April 2025 | Prepared by: Athey Creek Consultants

Truck Parking Detection Technologies

ENTERPRISE TRANSPORTATION POOLED FUND STUDY TPF-5(490)

FINAL REPORT

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipients Catalog No.
ENT 2025-4		

4. Title and Subtitle	5. Report Date
Truck Parking Detection Technologies	April 2025
	6. Performing Organization Code
7. Author(s) Dean Deeter and Tina Roelofs	8. Performing Organization Report No.
9. Performing Organization Name and Address Athey Creek Consultants 2097 County Road D, Suite C-100 Maplewood, MN 55109	10. Project/Task/Work Unit No. 11. Contract (C) or Grant (G) No. 2023-0171
12. Sponsoring Organization Name and Address ENTERPRISE Transportation Pooled Fund Study TPF-5(490) Michigan Department of Transportation (Administering State) PO Box 30050 Lansing, MI 48909	13. Type of Report and Period Covered FINAL Report 14. Sponsoring Agency Code

15. Supplementary Notes
Final Report: https://enterprise.prog.org/projects/truck-parking-technologies/

16. Abstract

More demand for truck parking than available capacity is a challenge facing state transportation agencies. When this occurs, trucks may choose to park on roadway shoulders. Many states have deployed systems to automatically monitor/detect truck parking availability and communicate this information to truckers as they are approaching truck parking facilities. This is typically accomplished through in/out systems that monitor/detect vehicles as they enter and leave truck parking lots or by space-by-space systems that monitor/detect individual truck parking spaces. ENTERPRISE members have had some experience with truck parking detection and expressed interest in better understanding these technologies, components, and dissemination mechanisms. Other key interests were innovative truck parking detection concepts and methods, safety concerns and roadway maintenance issues with trucks parking illegally or on the shoulders at rest areas, maintenance efforts for truck parking detection systems, and other industries that utilize vehicle detection technology. Documenting examples of these truck parking interests was accomplished through outreach with ENTERPRISE member states and a literature review.

17. Document Analysis/Descriptors	18. Availability Statement
Truck parking, truck parking detection technologies, trucks parked on shoulders	No restrictions.

19. Security Class (this report)	20. Security Class (this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	57	

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April 2025

Published by:

ENTERPRISE Transportation Pooled Fund Study TPF-5(490)
Michigan Department of Transportation (Administering State)
PO Box 30050
Lansing, MI 48909

Acknowledgements

This *Truck Parking Detection Technologies* report was prepared for the Evaluating New Technologies for Roads Program Initiatives in Safety and Efficiency (ENTERPRISE) Transportation Pooled Fund Study Transportation Pooled Fund (TPF)-5(490) program (https://enterprise.prog.org/). The primary purpose of ENTERPRISE is to use the pooled resources of its members from North America and the United States federal government to develop, evaluate, and deploy Intelligent Transportation Systems (ITS).

The cover page image is provided courtesy of BarneyElo on Pixabay.

Project Champions

Marlon Spinks from the Michigan Department of Transportation, Sinclair Stolle from the Iowa Department of Transportation, and Charles Tapp from the Texas Department of Transportation, were the ENTERPRISE Project Champions for this effort. The Project Champions served as the overall leaders for the project.

ENTERPRISE Members

The ENTERPRISE Board consists of a representative from each of the following member entities.

- Illinois Department of Transportation
- Iowa Department of Transportation
- Kansas Department of Transportation
- Michigan Department of Transportation
- Minnesota Department of Transportation
- Ontario Ministry of Transportation
- Texas Department of Transportation
- Wisconsin Department of Transportation

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List of Abbreviations

AI	Artificial Intelligence
API	Application Programming Interface
ATRI	American Transportation Research Institute
CCTC	Closed-Circuit Television Camera
CCTV	Closed-Circuit Television
CRE	Commercial Real Estate
DMS	Dynamic Message Sign
DOT	Department of Transportation
ELD	Electronic Logging Device
ENTERPRISE	Evaluating New Technologies for Roads Program Initiatives in Safety and Efficiency
FDOT	Florida Department of Transportation
FHWA	Federal Highway Administration
GPU	Graphics Processing Unit
IDOT	Illinois DOT
ITS	Intelligent Transportation System
IVR	Interactive Voice Response
KDOT	Kansas DOT
LiDAR	Light Detection and Ranging
MAASTO	Mid America Association of State Transportation Officials
MDOT	Michigan DOT
MnDOT	Minnesota DOT
O&M	Operations and Maintenance
OSOW	Oversize/Overweight
PFS	Pooled Fund Study

PTZ	Pan/Tilt/Zoom
RFI	Request for Information
RFP	Request for Proposal
RNN	Recurrent Neural Networks
ROW	Right-of-Way
RTMC	Regional Transportation Management Center
TIGER	Transportation Investment Generating Economic Recovery
TPAS	Truck Parking Availability System
TPF	Transportation Pooled Fund
TPIMS	Truck Parking Information Management System
TSPS	Truck Specialized Parking Services
TxDOT	Texas DOT
VMS	Variable Message Sign
WisDOT	Wisconsin DOT
XML	Extensible Markup Language

Chapter 1: Introduction

More demand for truck parking than available capacity is a challenge facing state transportation agencies. When this occurs, trucks may choose to park on roadway shoulders. Many states have deployed systems to automatically monitor/detect truck parking availability and communicate this information to truckers as they are approaching truck parking facilities. This is typically accomplished through in/out systems that monitor/detect vehicles as they enter and leave truck parking lots or by space-by-space systems that monitor/detect individual truck parking spaces.

The Evaluating New Technologies for Roads Program Initiatives in Safety and Efficiency (ENTERPRISE) Pooled Fund Study (PFS) members have had some experience with truck parking detection. However, there was an expressed interest in learning and providing a better understanding of these truck parking detection technologies, components, and dissemination mechanisms. This was accomplished by documenting examples through outreach with ENTERPRISE members states and a literature review.

Key interests and challenges that were focused on for this project included:

- Evaluations or summaries of experiences of truck parking detection types that have been deployed for several years.
- Innovative truck parking detection concepts and methods.
- Types of safety concerns and roadway maintenance issues with trucks parking illegally or on the shoulders at rest areas.
- Maintenance efforts for truck parking detection systems.
- Types of dissemination mechanisms that provide truck parking availability information.
- Other industries that utilize vehicle detection technology.

Project Purpose

To learn about:

- Truck parking detection technologies, components, and dissemination mechanisms.
- Innovative truck parking detection concepts and methods.
- Safety and roadway maintenance issues with trucks parking illegally at rest areas.
- Other industries that utilize vehicle detection.

This report includes the following sections:

- Chapter 2 Truck Parking Detection – Provides a description of the components of in/out and space-by-space truck parking detection systems. Descriptions of innovative detection methods for truck parking detection are also provided.
- Chapter 3 Private Sector Truck Parking Availability Mechanisms – Includes examples of how private rest areas provide truckers with information on available spaces.
- Chapter 4: Multi-State or Regional Truck Parking Detection Projects – Summarizes multi-state or regional truck parking detection efforts.

