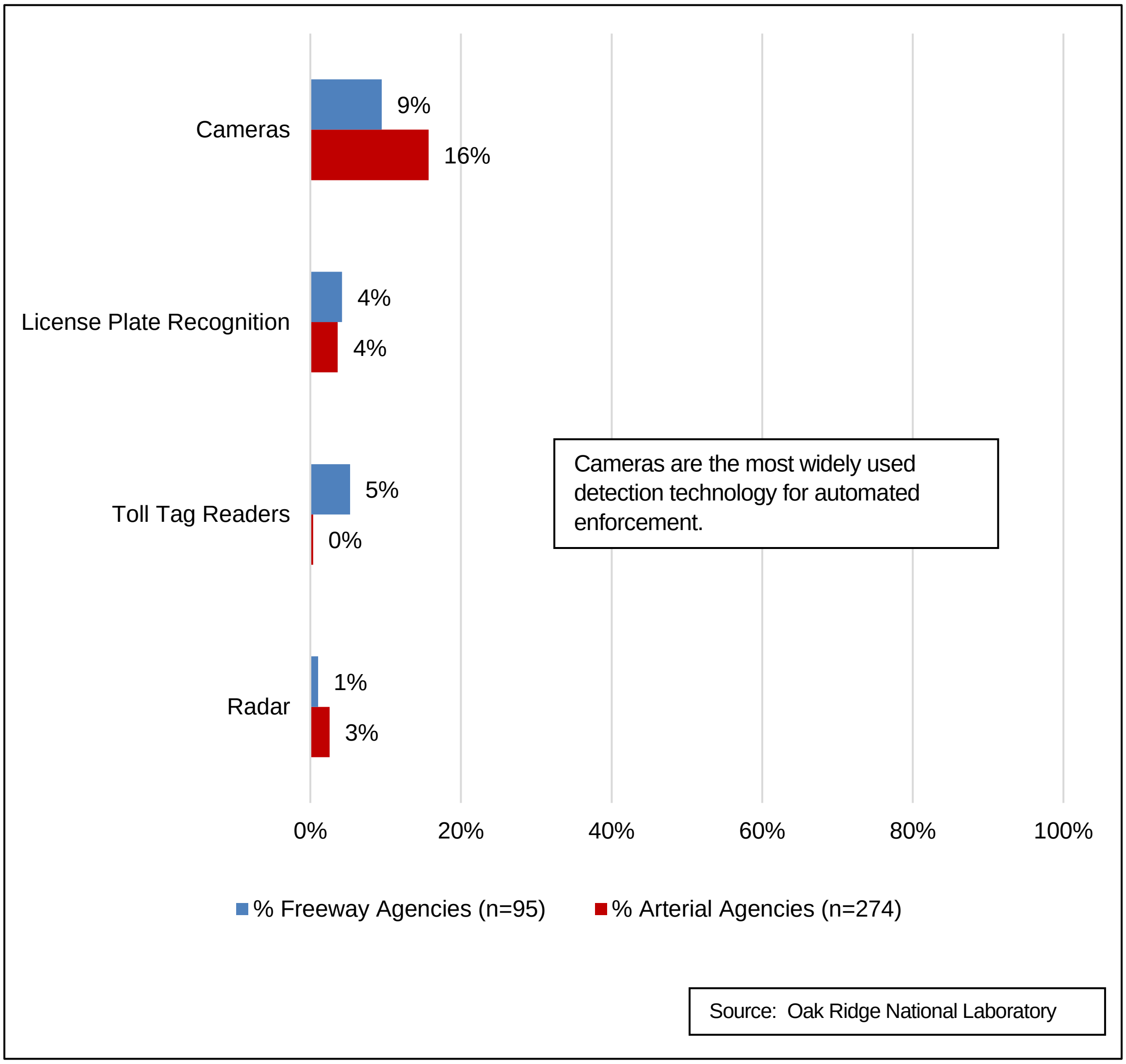


Figure 3-21. Use of Automated Enforcement Technologies by Freeway and Arterial Agencies

Freeway and Arterial Automated Enforcement Targets

Table 3-1 shows that the primary targets for automated enforcement on freeways are toll booth and speed enforcement with HOT lanes, truck lanes and HOV lanes also covered, although lightly so far. The use of automated enforcement by arterial agencies is generally more widespread than by freeway agencies, particularly for enforcing red light running.

Table 3-1 Types of Automated Enforcement Reported by Freeway and Arterial Agencies

Freeway Agencies (N=99)			Arterial Agencies (n=270)	
Toll Booth	5%		Red Light Running	16%
Speed	3%		Speeding	4%
High Occupancy Toll (HOT)	1%		School Zone	3%
Truck Lane	1%			
High Occupancy Vehicle (HOV)	1%			

Road Weather Systems

Transportation agencies frequently display a sophisticated capability to gather and employ weather information. They gather weather information from commercial and government providers as well as field sensors. They employ technology to detect hazardous conditions and provide warnings, as well as decision support systems to manage winter maintenance.

Weather Data Sources

Transportation agencies use a variety of sources for weather data. Figure 3-22 shows that by far the most frequently reported source of weather information by both freeway and arterial agencies is the National Weather Service. Freeway agencies also employ field sensors frequently while arterial agencies do so about one third as often. Both agency types also use private providers and agency field personnel as important sources. Other sources are used, but lightly by comparison.

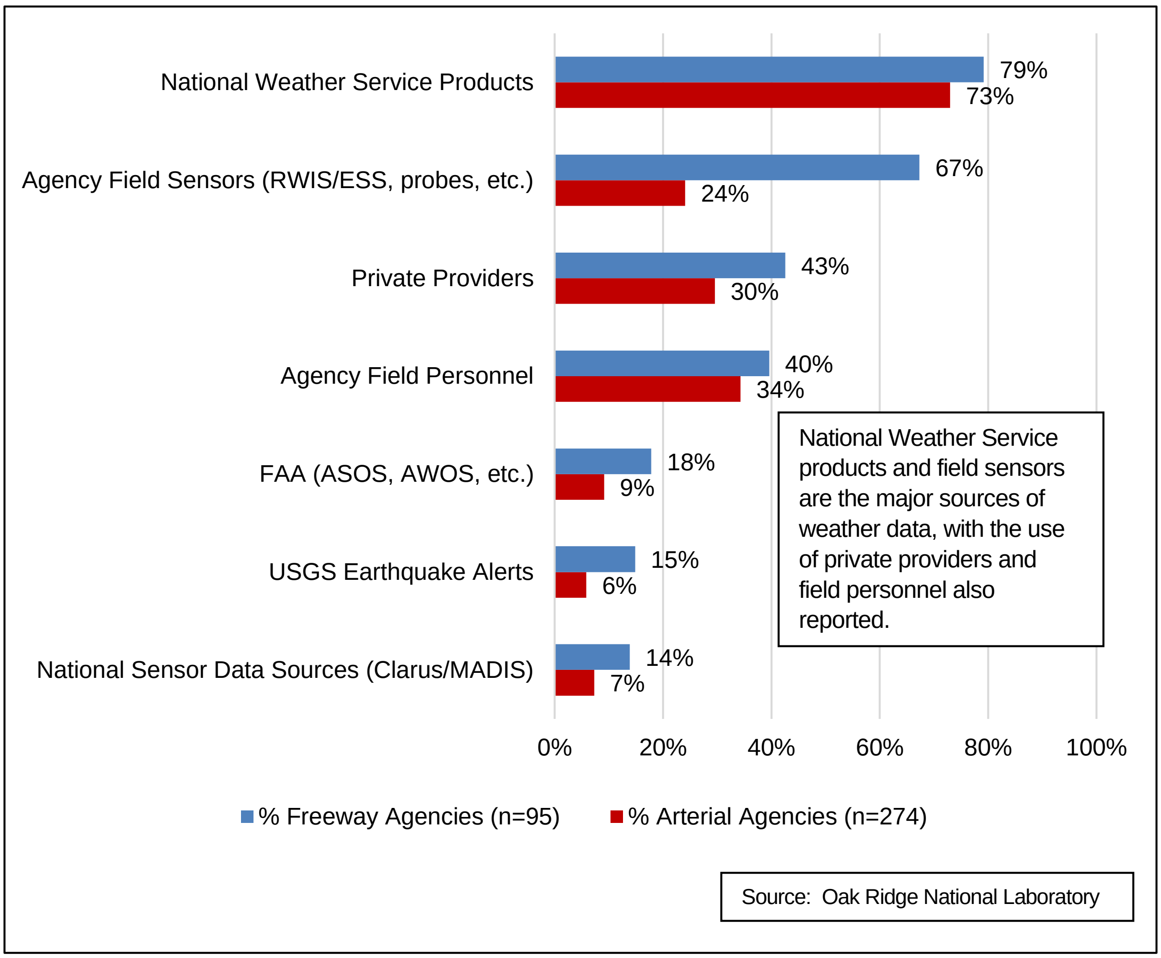


Figure 3-22. Sources of Road Weather Information for Freeway and Arterial Agencies

Types of Weather Technologies Deployed

Figure 3-23 shows the extent of adoption of various weather related technologies. About two thirds of freeway agencies and a fifth of arterial agencies have deployed Environmental Sensor Stations (ESS) and safety warning systems. The use of a Maintenance Decision Support System for winter maintenance is reported mainly by freeway agencies.