- Chapter 5 ENTERPRISE Member Agencies Truck Parking Efforts – Describes current or upcoming truck parking efforts of the ENTERPRISE member agencies.
- Chapter 6: Literature Search – Summarizes the findings of the literature search that identified truck parking detection types, experiences, and the status of efforts. In addition, the literature search documented safety issues with trucks parking illegally or on the shoulders of rest areas, roadway maintenance issues with trucks parking on the shoulder, technology maintenance with truck parking detection systems, and other industries with vehicle counting detection systems.
- Chapter 7: Summary and Implementation – Provides an overall project summary and suggested implementation based on project results.
- Appendix A – Provides additional details on each resource reviewed as part of the literature search conducted for the project.

Chapter 2: Truck Parking Detection

Through ENTERPRISE member engagement and the literature search conducted and presented in Chapter 3 there were various truck parking detection components and innovative truck parking detection concepts identified.

The initial research identified two primary methods by which truck parking space availability is estimated:

- **In/Out**: Monitoring vehicles that travel in and out of truck parking lots.
- **Space-by-Space**: Monitoring individual truck parking spaces.

As the resources were reviewed during the literature search of truck parking detection technologies and as input from ENTERPRISE members was conducted, several technology components related to each method were identified. Descriptions of these components are included in this section to assist in understanding each truck parking detection technology component.

2.1 Common Occupancy Detection Components

The table below provides a description of in/out or space-by-space components that may be used individually or with other components to monitor truck occupancy in parking lots. Examples and experiences with these truck parking detection components are provided in the following sections of this report.

Table 1: Truck Parking Detection Occupancy Components

Component	Description
Artificial intelligence (AI) analytics	AI prediction models can use neural networks to help predict parking occupancy through similarity analysis. Recurrent Neural Networks (RNN) are necessary for a prediction model to “memorize” the historical change in the processed sequence and predict the future occupancy level of truck parking lots. (1)
Camera-based detection	Use cameras to build a 3D image of the parking area so available spaces can be automatically detected. (2)
Closed-circuit television (CCTV) cameras	Provides a view of truck parking spaces to validate truck parking counts. (3) CCTV cameras monitor the number of available truck parking spaces to validate other systems. (2)

Component	Description
In-pavement: loop system	The inductive- loop detector consists of loops of wire embedded into sawcuts in the road pavement. A conductive metal object, such as a vehicle passing over or stopped within the sensor's detection area, decreases the loop's inductance (an electrical property), producing an electrical signal that is transmitted through a curbside junction box (a "pull box") to an electronics unit housed in a controller cabinet. The electronics unit analyzes the signal, interpreting it as the presence or passage of a vehicle, and sends an appropriate call to the controller. (4)
In-pavement: puck sensors/magnetometer	In-pavement sensors detect the presence of a vehicle as it parks within a boundary around them. (3)
Laser scanner: side mounted	A laser is used to detect the presence of a vehicle. When a vehicle passes the scanner's beams, the beams are reflected. (5)
Laser scanner: overhead mounted	A laser is used to detect the presence of a vehicle. When a vehicle passes beneath the scanner's beams, the beams are reflected at the ingress and egress points. (5)
Light curtain: overhead mounted	A light beam is used to detect the presence of a vehicle. When a vehicle passes beneath the scanner's beams, the beams are obstructed. (5)
Radar (e.g., microwave, doppler)	In-pavement vehicle detection sensors use microwave radar-based technology to detect a vehicle entering or leaving a space. (3) Radar sensors transmit low-energy microwave radiation that is reflected by all objects within the detection zone. There are different types of radar sensor systems: - Doppler systems that use the frequency shift of the return to track the number of vehicles and determine speed very accurately. - Frequency-modulated continuous wave radar radiates continuous transmission power such as a simple continuous wave radar and is used to measure flow volume, speed, and presence. (6)
Video	Video is used for overall system reliability with human error correction, video pattern recognition to allow the video system to analyze how many parking spaces are occupied in real time, and verifying the accuracy of sensors by comparing their results. (2) Video cameras should be positioned at strategic locations to capture entering/exiting trucks and to provide a view of all truck parking spots. Parked trucks are counted in fixed increments (ex. every 5-minutes) by reviewing the video footage. (7)

Component	Description
Video cameras with stereoscopic video analytics	Video cameras with stereoscopic video analytics can be used to gather data and disseminate it through a roadside dynamic message sign (DMS), an internet/website information portal, or an onboard geolocation application that informs drivers of parking availability downstream from their current direction of travel. (2)

(1) A Comprehensive Solution for Truck Parking Based on Artificial Intelligence (2021)
(2) Best Practices for Truck Parking Availability Detection and Information Dissemination (2018)
(3) Commercial Truck Parking Detection Technology Evaluation for Columbia County Rest Areas (2016)
(4) A New Look at Sensors (2007)
(5) SmartPark Technology Demonstration Project Phase 1 (October 2013)
(6) Sensor Technologies for Intelligent Transportation Systems (2018)
(7) South Dakota DOT Rest Area & Truck Pullout Truck Parking Analysis (2018)

2.2 Innovative Detection

The table below provides a description of innovative detection approaches discovered and discussed by the project team during this project. These offer alternate approaches to truck parking detection as compared to the common detection described in Section 2.1 that could be utilized for truck parking detection as discussed and suggested by the ENTERPRISE members.

Table 2: Truck Parking Innovative Detection

Innovative Detection	Description
Rest Area Free Wi-Fi Access	As a trucker parks at a rest area, they would log into the free Wi-Fi to confirm they are parking a truck at the rest area and indicate the duration of their stay. This could enable truck parking information systems to understand not only currently occupied spaces but estimates of when the vehicles may vacate the spaces. No field demonstrations or evaluations of the accuracy of data were identified.
Crowdsourcing	According to the chief marketing officer at Trucker Path, many drivers use a phone app that seeks to crowdsource a solution to the parking crisis by allowing drivers to rate, review, and even add new parking spots on a constantly updated map. See Chapter 3.

Innovative Detection	Description
Satellite Imagery	Through detection on aerial images and estimation for unobserved regions, a deep neural network is applied to aerial images to detect parking areas. The segmentation results are fused to increase the robustness of detections and the detected parking areas are combined with information on the road network. In combination with a satellite system and inertial data, the imagery is precisely georeferenced through bundle adjustment.
AI Image Processing	AI imaging processes camera images (off-site) to deliver parking availability information. McLeod Software, a transportation management technology company, has been using machine learning in its rate predictor tool for a while but is now looking at AI to manage unstructured data and the potential for developing AI tools to make fleets more efficient and profitable.

Chapter 3: Private Sector Truck Parking Availability Mechanisms

Privately owned rest areas may provide truck parking availability at their locations. In addition, crowdsourcing and truck parking prediction products may be used to alert trucks of spaces available. An example of each approach is described below.

Private Rest Areas

Private rest areas are not operated by a department of transportation (DOT). Some of these private rest areas may provide truckers with information on available spaces. These locations may charge for truckers to park per day, per week, or monthly.

Truck Parking Club and Pilot Flying Prime Parking are online reservation systems providing truckers with the option to reserve and book a space. By selecting a location, the spaces available are provided. Private landowners operating the truck parking rest areas are responsible through an online dashboard to enter spaces available.

At these private rest area locations in addition to the online reservation systems there are also on-site staff to update the number of spaces available manually. Therefore, it is understood that a technology detection system is not typically deployed at these locations.