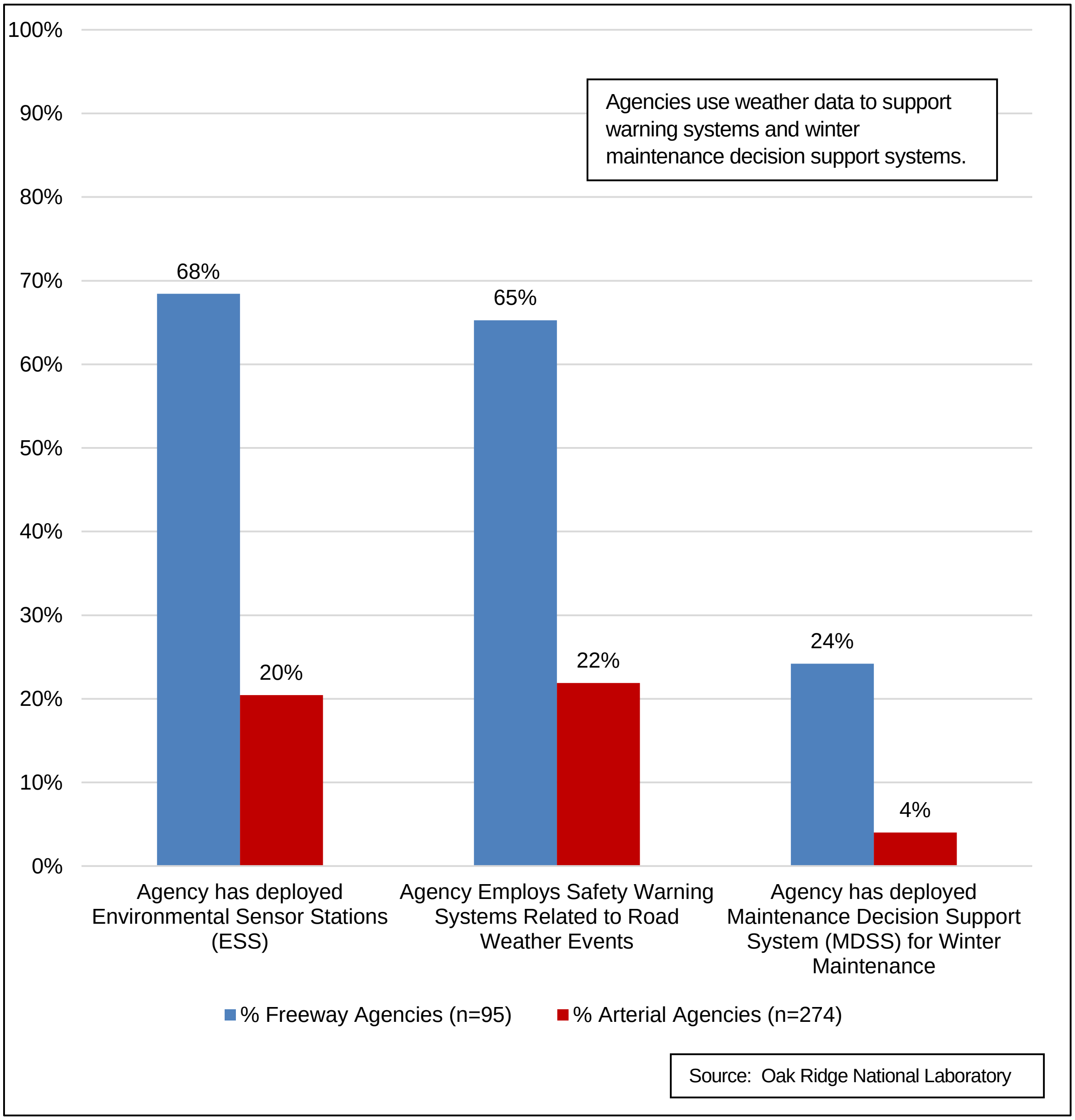


Figure 3-23. Deployment of Weather Technologies by Freeway and Arterial Agencies

Weather Hazards Warning

Figure 3-24 shows the particular hazards covered by road weather safety warning systems for freeway and arterial agencies. The three hazards most commonly covered are icy pavement, high winds, and fog, all reported by about half of freeway agencies and less often by arterial agencies.

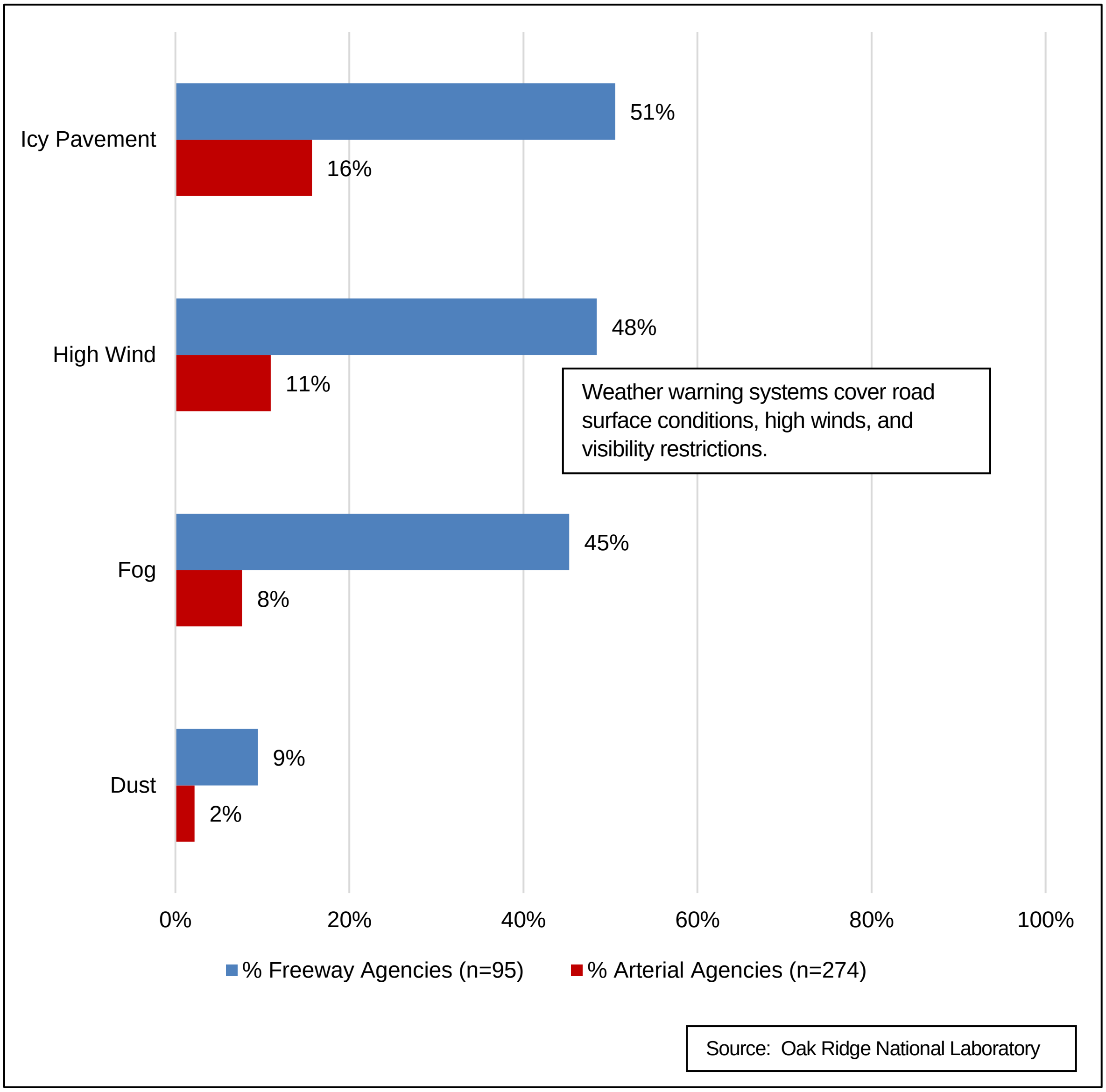


Figure 3-24. Hazards Covered by Weather Safety Warning Systems for Freeway and Arterial Agencies

Integrated Corridor Management

Integrated Corridor Management (ICM) is a concept defined by close interagency coordination along a defined corridor made possible by the use of ITS technology. With ICM, the different transportation agencies manage the transportation corridor as a single system.

Number of Corridors

Figure 3-25 shows the number of corridors reported by agencies that participate in an integrated corridor. Most commonly, agencies are part of only a single corridor; however, a substantial number of agencies are part of multiple corridors.