Crowdsourcing and Truck Parking Prediction

Trucker Path is a mobile application that truckers update on how many spots a location has and what time the parking information was updated. There are also truck parking predictions available to view what parking is typically like on a selected day of the week and time. See Figure 5. Again, it is understood that a technology detection system is not utilized for this crowdsourcing application.

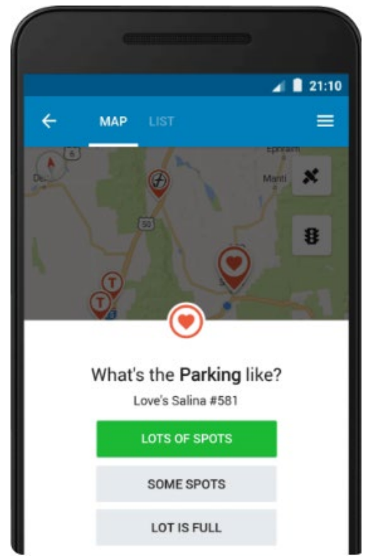

Figure 1: Trucker entry of spots available (Source: Trucker Path)

Chapter 4: Multi-State or Regional Truck Parking Detection Projects

There are a number of states that have coordinated efforts to deploy truck parking detection systems. Three recent efforts reviewed for this project include the following.

- I-5 Joint Regional Trucking Parking Information Management System (TPIMS)
- I-10 Corridor Coalition Truck Parking Availability System (TPAS)
- Mid America Association of State Transportation Officials (MAASTO) TPIMS

ENTERPRISE member states are involved in the I-10 TPAS project and the MAASTO TPIMS effort.

Additional details on these three efforts are included in the table below.

Table 3: Multi-State Truck Parking Detection Efforts

Description	States/Year
I-5 Joint Regional TPIMS Oregon, Washington, and California were awarded $12.3 million in federal grant funds in February 2024 for their joint Regional TPIMS project. The project will deploy a real-time truck parking information system at 54 truck parking areas along I-5 through all three states. The project is to kick off with initial planning and outreach to trucking groups and other communities. The project should be complete and serving truckers in 2027. The system will use sensors and cameras in truck parking areas to collect data and feed that information to truckers in real time. Truckers will be able to access the parking availability information in a few different ways, depending on what state they're in and the location: Digital roadside signs, directly to their cabs if they have compatible in-cab technology, and via smartphone apps or travel websites. Making the system flexible and providing options for truckers are key parts of its design. *Source: Oregon DOT News Release: Truck Parking on Interstate 5 will be safer and easier thanks to new grant-funded project (2024)*	• Oregon • Washington • California Project Start: 2024 Live System: 2027
I-10 Corridor Coalition TPAS The I-10 TPAS is a technology system that will detect, monitor, and provide real-time truck parking availability information to truck drivers, dispatchers, and other interested stakeholders. Once implemented, the system will monitor and report on the availability of approximately 550 truck parking spaces at 37 public rest areas in California, Arizona, New Mexico, and Texas. Using roadside dynamic message signs, smartphone and in-cab applications, websites, and other traveler information sites, truck drivers and dispatchers can make informed parking decisions that will help improve safety, efficiency, and	• California • Arizona • New Mexico • Texas* Project Start: 2020 • Live System: 2024

Description	States/Year
mobility, and reduce emissions along the I-10 corridor. The TPAS project began in 2020. *Source: I-10 Connects TPAS*	
MAASTO TPIMS In 2016, eight members of the Mid America Association of State Transportation Officials came together to improve commercial freight safety and efficiency in the Midwest. The project collaborated with the Federal Highway Administration (FHWA) which provided Transportation Investment Generating Economic Recovery (TIGER) grant funding to help launch the project. Vehicle detection systems measure available parking in select lots across each state, the parking data goes to states and 3rd party processors, and then the data is delivered to drivers through DMS, navigation applications and systems, and/or 511 websites. States had the flexibility to choose technologies they would use, as long as they satisfied the project's requirements. States committed to their own budgets and schedules that supported those of the overall project. The Mid-America Freight Coalition was brought on board to serve as the project's data warehouse and to assess performance after launch. *Source: trucksparkhere.com*	• Indiana • Iowa* • Kansas* • Kentucky • Michigan* • Minnesota* • Ohio • Wisconsin* Project Start: 2016 Live System: 2019

**ENTERPRISE member*

Chapter 5: ENTERPRISE Member Agencies Truck Parking Efforts

This section describes current or upcoming truck parking efforts within the member ENTERPRISE states as of October 2024.

5.1 Illinois DOT

Illinois DOT (IDOT) will be installing truck parking lot monitoring systems throughout Illinois. A study was conducted in 2021 to determine which technology or combination of technologies would best provide accurate parking lot information to TrucksParkHere.com. The study recommended an open-source software system together with pole-mounted wide-angle cameras. The system can be located in a data center or in a cloud and service hundreds of parking lots with a single Graphics Processing Unit (GPU) server. Images can be pulled by the central server or pushed from the cameras over a public or private network. Because the 180-degree field-of-view cameras can only accurately identify vehicles about 35 meters to either side of the camera, it is recommended that one camera be installed for every 10 to 12 stalls. Trucks appearing in more than one camera image can be merged using their stall number. *Source: Truck Parking Stall Occupancy Sensor Accuracy Study (2021)*

5.2 Iowa DOT

There are 44 existing TPIMS sites along I-80, I-380, I-280, I-35, and I-29 in Iowa that were deployed as part of the MAASTO TPIMS project. These TPIMS sites included 30 Iowa Department of Transportation (DOT) sites (e.g., rest areas, weigh stations) and 14 private sites (e.g., truck stops, restaurant, casino). Real-time truck parking availability was available for select sites on the Iowa DOT traveler information website. See Figure 2. The type and quantity of in-place field equipment varied by site and may have included pan-tilt-zoom cameras, magnetometers, base stations, repeaters, and cabinets. Iowa DOT, as of August 2024, had developed truck parking specifications to include in a Request for Proposal (RFP) to replace or update the existing TPIMS. The magnetometers that were initially installed failed at a very high rate.

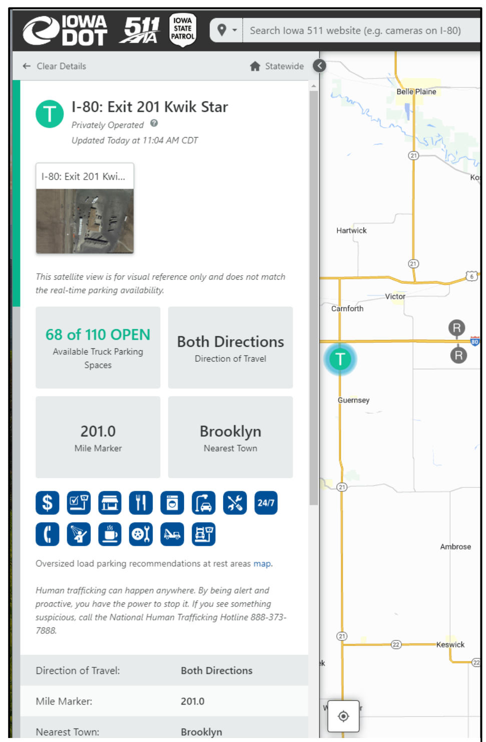

Figure 2: Iowa DOT 511 website trucker spots available (Source: Iowa DOT 511)

5.3 Kansas DOT

Kansas DOT (KDOT) as part of the MAASTO TPIMS project deployed space-by-space truck parking detection at 16 sites using computer vision. KDOT maintains a

TPIMS website that allows users to register for access to the real-time truck parking data for public rest areas along I-70 and I-135.

5.4 Michigan DOT

Michigan DOT (MDOT) provides the number of open spaces at 6 locations along I-94 and at 1 location on 8 Mile Road. See Figure 3. Five of the locations are private truck parking locations. *Source: Michigan DOT miDrive*

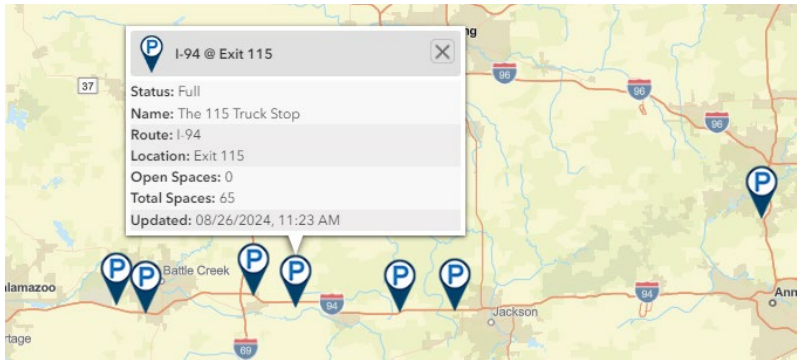

Figure 3: MDOT truck parking availability (Source: Michigan DOT miDrive)

Magnetometers are used for entry and exist detection for public rest areas and per space detection using video cameras for private facilities. MDOT provides real-time parking availability at these locations via DMS, smartphone apps, in-cab displays and websites. Private truck parking locations are displayed on the sign only by their exit number to remove the perception of advertising. *Source: National Coalition on Truck Parking: Technology and Data Working Group - Truck Parking Availability Detection and Information Dissemination (2018)*

5.5 Minnesota DOT

Minnesota DOT (MnDOT) conducted a pilot study from 2012 – 2017 at three (3) state sponsored truck parking facilities. A multi-camera-based approach was used for parking detection. Information was disseminated through a commercial operator-accessible web parking information portal, an in-cab geolocation application that integrated within an existing on-board logistics device to support driver and carrier trip operations, and roadside electronic message signs. The detection performance was evaluated through extensive observations of historical data harvested under a variety of parking and environmental scenarios. Per space detection performance is typically better than 95 percent, which correlated with overall space occupancy count discrepancies between ±1 to ±3 counts. *Source: A Comprehensive System for Assessing Truck Parking Availability (2017).*

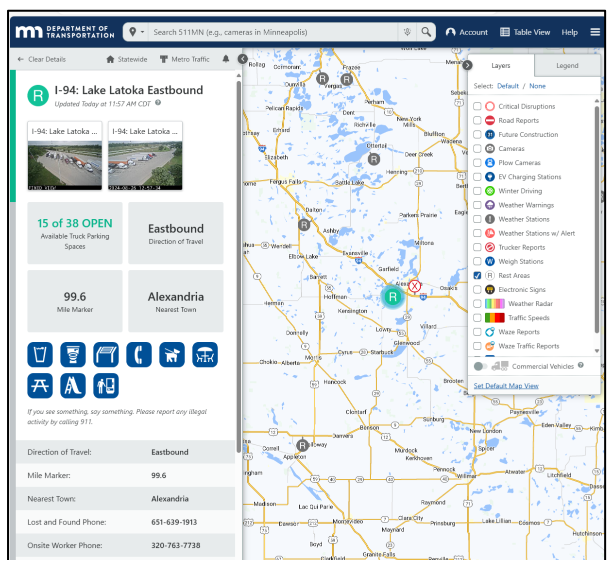

Figure 4: MnDOT 511 website trucker spots available (Source: MnDOT 511)

MnDOT, as part of the MAASTO TPIMS project, deployed in-pavement truck sensors for space-by-space detection at seven (7) locations. Truckers are able to view the number of available truck parking spaces on MnDOT's traveler information system. See Figure 4.

As of October 2024, MnDOT was going through an RFP process for vendors to install their equipment for truck detection and provide a data feed for integration into MnDOT's 511 traveler information system. Camera images will be used to determine truck parking availability. This is a pilot project that may lead to a full-scale deployment.

5.6 Texas DOT

Texas DOT (TxDOT), as part of the I-10 Corridor Coalition Truck Parking Availability System, will deploy TPAS at 16 safety rest areas and 2 travel information centers. The deployment will consist of vehicle detection and CCTV cameras and dynamic parking availability signs. *Source: I-10 Truck Parking Availability System Texas*

Texas Transportation Institute has developed a visualization tool for TxDOT employees to use to evaluate and monitor truck parking. See Figure 5. This is not in real-time; it is used for analysis. INRIX trip data of route details and way points are analyzed to see where a truck trip originated, where the truck stops, and where it is headed to; determine how fast the truck traveler and how long the trip took; and identify what bottlenecks occurred along the way. *Source: Big Data Saves DOTs Time, Resources for Truck Parking Analysis*

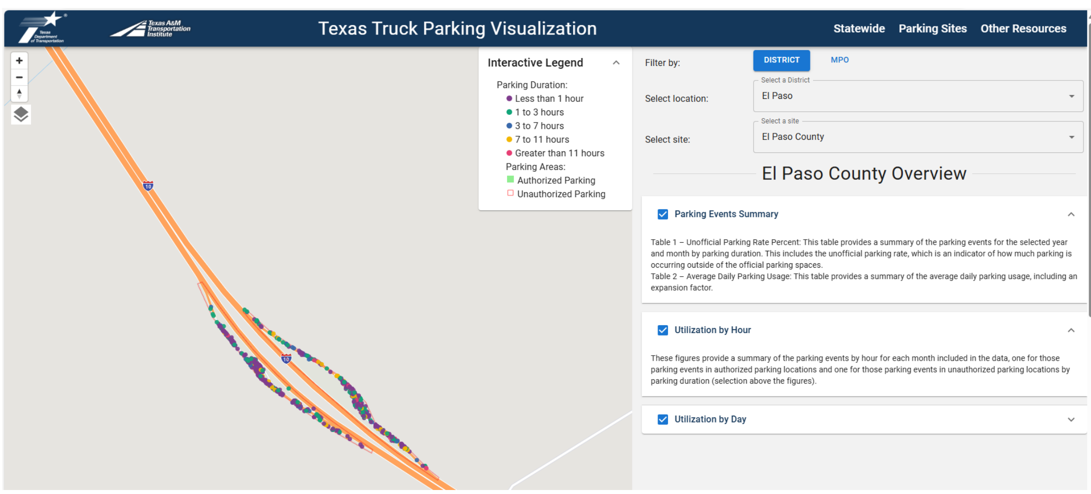

Figure 5: Texas Truck Parking Visualization (Source: Texas Truck Parking Visualization)

5.7 Wisconsin DOT

Wisconsin DOT (WisDOT) deployed TPIMS in 2016 at four (4) sites using in and out detection with magnetometers and space-by-space detection with video pattern recognition (cameras). The system was expanded using the same detection components through participation in the MAASTO TPIMS project to seven (7) sites. *Source: National Coalition on Truck Parking: Technology and Data Working Group - Truck Parking Availability Detection and Information Dissemination (2018)*

WisDOT TPIMS monitor 505 stalls along 250 miles from Dunn County to Rock County on I-94. The information is disseminated on DMS.