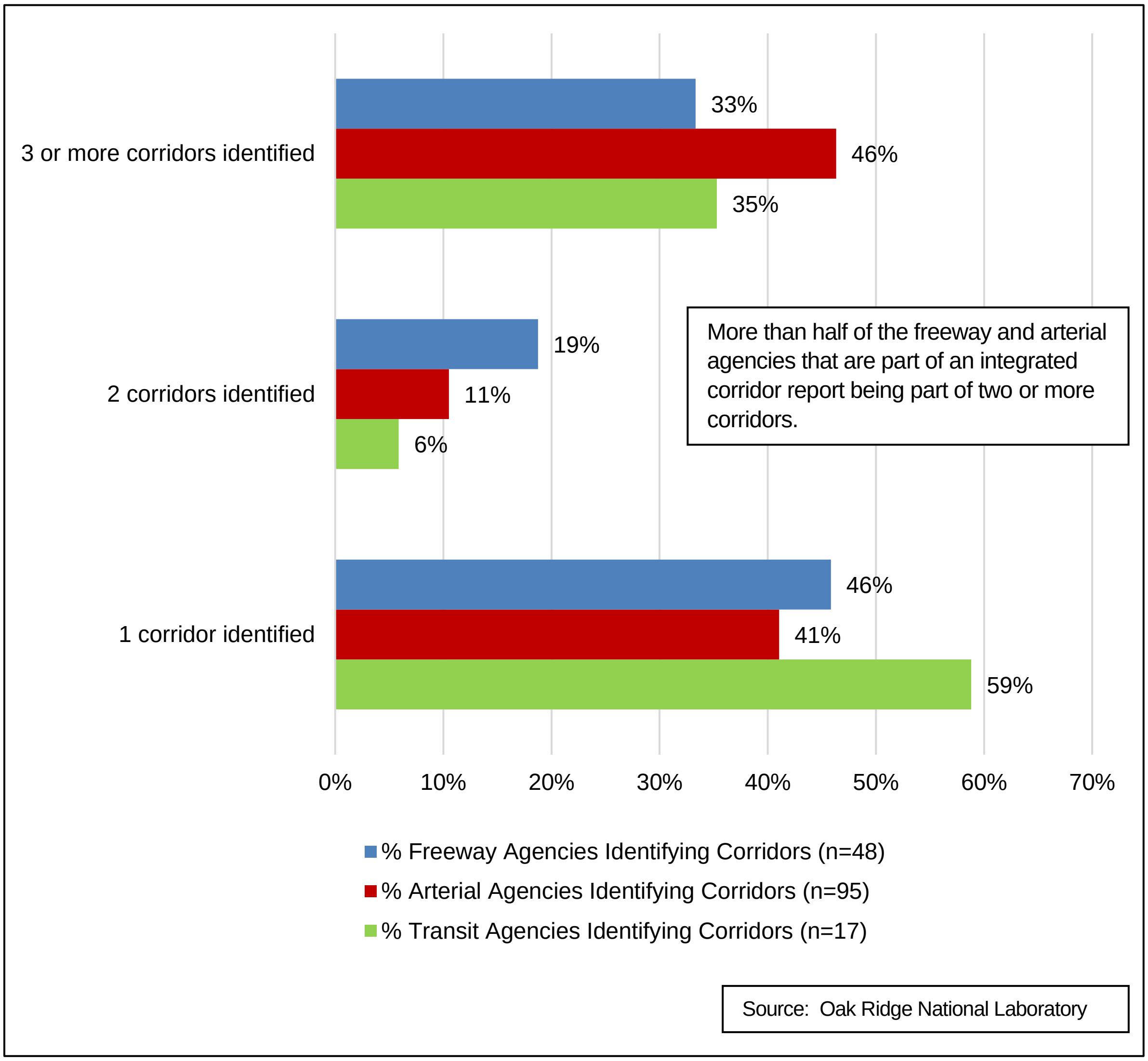


Figure 3-25. Number of Integrated Corridors Identified

Formality of Interagency Coordination

A critical factor for the ICM concept to succeed is the level of coordination between participating agencies. Figure 3-26 shows that the current level of coordination between freeway, arterial, and transit agencies falls short of the tightly integrated team that is the ultimate goal for integrated corridors. The majority of agencies report either ad hoc coordination without regular meetings, or informal working groups that meet regularly. Just under half of freeway, 17% of arterial, and 12% of transit agencies report being part of a formally established working group overseeing corridor management. An even smaller number of agencies are part of a fully realized integrated corridor that is a legal entity with dedicated resources and a governing board.

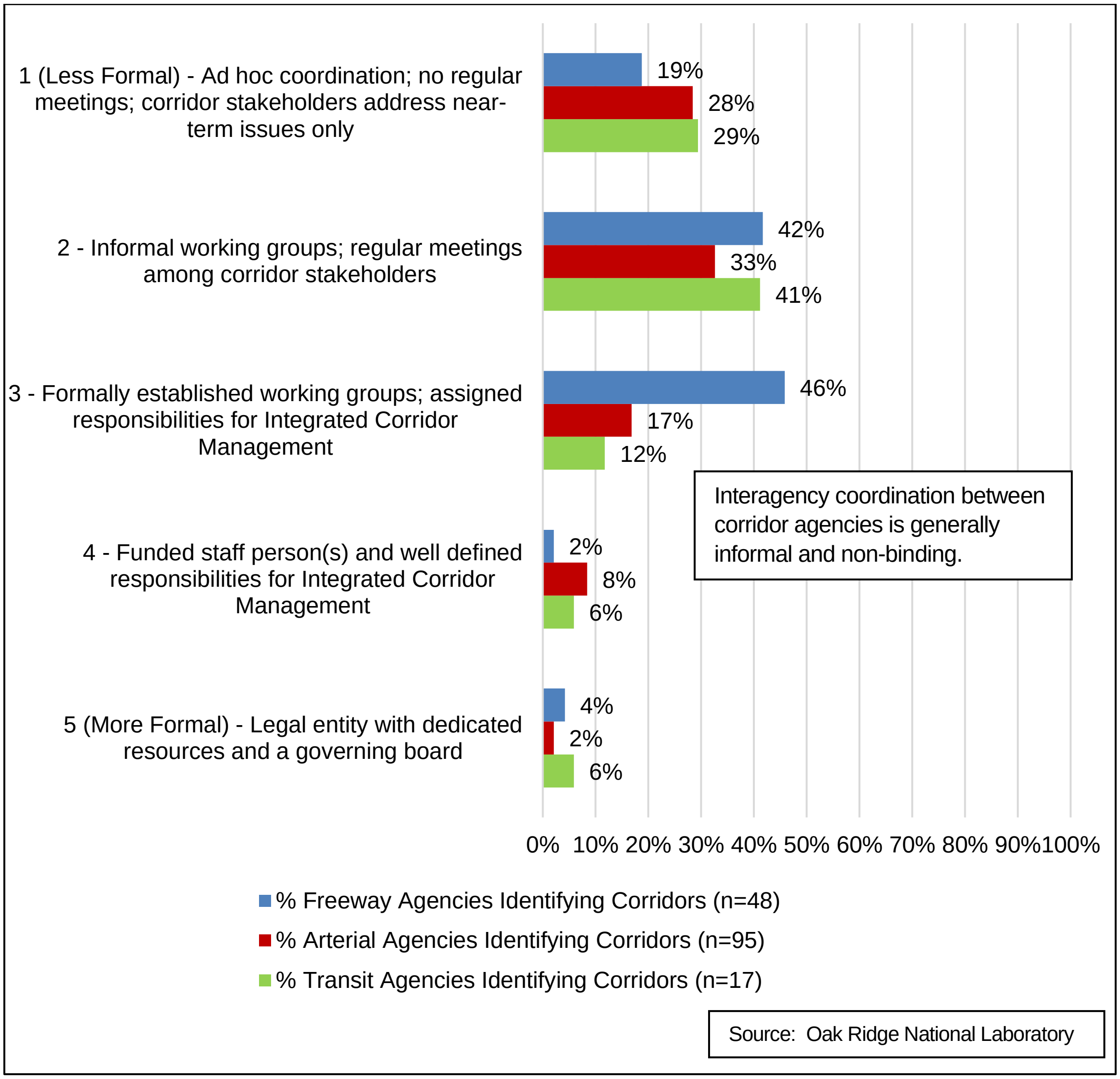


Figure 3-26. Formality of Coordination within Corridors

Development of an ICM Concept of Operations

In spite of the relatively informal interagency coordination shown above, agencies involved with corridors have made good progress in developing documentation in the form of a concept of operations (ConOps) which includes shared operating objectives. Figure 3-27 shows that completing a ConOps is clearly an important priority: it has been developed, is under development, or is planned by 77% of freeway agencies, 49% of arterial agencies, and 53% of transit agencies operating in an integrated corridor. Some agencies report working on additional documents defining the governance of a corridor.