Chapter 6: Literature Search

ENTERPRISE members noted several interests and challenges with truck parking and truck parking detection technologies.

- There are many truck parking detection types that have been deployed for several years, and members were interested in any evaluations or summaries of experiences.
- If there are no truck spots available for parking at a rest area, truckers may park illegally or on the shoulder at a rest area. This creates safety issues; however, members were unclear of what types and how significant these safety concerns are.
- There are roadway maintenance issues with trucks parking on shoulders, and the members were unclear of how significant these maintenance issues become as trucks park illegally on shoulders at a rest area.
- With new truck parking detection systems deployed to count available spaces for truck parking, the ENTERPRISE members were interested in learning the maintenance efforts required for the technology utilized.
- The real-time nature of truck parking detection technologies provides a variety of mechanisms for truckers to receive and understand the information. Members were interested in the dissemination methods utilized.
- Members were also interested in other industries that utilize detection technologies to count vehicles.

These interests and challenges helped to define the key information reviewed during the literature search documented in this section. The literature search identified truck parking detection types, experiences, and the status of efforts. In addition, the literature search documented safety issues with trucks parking illegally or on the shoulders of rest areas, roadway maintenance issues with trucks parking on the shoulder, technology maintenance with truck parking detection systems, and other industries with vehicle counting detection systems.

The results from the literature search for this project were not meant to provide an exhaustive list of truck parking detection technologies but to identify overall technologies used to detect trucks at rest areas. The literature search was conducted from May – October 2024.

The following sections list the resources reviewed and note key findings of the truck parking detection systems.

6.1 Resources Reviewed

The literature search mostly focused on resources published from 2013 to 2024 and included online news releases, research reports, facts sheets, and project web pages. A total of 20 resources were reviewed that included information on truck parking detection and are listed in Table 4. The table provides a link to the source if available, the year published, and notes which states were referenced in the source.

Table 4: Truck Parking Detection Resources Reviewed

Resource #	Source	Year	State(s) Referenced
1	ARDOT Truck Parking Survey Results	2024	CO, IA, KY, MI, WI, AZ, NJ, KS
2	Truck parking on Interstate 5 will be safer and easier thanks to new grant-funded project	2024	OR, WA, CA
3	Evaluation of Iowa Truck Parking Information and Management System Phase 2: Performance Measures and Data Analysis	2023	IA
4	North/West Passage Truck Parking Information Management System Assessment	2023	MN, CA, AZ, NM, TX, WA, SD, VA
5	TPAS FactSheet	2023	CA, AZ, NM, TX
6	Appendix H: Washington Truck Parking Assessment	2022	WA
7	ATRI Truck Parking Information Systems: Truck Driver Use and Perceptions	2021	TN, FL, CO, MI, MN, VA
8	Making Space for Big Rigs: TTI Helps TxDOT Evaluate Technologies to Facilitate Truck Parking	2021	TX
9	Truck Parking Stall Occupancy Sensor Accuracy Study	2021	IL
10	PA Turnpike Installing Truck Parking Technology at 10 Service Areas	2021	PA Turnpike
11	Florida DOTs Truck Parking Availability System – Case Study	2019	FL
12	State DOTs Are Provided Parking Software for Trucks at Rest Stops	2019	OH
13	SmartPark Technology Demonstration Project Phase II	2018	TN
14	National Coalition on Truck Parking: Technology and Data Working Group - Truck Parking Availability Detection and Information Dissemination	2018	FL, IN, IA, KY, MI, MN, OH, WI, KS
15	South Dakota DOT Rest Area & Truck Pullout Truck Parking Analysis	2018	SD
16	A Comprehensive System for Assessing Truck Parking Availability	2017	MN
17	Commercial Truck Parking Detection Technology Evaluation for Columbia County Rest Areas	2016	FL
18	SmartPark Technology Demonstration Project Phase 1	2013	TN

Resource #	Source	Year	State(s) Referenced
19	I-10 Corridor Coalition Truck Parking Availability System (TPAS)	N.d. (website)	CA, AZ, NM, TX
20	The Eastern Transportation Coalition – Truck Parking	N.d. (website)	VA

For each of the 20 resources reviewed in the table above, a description of the project, detection type, location, dissemination mechanism, status, and related sources were documented. This detailed information for each source is included in Appendix A. Figure 6 provides one example of the detailed information included in Appendix A for each source reviewed.

Project Description and Experience	Detection Type	Location	Dissemination	Status	Source (See Table 5.1)
SmartPark Technology Demonstration Project • Phase I tested laser scanning and light curtain technology to determine if either was appropriate for use in truck parking applications. In Phase II, side-fired laser side scanners were implemented at the ingress and egress points of the truck parking areas used for the project to monitor vehicles entering and exiting the site. Phase II also expanded the system to include traveler information dissemination. • The most optimal configuration of technologies is a side scanner combined with Doppler radar at both the ingress and egress points of the selected truck parking area. • The reservation concept relied on an honor system; truckers simply did not use it. • The system must be calibrated at least once per day to maintain acceptable accuracy levels. • DMS was the most useful. Mobile applications usage would be far more widespread if the data integrates with other applications that are already in use. • Future deployments will ideally replace all the static cameras with pan/tilt/zoom (PTZ) cameras, also reducing the number of cameras needed. There is an ongoing need, however, to be able to view the entire parking facility in order to perform calibrations and identify issues on site.	In/out • Side laser scanners combined with Doppler radar • Light curtains combined with Doppler radar • Overhead laser scanners combined with Doppler radar	Tennessee • 1 site – Phase 1 • 2 sites – Phase 2	• DMS • Mobile application • Public website • Interactive voice response system (IVR)	Operational Test	Source 7: ATRI Truck Parking Information Systems: Truck Driver Use and Perceptions (2021) Source 13: SmartPark Technology Demonstration Project Phase II (2018) Source 18: SmartPark Technology Demonstration Project Phase 1 (2013)

Figure 6: Example of information documented from sources reviewed
(See Appendix A for detailed information documented)

To summarize the results of the literature search, Table 5 was populated to note the state and truck parking effort, list the truck detection components used in the deployment, indicate the number of deployment sites, note the status of the project, and indicate the sources used to populate the table.

Table 5: Literature Search: Summary

Project	In/Out Detection Components	Space-by-Space Detection Components	# of Sites	Status	Reource # (See Table 4)
TN: SmartPark Technology Demonstration Project	• Side lasers and doppler radar • Light curtains and Doppler Radar • Overhead laser and doppler radar	-	3	Operational Test Phase 1 (2013) and Phase 2 (2018)	7, 13, 18
FL: Truck Parking Availability System	• Microwave	• In-ground	74	Deployed (2019)	7, 11, 14
FL: Commercial Truck Parking Detection Technology Evaluation for Columbia County Rest Areas	-	• Magnetic and infrared • Microwave radar	2	Evaluation (2016)	17
TX: TTI Helps TxDOT Evaluate Technologies to Facilitate Truck Parking	• Side laser	• In-pavement infrared/magnetic sensors	2	Evaluation (2021)	8
CO: Truck Specialized Parking Services (TSPS)	• Loop systems	• Video detection	6	Deployed	1, 7
IN: MAASTO TPIMS	• Magnetometers (in-ground wireless pucks)	-	20	Deployed (2019)	14
IL: Truck Parking Stall Occupancy Sensor Accuracy Study	• Magnetometers (in-ground wireless pucks)	• In-pavement sensors • Camera video	1	Test (2021)	9

Project	In/Out Detection Components	Space-by-Space Detection Components	# of Sites	Status	Reource # (See Table 4)
IA: MAASTO TPIMS	• Video (For areas with more than 25 stalls)	• In-pavement (for areas with less than 25 stalls)	24	Deployed (2019)	1, 3, 15
KS: MAASTO TPIMS	-	• Computer vision	16	Deployed (2019)	1, 15
KY: MAASTO TPIMS	• Radar	-	23	Deployed (2019)	1, 15
KY: Space-by-Space Detection Evaluation	• AI analytics	• Closed-circuit Television Camera (CCTC) and Multiview cameras • AI video analytics	Unknown	Evaluation	1
MI: MAASTO TPIMS	• In-ground sensors • Camera-based detection	-	30	Deployed (2019)	1, 7, 14
MI: TPIMS	• Wireless magnetometers	• Video cameras	15	Deployed (2014)	14
MN: MAASTO TPIMS	-	• In-pavement puck sensors	7	Deployed (2019)	4, 14
MN: University of Minnesota Pilot Study	-	• Video cameras with stereoscopic video analytics	3	Deployed (2017)	4, 7, 14
OH: MAASTO TPIMS	• In-ground sensors	-	51	Deployed (2019)	12, 14

Project	In/Out Detection Components	Space-by-Space Detection Components	# of Sites	Status	Reource # (See Table 4)
WI: MAASTO TPIMS	• Magnetometer	• Video pattern recognition (cameras)	7	Deployed (2019)	1, 14
WI: TPIMS	• Magnetometer	• Video pattern recognition (cameras)	4	Deployed (2016)	14
AZ, TX, NM, CA: I-10 Corridor Coalition TPAS	• Indirect sensing (Texas, New Mexico, and California	• Direct sensing (Arizona)	37	Deployed (2024)	1, 4, 5, 19
OR, WA, CA: I-5 Joint Regional TPIMS	• TBD	• TBD	54	Awarded (2024)	2
WA: TPIMS	• TBD	• TBD	28	Planning (2023)	4, 6
WA: TPIMS Pilot Project	-	• In-pavement puck sensors	2	Deployed (2019)	4, 6
MT: TPIMS Pilot Project	• TBD	• TBD	2	Pilot Project (2023)	4
SD: Rest Area & Truck Pullout Truck Parking Analysis	• Video cameras	• Video cameras	30	Deployed (2018)	4, 15
VA: The Eastern Transportation Coalition – Truck Parking	• Pavement puck sensors	• Pavement puck sensors	5	Deployed (2018)	4, 7, 20
PA Turnpike: Installing Truck Parking Technology at 10 Service Areas	• Unknown	• Unknown	10	Deployed (2021)	10
NJ: Pilot Test	• In-pavement	-	Unknown	Pilot Test	1

In addition to the resources identified in Table 4, four resources were found that included information on truck parking safety and maintenance as noted in Table 6. Results from the review of these sources are included in the following section (6.2 Key Findings).

Table 6: Truck Parking Safety and Maintenance Resources Reviewed

Resource #	Source	Year	State Referenced
21	Maryland Statewide Truck Parking Study	2020	MD
22	Texas Statewide Truck Parking Study	2020	TX
23	Minnesota Statewide Truck Parking Study	2019	MN
24	Truck Parking: An Emerging Safety Hazard to Highway Users	2017	OR

6.2 Key Findings

This section provides a summary of key findings from review of the resources from Section 6.1.

There were 23 agencies identified from the review of resources with truck parking detection efforts. See Figure 7.

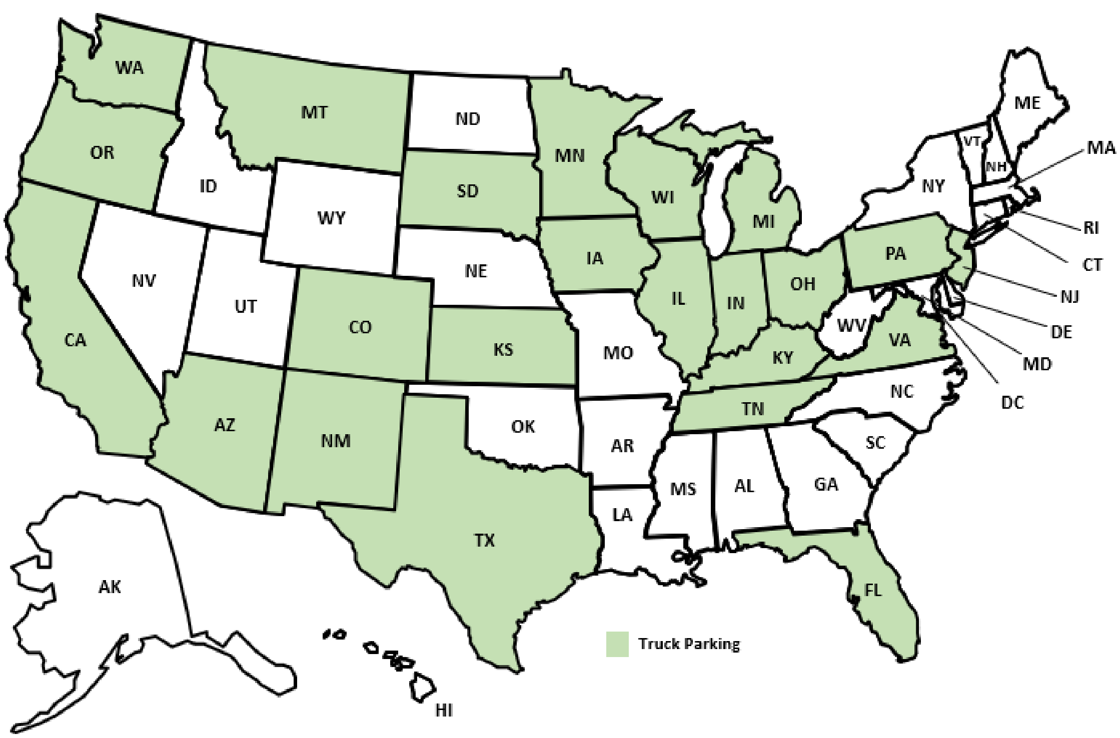

Figure 7: Agencies with truck parking detection efforts from Literature Search

Findings from the resources reviewed were grouped into the following categories:

- Detection components
- What worked well
- What did not work well
- Lessons learned
- Dissemination
- Calibration
- Safety
- Roadway maintenance
- Technology maintenance
- Maintenance funding

Specific information found related to these categories from the sources reviewed is provided below.

6.2.1 Truck Parking Detection Components

There were 12 in/out truck parking detection components and 7 space-by-space components identified in the resources reviewed. In-pavement puck sensors were utilized the most often for both in/out detection and space-by-space detection. See Table 7.