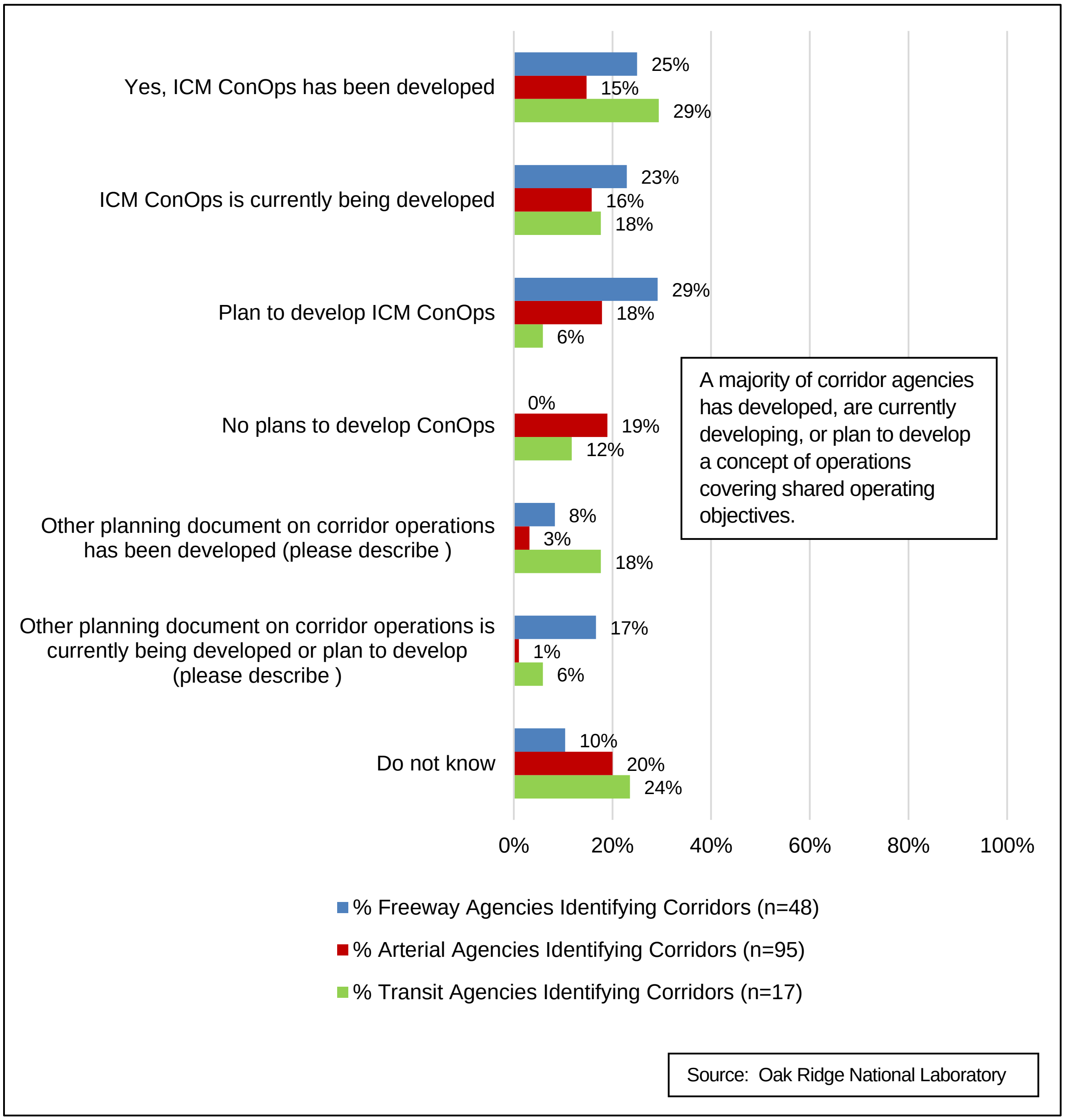


Figure 3-27. Corridor Planning Documents Status

Development of ICM Response Plans

The agencies involved with integrated corridors are making progress in developing a documented set of response plans or strategies designed to optimize performance in the corridor as a whole. Figure 3-28 shows that the majority of corridor agencies have developed, are developing, or plan to develop response plans or strategies, with only a small number of agencies as yet having no plans to do so.

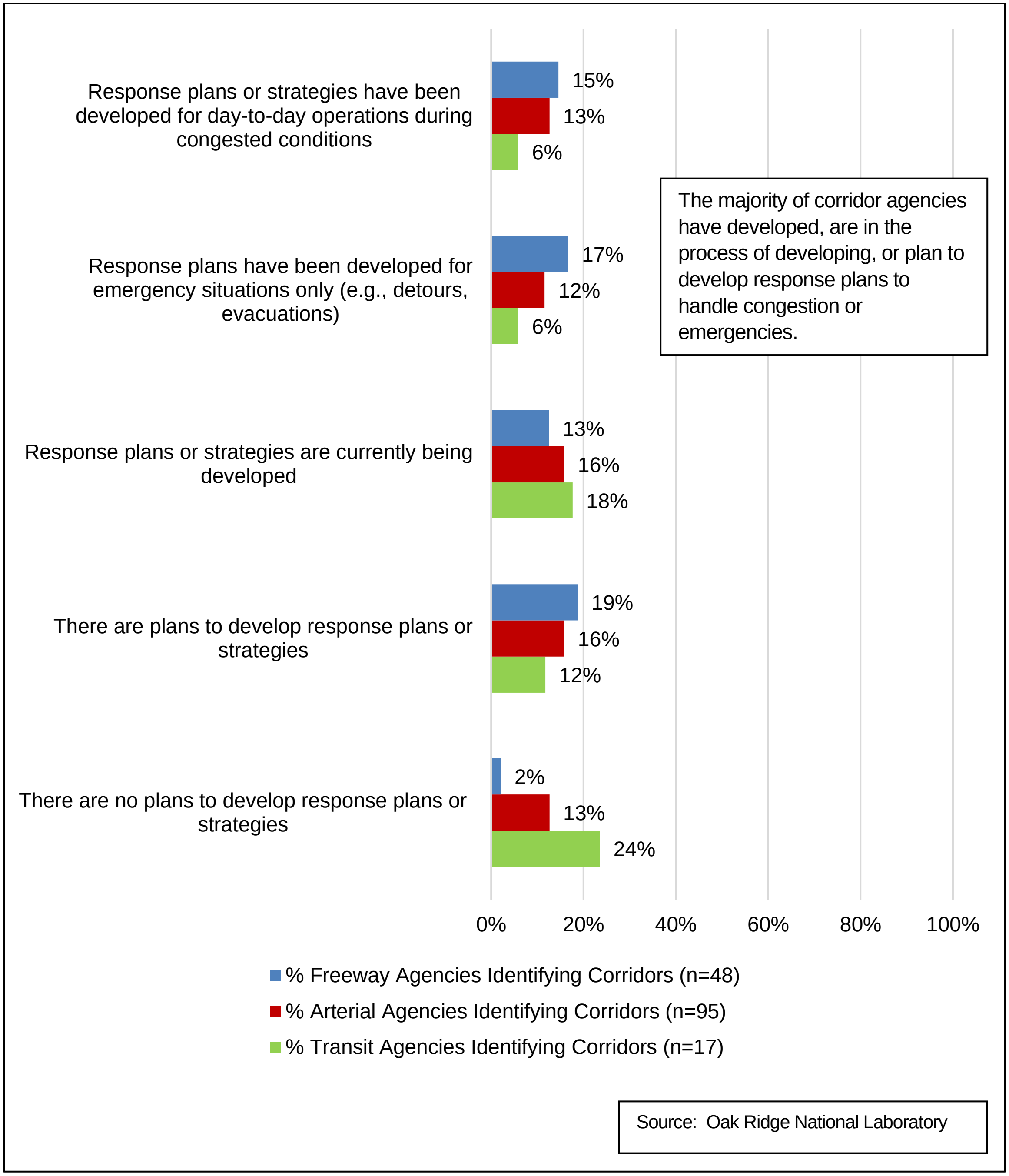


Figure 3-28. Corridor Response Planning

ICM Performance Measures

A critical step for integrated corridor management is the adoption of performance measures that are corridor level and multimodal by the participating agencies. Figure 3-29 shows that about half of the agencies involved with corridors have identified corridor level/multimodal performance measures or have plans to do so.

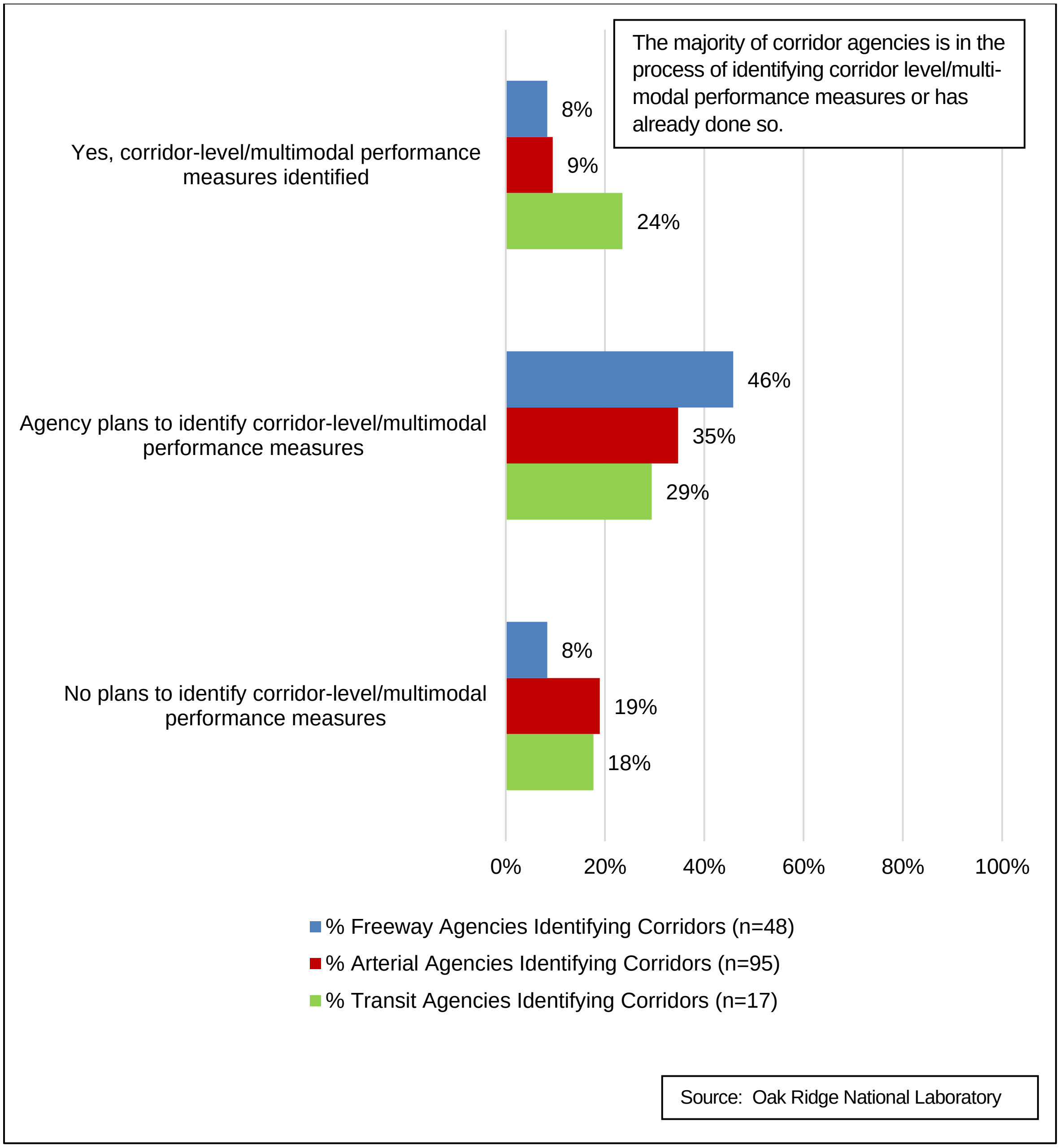


Figure 3-29. Use of Corridor Level/Multimodal Performance Measures

ICM Interagency Data Sharing

Real-time data sharing between transportation agencies is critical to ICM operations. Figure 3-30 shows that transportation agencies that share data with one another do so using methods of varying sophistication. At the top is the use of an information clearing house or information exchange network in which data from multiple sources is aggregated and made available to all agencies. At the bottom of sophistication is manual sharing of data in response to a request, reported by the largest percentage of agencies. In between are instances of automated sharing of video and data from one agency direct to another. Only a small percentage of agencies report the use of an Information Clearing House for data transfer.

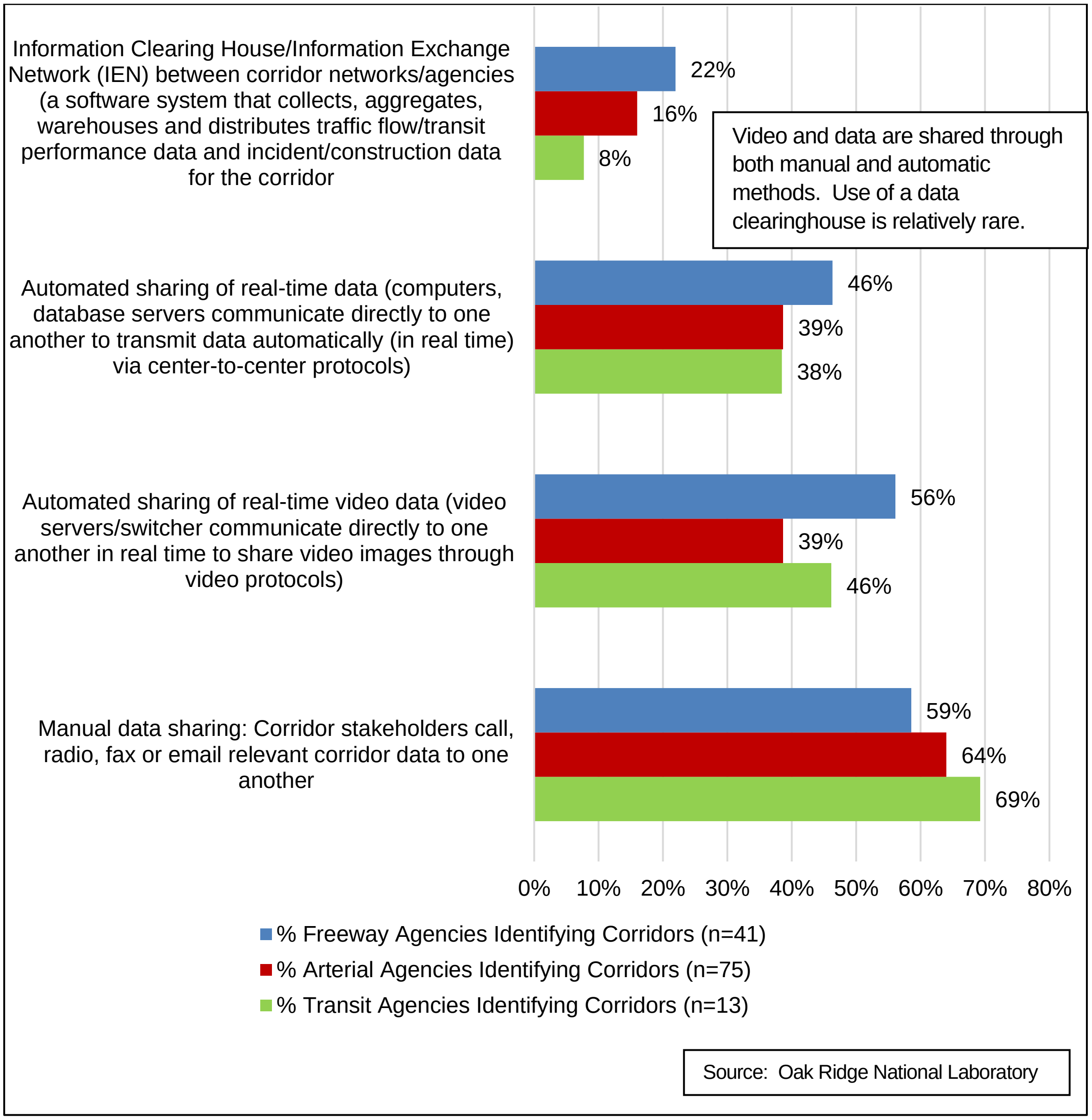


Figure 3-30. Types of Interagency Data Sharing

Joint Planning for Operations

Interagency coordination outside integrated corridors is carried out through planning for operations. Planning for operations is a joint effort between operations and planning that encompasses the important institutional underpinnings needed for effective regional transportation operations collaboration and coordination.

Commitment to Regional Coordination

Figure 3-31 shows the existence of a significant commitment to joint planning for operations by freeway and arterial agencies operating outside an integrated corridor. Being part of a regional ITS architecture was reported by 93% of freeway and 61% of arterial agencies. A related measure of commitment is the extent that agencies participate in a regional concept for transportation operations, which was also widely reported.

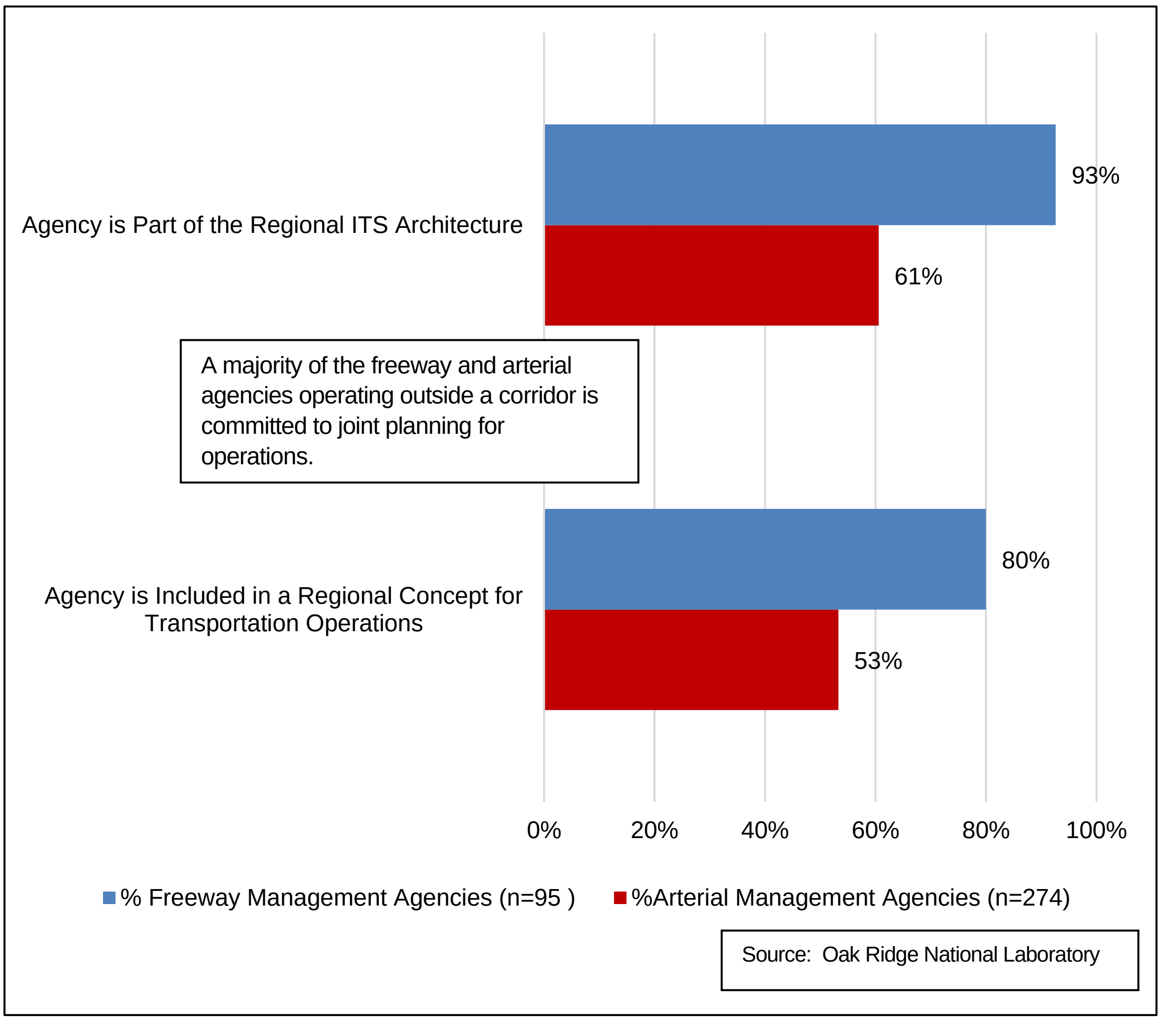


Figure 3-31. Planning for Operations by Freeway and Arterial Agencies

Formality of Regional Coordination

Participation in regional coordination activities is becoming common as shown in Figure 3-32. A majority of freeway agencies and more than a quarter of arterial agencies participate in regular meetings with other agencies to coordinate planning and operations. Participation in interagency agreements to integrate operations and to share data is reported about a third as often. Commitment to regional coordination activities is not universal, with 28% of freeway agencies and 40% of arterial agencies reporting no participation in interagency meetings to coordinate planning and operations.