Table 7: Literature Search: Detection Components

In/Out Components	# of Projects	Space-by-Space Components	# of Projects
In-pavement: Puck sensors	7	In-pavement: Puck sensors	8
In-pavement: Loop system	1	Microwave radar	1
Laser scanner: Side mounted	1	AI analytics	1
Light curtain: Overhead mounted	1	Video	4
Laser scanner: Overhead mounted	1	CCTC and Multiview cameras	1
Microwave	1	Computer vision	1
AI analytics	1	Video cameras with stereoscopic video analytics	1
Radar	1		
Doppler radar	1		
Video	2		
CCTV cameras	1		
Camera-based detection	1		

6.2.2 What Worked Well

The following bullets, as cited in the reports reviewed for this project, note what worked well with truck parking detection.

- Tennessee: The most optimal configuration of technologies is a side scanner combined with Doppler radar at both the ingress and egress points of the selected truck parking area. *Source 18, Table 4: SmartPark Technology Demonstration Project Phase 1 (October 2013)*
- Tennessee: Side mounted laser scanners are less intrusive than overhead laser scanners. *Source 13, Table 4: SmartPark Technology Demonstration Project Phase II (May 2018)*
- Florida: Overall, it was found that all three technologies (Vendor 1: magnetic and infrared, Vendor 2: microwave, Vendor 3: microwave) performed well, with accuracy rates of 95%. *Source 17, Table 4: Commercial Truck Parking Detection Technology Evaluation for Columbia County Rest Areas (2016)*
- Texas: Preliminary evaluation indicated that both systems (Side laser (Light Detection and Ranging (LiDAR)) and in-pavement infrared/magnetic sensors) seem to be working well, keeping accurate tallies of the number of trucks versus the number of spaces. *Source 8, Table 4: Making Space for Big Rigs: TTI Helps TxDOT Evaluate Technologies to Facilitate Truck Parking (March 2021)*
- Illinois: Recommendation for pole-mounted wide-angle cameras with an open-source video analytics software system to pull images by the central server or push from the cameras over a public or private network. Accuracy results:
  - Video Analytics Solution 1: 96%
  - In-pavement (measured after repairs, 22% failed with the first year of use): 88%
  - Over-height (97% accurate without the presence of maintenance vehicles): 42%
  - Video Analytics Solution 2 (required head-on view of vehicles): 12%

  Source 9, Table 4: Truck Parking Stall Occupancy Sensor Accuracy Study (2021)
- Michigan: The DMS are placed a maximum of 30 minutes or 30 miles upstream from the farthest destination on the sign. This spacing standard is used to minimize the likelihood that the number of available spaces would change significantly prior to a trucker's arrival at the parking facility. The data on the signs updates approximately every 3 to 5 minutes. Private truck parking locations are displayed on the sign only by their exit number to remove perception of advertising. *Source 14, Table 4: National Coalition on Truck Parking: Technology and Data Working Group - Truck Parking Availability Detection and Information Dissemination (2018)*
- Washington*:* WSDOT partnered University of Washington to pilot a TPIMS in 2019 which included an algorithm to predict future truck parking availability up to four hours in advance with about 12 percent error. *Source 4, Table 4: North/West Passage Truck Parking Information Management System Assessment (2023)*

6.2.3 What Did Not Work Well

The following bullets, as cited in the reports reviewed for this project, note what did not work well with truck parking detection.

- Tennessee: The parking reservation concept relied on an honor system; truckers simply did not use it. *Source 13, Table 4: SmartPark Technology Demonstration Project Phase II (May 2018)*
- Colorado: In-ground detection sensors can be a problem for snowplow damage. *Source 1, Table 4: ARDOT Truck Parking Survey Results (2024)*
- Iowa: The in-pavement sensors have failed at a very high rate. *Source 1, Table 4: ARDOT Truck Parking Survey Results (2024)*
- Kentucky: Too much ground truthing (manually counting spaces using camera snapshots) is needed with the current technology (radar sensors) in order to keep counts accurate. *Source 1, Table 4: ARDOT Truck Parking Survey Results (2024)*
- Minnesota: MnDOT has noted challenges with the longevity and performance of the puck technology used to detect truck parking availability. A combination of technology and operating condition challenges, including inclement weather like ice and freezing rain, have led to battery performance and puck failure issues. *Source 4, Table 4*: *North/West Passage Truck Parking Information Management System Assessment (2023)*

6.2.4 Lessons Learned

The following bullets as cited in the reports reviewed for this project note lessons learned with truck parking detection.

- Tennessee: Future deployments will ideally replace all the static cameras with pan/tilt/zoom (PTZ) cameras, also reducing the number of cameras needed. *Source 13, Table 4: SmartPark Technology Demonstration Project Phase II (May 2018)*
- Colorado: Demand an agnostic solution with an Application Programming Interface (API). This will allow companies in the private sector to help you share the information that is being collected and not tie you to one provider. *Source 1, Table 4: ARDOT Truck Parking Survey Results (2024)*
- Kentucky: Not all sites can be designed the same. Consider implementing a testbed to try multiple technologies with various conditions, such as driver behavior or weather and technology comparison. *Source 1, Table 4: ARDOT Truck Parking Survey Results (2024)*
- Kentucky: Integrate low-cost verification cameras for the roadside DMS/signage. *Source 1, Table 4: ARDOT Truck Parking Survey Results (2024)*
- California: Select the detection technology according to the conditions of the site (e.g., fog, weather, reliability of cellular connection service provider especially in rural areas). *Source 1, Table 4: ARDOT Truck Parking Survey Results (2024)*
- Virginia: The Eastern Transportation Coalition summary of key lessons learned: need stakeholder outreach and buy-in, interoperability of systems and technologies ensures

flexibility, consider ongoing operations and maintenance costs, maintain a balance between a consistent regional approach and state flexibility, private sector participation is desirable but hard to achieve, dissemination systems should be diverse and should prioritize safety, sharing lessons learned helps achieve gradual improvements, and need to ensure that there is adequate truck parking capacity. *Source 20, Table 4: The Eastern Transportation Coalition – Truck Parking (website)*

- New Jersey: Place devices in areas where they cannot be blocked by a truck otherwise they do not work correctly. *Source 1, Table 4: ARDOT Truck Parking Survey Results (2024)*

6.2.5 Dissemination

The following bullets as cited in the reports reviewed for this project describe dissemination mechanisms of truck parking information.