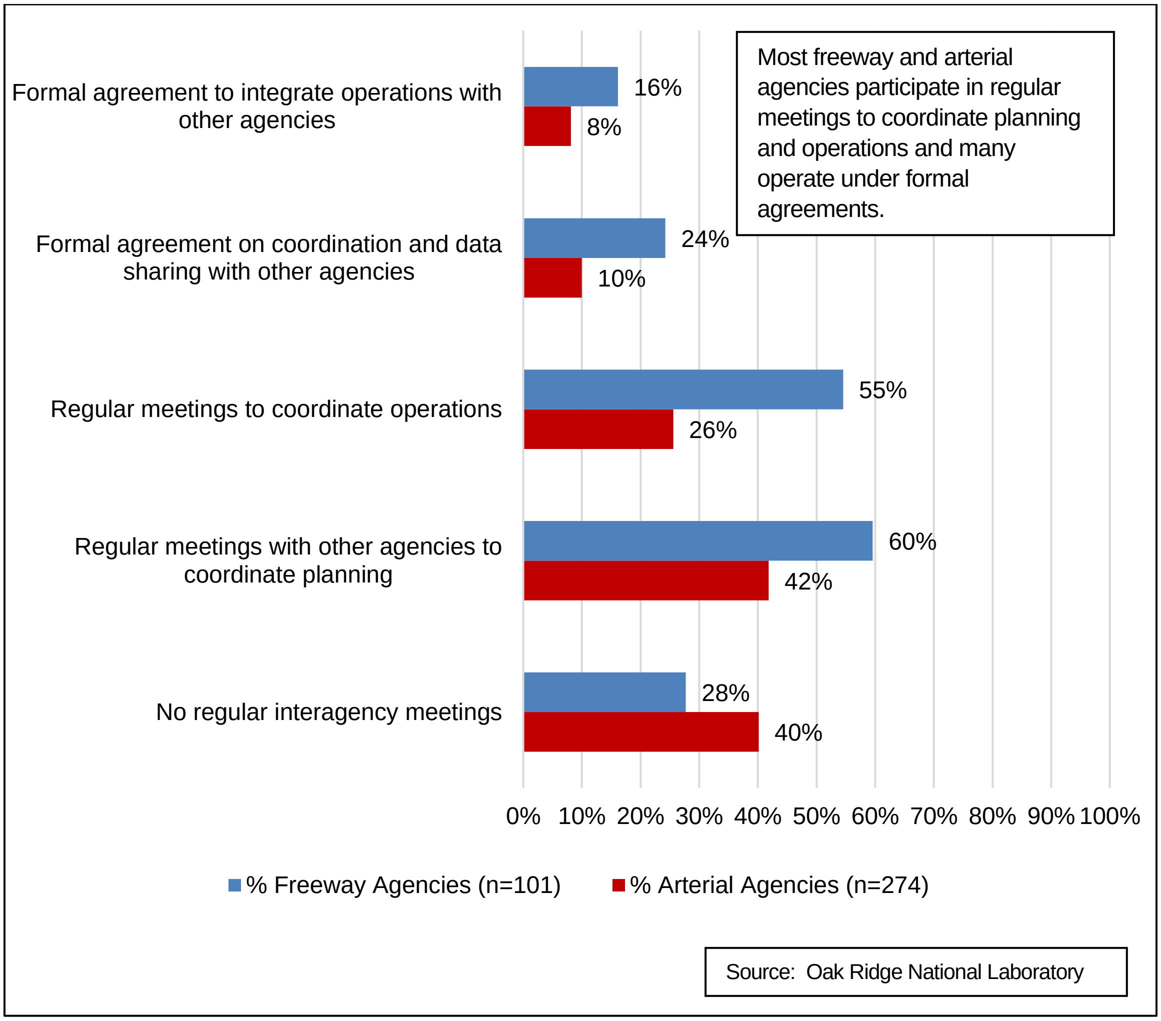


Figure 3-32. Agency Participation in Regional Coordination Activities

Coordination of Traffic Signal Operations

Figure 3-33 shows the use of documented plans for coordinated management and operation of traffic signals by arterial agencies. Just over half of the arterial agencies report employing a documented plan including objectives and performance measures to guide management, operation, and maintenance of traffic signals. Arterial agencies also participate in regional programs coordinating signal timing across jurisdictional boundaries frequently. In addition, a quarter of arterial agencies have deployed traffic adaptive signal control to improve coordinated signal timing.

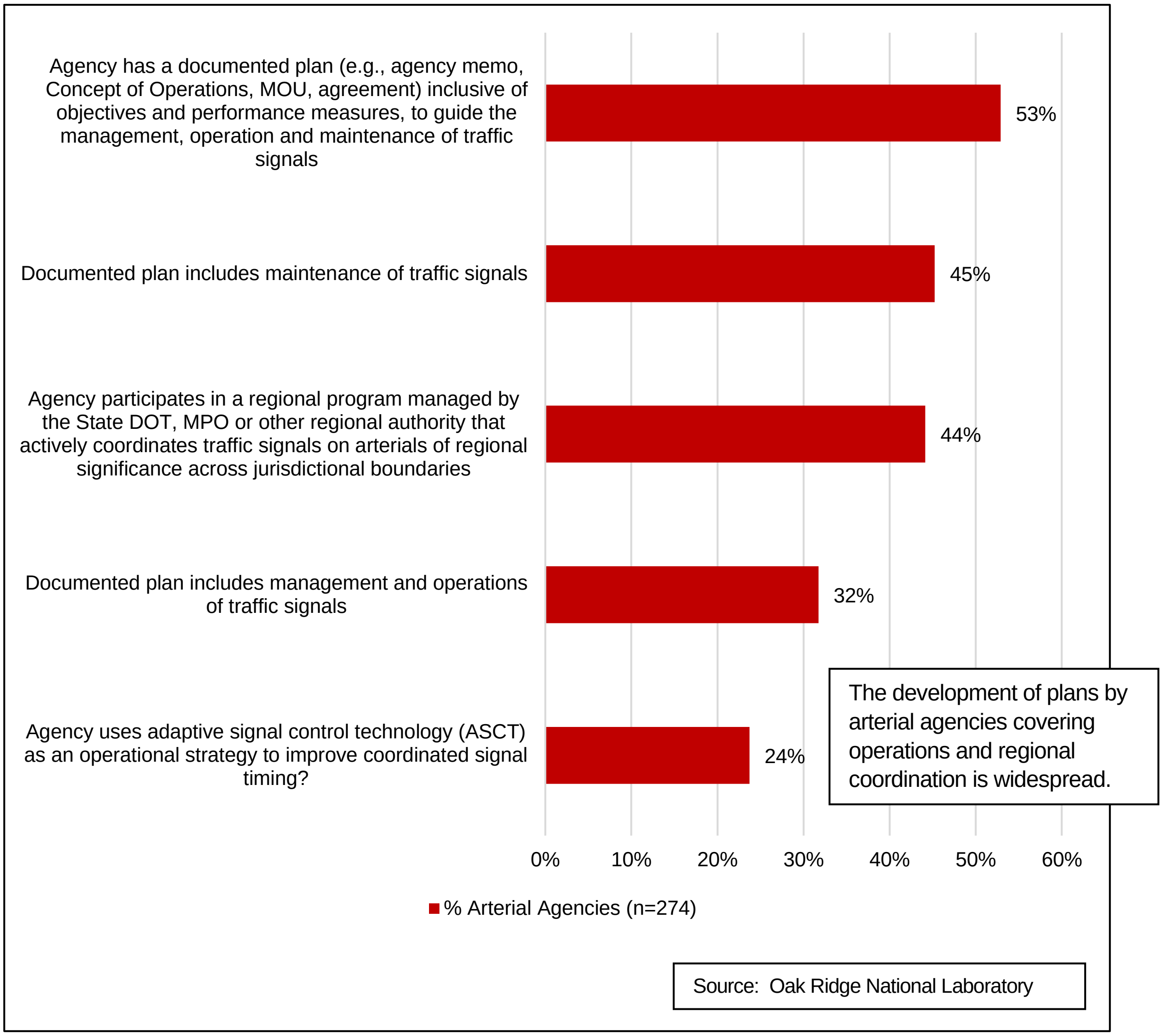


Figure 3-33. Coordination and Management of Traffic Signal Operations

Open Data Policy

The U.S. Department of Transportation (DOT) has implemented several initiatives to make the government more open to the public, including a formal Open Data Policy. Figure 3-34 shows that the Open Data Policy has been implemented or is in in the process of being implemented by three quarters of freeway and transit agencies; however, only a third of arterial agencies have done so. Nearly two thirds of arterial agencies report having no current plans for an open data policy, far more often than transit or freeway agencies.

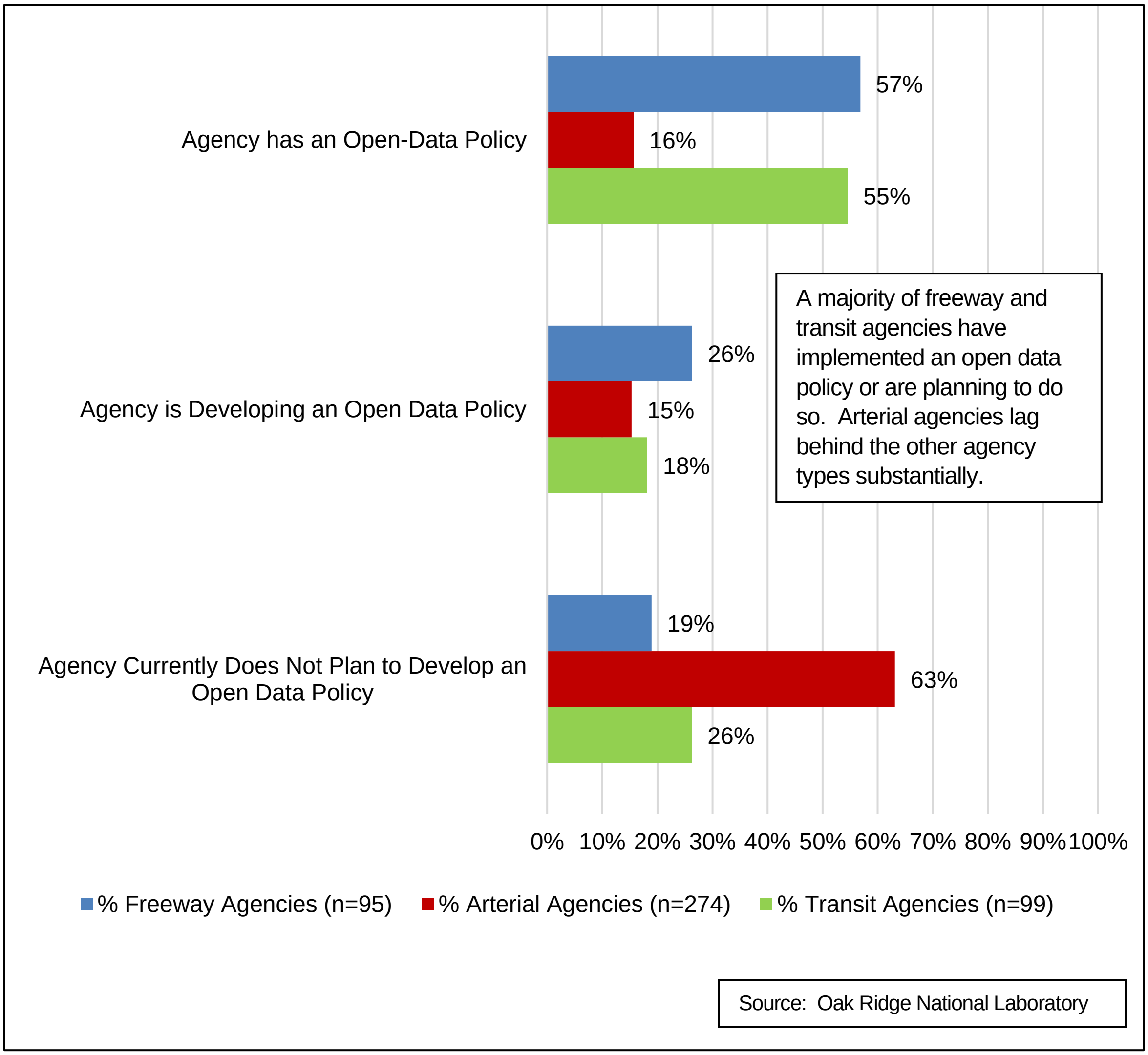


Figure 3-34. Status of Agency Open Data Policy

Maintenance of ITS Technology

ITS technologies are complex, integrated amalgamations of hardware, technologies, and processes for performing an array of functions, including data acquisition, command and control, computing, and communications. System maintenance refers to a series of methodical, ongoing activities designed to minimize the occurrence of systemic failures and to mitigate their impacts when failures do occur.

Assessment of Maintenance Status

Figure 3-35 shows how freeway and arterial agencies collect information on the maintenance status of field devices. The two primary methods for freeway agencies are real-time monitoring and complaint calls to identify maintenance issues needing attention; with inspections a less frequently used method. Arterial agencies employ all three methods equally.

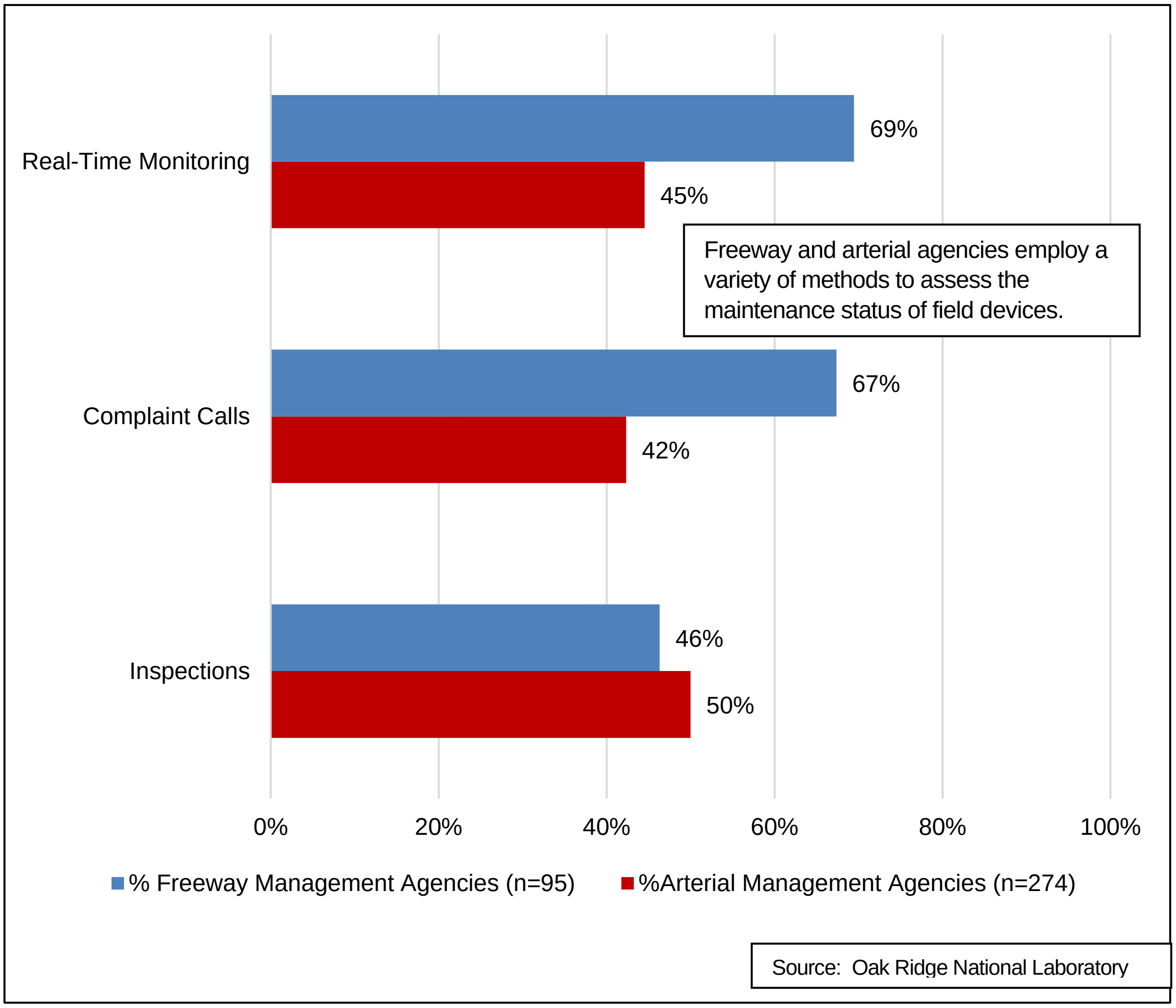


Figure 3-35. Sources of Data on the Overall Health of ITS Devices

Maintenance Decision Factors

Figure 3-36 shows how freeway agencies decide whether to do maintenance on ITS devices or to replace the unit. Maintenance decisions are primarily dictated by a planned program of preventive maintenance, inspection, or reaction to failure. Replacement decisions are primarily based on reaction to failure or obsolescence.

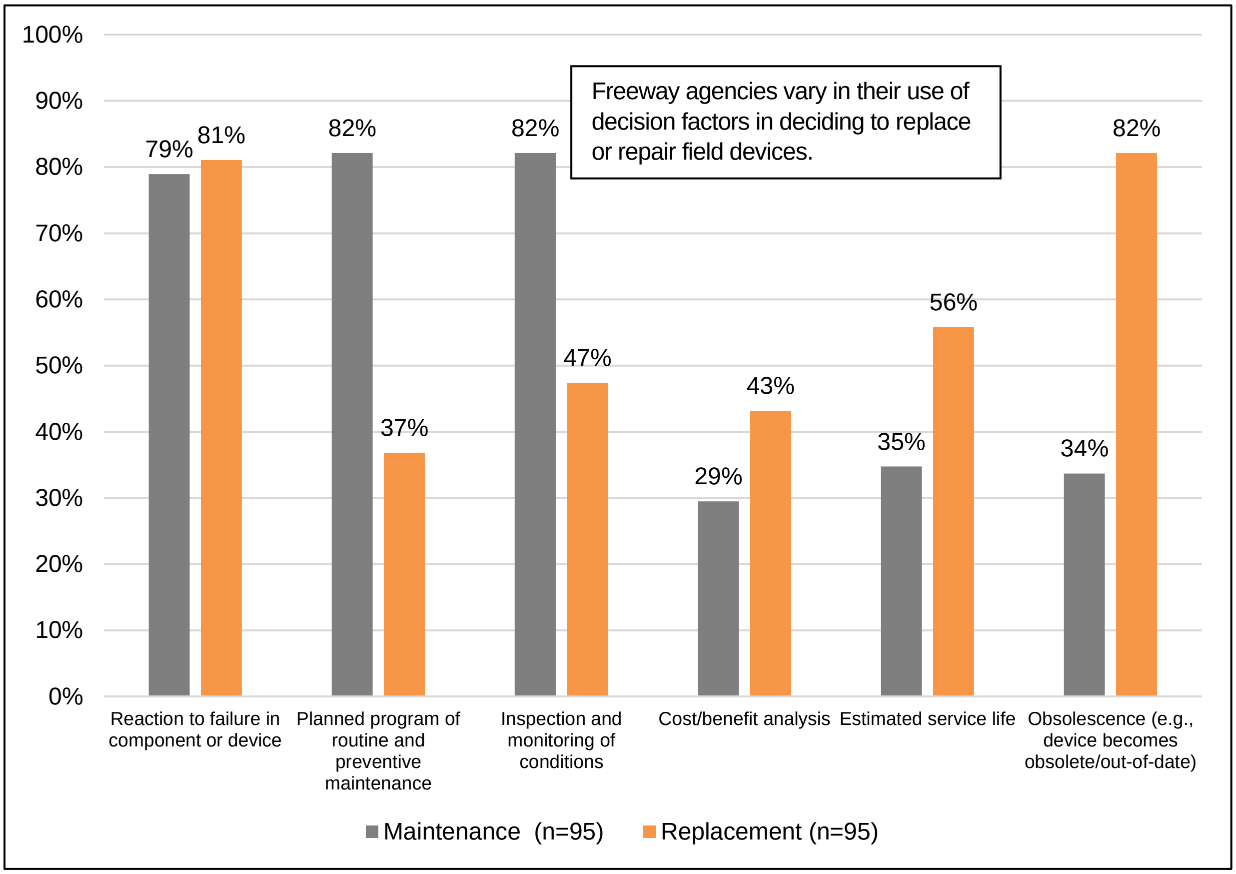


Figure 3-36. Factors used to Decide to Maintain or Replace Freeway ITS Devices

Chapter 4 Summary Findings

Summary Findings

- Interest in CV technology has advanced very rapidly, although unevenly, with freeway agencies planning CV deployments more than twice as often as arterial or transit agencies.
- The focus of planned CV deployments is safety and mobility applications: Freeway agencies most often plan to deploy advanced traveler information, road weather, work zone warning, and incident and emergency management. Top four CV applications for arterial agencies are intelligent traffic signal systems, advanced traveler information, incident and emergency management, and pedestrian and bicycle warning systems. Transit agencies most often plan to employ CV systems to support signal priority, fee payments, advanced traveler information, and pedestrian warning systems. As yet, there is little emphasis on Eco (environmental) applications.
- Planned timing for CV deployments covers a wide range. Most agencies plan to deploy CV in the next three years but a third of the agencies plan to deploy later, in some cases in seven or more years. This may reflect uncertainty reflected in reasons for not deploying or lack of confidence that required assistance will be provided.
- There is no single reason why agencies do not plan to deploy CV in the near term. Agencies not deploying CV were asked about their reasons for this decision. Many issues were raised and a total of six issues were cited by at least a quarter of the agencies. Having other higher priorities, limitations in staffing capability, and cost were most commonly cited, followed closely by institutional issues, technical risks, and unclear benefits. On the other hand, privacy and security concerns were only lightly selected as important factors.
- Agencies not deploying CV require a variety of types of assistance to choose to deploy. The same agencies not deploying CV were asked about specific types of assistance or resources they would need to change their position and decide to deploy CV technology. Funding was most often cited, but also frequently selected were procurement information, cost data, benefit-cost analysis, training, and technical assistance.
- The readiness status of agencies for CV deployment is mixed. A majority of agencies planning to deploy CV have hired a chief technology or chief information officer. Most freeway and arterial agencies have obtained a license for DSRC or are planning to do so. More than half of all agency types in incorporating CV in planning documents and implementing CV interfaces. On the other hand, more than half of the agencies planning to deploy are only slightly familiar or not at all familiar with the Connected Vehicle Reference Implementation Architecture or the Systems Engineering Tool-Intelligent Transportation (SET-IT).
- Data dissemination with social media has become widespread. Four of the top six media used by all three agencies are social media. Twitter, websites, email, and Facebook are very widely used to distribute traveler information.

- Crowdsourced data collection is expanding, particularly for freeway agencies. Sources like Waze, commercial providers, and Google maps traffic are widely used. Arterial agencies employ the same sources but about one fourth as often as freeway agencies.
- ITS technology is being used in a variety of safety and security applications. Systems deployed at work zones include portable CCTV, travel time, queue detection and warning, traffic monitoring, and dynamic lane merge. Transit agencies deploy audio/visual surveillance at bus and rail stations, transfer stations, and bus stops.
- Arterial agencies are rapidly catching up with freeway agencies in the deployment of ITS technology. Just short of 80% of signalized intersections are under surveillance. The use of Bluetooth readers and radar sensors has doubled in three years and nearly a quarter of agencies have adopted traffic adaptive signaling.
- Transit agencies have also made significant progress in the use of technology. The adoption of AVL and electronic fare payment nearly doubled since 2013. In addition, transit agencies have deployed a suite of sophisticated technologies to aid handicapped travelers including audio and visual announcements, audio and Braille fare vending machines, interactive voice systems, and the use of smartphone apps to aid navigation within a station.
- Freeway agencies employing ramp metering get the maximum benefit through the use of sophisticated control strategies. Three fourths of agencies using ramp metering employ dynamic timing based on traffic conditions along a corridor.
- ITS technology has enabled agencies to employ decision support systems for a variety of situations. Both freeway and arterial agencies report the use of decision support systems to manage incidents, road weather, emergencies, maintenance of field devices, and evacuation.
- Agencies operating in an integrated corridor are developing documents governing combined operations. Currently, most agencies involved with integrated corridor management do so informally, with only a small portion reporting being part of a formal or legal organization. However, in spite of the lack of formality, more than 80% of all agencies involved with integrated corridor management have developed a concept of operations, are in the process, or plan to do so. A similarly high percentage of agencies have developed or plan to develop a documented set of response plans and strategies to optimize performance in the corridor as whole. In addition, at least half of the agencies operating in a corridor are developing corridor-level/multimodal performance measures.
- ITS technology has revolutionized the ability of traffic managers to measure performance. More than half of freeway and a quarter of arterial agencies have adopted a performance management approach. These agencies have adopted a suite of performance measures and compare operational data to performance targets in order to diagnose and overcome specific issues impacting quality of service.
- ITS technology supports operations coordination for agencies operating outside an integrated corridor as well. More than half of freeway agencies and a third of arterial agencies report meeting regularly to coordinate planning and operations. Just under half of the arterial agencies also participate in regional coordination programs to coordinate traffic signal timing across jurisdictional boundaries.

List of Acronyms

AVL	Automatic Vehicle Location
CAD	Computer Aided Dispatch
CCTV	Closed Circuit Television
CIO	Chief Information Officer
ConOps	Concept of Operations
CTO	Chief Technology Officer
CV	Connected Vehicle
CVRIA	Connected Vehicle Reference Implementation Architecture
CWS	Curve Speed Warning
DMS	Dynamic Message Signs
DOT	Department of Transportation
DSL	Digital Subscriber Line
DSRC	Dedicated Short Range Communications
EES	Environmental Sensor Stations
FCC	Federal Communication Commission
GPS	Global Positioning System
HAR	Highway Advisory Radio
HOT	High Occupancy Toll
HOV	High Occupancy Vehicle
ICM	Integrated Corridor Management
IDTO	Integrated Dynamic Transit Operations
IEN	Information Exchange Network
ITS	Intelligent Transportation System
PCW	Pedestrian and Bicycle in Crosswalk Warning
RWIS	Road Weather Information Systems
RSWZ	Reduced Speed/Work Zone
SET-IT	System Engineering Tool Intelligent Transportation
TV	Television
VIDS	Video Imaging Detectors

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