- American Transportation Research Institute (ATRI): According to a driver survey conducted in 2019 where 1,103 drivers completed the survey that Variable Message Signs (VMS) and third-party apps were used to identify available truck parking. Approximately 25 percent indicated that they used truck parking apps exclusively while 14.2 percent indicated relying exclusively on VMS. A plurality of 32 percent indicated that they use both. *Source 7, Table 4: ATRI Truck Parking Information Systems: Truck Driver Use and Perceptions (2021)*
- ATRI: According to a driver survey conducted in 2019 where 1,103 drivers completed the survey, over 70 percent indicated that they had seen VMS with truck parking information. *Source 7, Table 4: ATRI Truck Parking Information Systems: Truck Driver Use and Perceptions (2021)*
- Tennessee: The truck parking availability information system consisted of DMSs, a mobile application, a public Web site, and an interactive voice response system (IVR) to disseminate the real-time information. DMS was the most useful. Mobile application usage would be far more widespread if the data integrated with other applications that are already in use. *Source 13, Table 4: SmartPark Technology Demonstration Project Phase II (May 2018)*
- Michigan: The DMS are placed a maximum of 30 minutes or 30 miles upstream from the farthest destination on the sign. This spacing standard is used to minimize the likelihood that the number of available spaces would change significantly prior to a trucker's arrival at the parking facility. The data on the signs updates approximately every 3 to 5 minutes. Private truck parking locations are displayed on the sign only by their exit number to remove perception of advertising. *Source 14, Table 4: National Coalition on Truck Parking: Technology and Data Working Group - Truck Parking Availability Detection and Information Dissemination (2018)*
- California, Arizona, New Mexico, and Texas: A survey of over 500 responses from drivers and dispatchers indicated that the preferred method for receiving real-time information is roadside DMS (43%) and expressed a preference for signs that display at least two or three upcoming sites. Drivers also preferred a sign that shows rest areas within five to 45 miles and the total number of available spaces. *Source 5, Table 4: TPAS FactSheet (2023)*

6.2.6 Calibration

The following bullets, as cited in the reports reviewed for this project, note calibration efforts with truck parking detection.

- Tennessee: The system must be calibrated at least once per day to maintain acceptable accuracy levels. Detection Type: In/Out – Side laser scanners combined with doppler radar, light curtains combined with Doppler radar, overhead laser scanners combined with Doppler radar. *Source 13, Table 4: SmartPark Technology Demonstration Project Phase II (May 2018)*
- Tennessee: There is an ongoing need to be able to view the entire parking facility in order to perform calibrations and identify issues on site. Detection Type: In/Out – Side laser scanners combined with doppler radar, light curtains combined with Doppler radar, overhead laser scanners combined with Doppler radar. *Source 13, Table 4: SmartPark Technology Demonstration Project Phase II (May 2018)*
- Indiana: The system will be recalibrated once a day, and the information will be automatically updated to the system every 15 minutes to appear on DMS. Detection Type: Magnetometers (in-ground wireless pucks). *Source 14, Table 4: National Coalition on Truck Parking: Technology and Data Working Group - Truck Parking Availability Detection and Information Dissemination (2018)*
- Kentucky: Calibration was modified to take snapshots for manual counting. On-site cameras take multiple snapshots of their respective lot(s) for full coverage. Detection Type: CCTV and Multiview cameras, AI analytics. *Source 1, Table 4: ARDOT Truck Parking Survey Results (2024)*
- Kentucky: Drivers park in front of the sensors, park in unmarked spaces, enter or exit in the wrong direction, etc. Some software changes were made, and manual calibrations are used to compensate for these scenarios. Detection Type: CCTV and Multiview cameras, AI analytics. *Source 1, Table 4: ARDOT Truck Parking Survey Results (2024)*

6.2.7 Safety

The following bullets, as cited in the reports reviewed for this project, note safety issues with trucks illegally or improperly parking.

- Oregon: In Oregon, crash trends in terms of time-of-day, day of the week, and month of the year follow the time periods drivers stated having trouble finding safe and adequate parking. *Source 24, Table 5: Truck Parking: An Emerging Safety Hazard to Highway Users (2017)*
- Oregon: In Oregon on a high-use corridor, namely US-97 of the 784 large truck crash crashes from 2007 to 2018, 708 were at-fault crashes and 3 of those were caused by a large truck being improperly parked. *Source 24, Table 5: Truck Parking: An Emerging Safety Hazard to Highway Users (2017)*
- Maryland: An observation from an attendee at the Maryland Truck Parking Workshop highlighted the risk of undesignated parking (safety) as follows: although crashes with trucks

parked on roadway shoulders or on/off ramps are infrequent, they are often fatal. *Source 21, Table 5: Maryland Statewide Truck Parking Study (2020)*

- Maryland: Emergency stop areas and paved roadside lots within highway right-of-way (ROW) may offer an opportunity for parking the trucks, but safe ingress/egress is the main concern related to these locations. *Source 21, Table 5: Maryland Statewide Truck Parking Study (2020)*
- Maryland: Using INRIX Truck GPS data, the average daily number of trucks parked in undesignated areas by time of day was identified. Not all of the unmet truck parking demand has the same priority. For example, trucks parking along dead-end connectors to warehouses for short periods of time may not raise concern to the local community or affect safety compared to truck parking along highway shoulders, on/off ramps, or other roadside lots. *Source 21, Table 5: Maryland Statewide Truck Parking Study (2020)*
- Maryland: Undesignated truck parking on heavy use corridors is a significant safety concern because trucks are a large, fixed object that could be hit by other roadway users and/or block the sight distance for other roadway users coming down ramps and roadways. *Source 21, Table 5: Maryland Statewide Truck Parking Study (2020)*
- Minnesota: Due to limited shoulder widths on many roads, oversize/overweight (OSOW)/superloads can lead to the vehicle becoming a collision hazard for other vehicles on the road. *Source 23, Table 5: Minnesota Statewide Truck Parking Study (October 2019)*
- Texas: Unauthorized parking, or truck parking outside of a dedicated truck parking facility, introduces safety and security risks for drivers as well as the traveling public. Trucks parked on shoulders and ramps can reduce visibility, damage pavement, and result in crashes. *Source 22, Table 5: Texas Statewide Truck Parking Study (April 2020)*

6.2.8 Roadway Maintenance

The following bullets, as cited in the reports reviewed for this project, note roadway maintenance issues with trucks parking in undesignated parking locations.

- Maryland: Undesignated truck parking locations are not designed to support the weight of a truck, resulting in increased damage to infrastructure and decreased infrastructure longevity. *Source 21, Table 5: Maryland Statewide Truck Parking Study (2020)*
- Texas: Highway maintenance costs may also increase as a result of inadequate truck parking infrastructure. When trucks park on ramps, shoulders, or land directly adjacent to the paved right of way, the weight of the truck damages the pavement or ground. If truck parking repeatedly occurs in a location not designed to handle this weight, the pavement quality will deteriorate and compromise the overall integrity of the pavement. *Source 22, Table 5: Texas Statewide Truck Parking Study (April 2020)*

6.2.9 Technology Maintenance

The following bullets, as cited in the reports reviewed for this project, note maintenance of the technology for truck parking detection. Calibration is also a major factor in maintenance of truck parking technologies (See 6.2.6 Calibration).

- Tennessee: The detectors, if installed properly, are able to accurately identify vehicles entering and exiting a site. However, given the "check-in-check-out" approach to detecting parking occupancy, any error from the detectors compounds over time. Even small error rates can result in the traveler information component disseminating incorrect information after 1–2 days without intervention. During the testing period, the orientation of one detector was altered due to impact by a truck. After this impact the detector accuracy was reduced and the system needed to be taken offline until the orientation could be rectified. The detectors are highly sensitive to orientation with respect to the roadway. *Source 13, Table 4: SmartPark Technology Demonstration Project Phase II (May 2018)*
- Minnesota: A University of Minnesota TPIMS pilot study required a system deployed at three (3) Minnesota rest areas to be operational 24/7 and perform any recalibrations without any human interaction which led to a camera based approach. The system operated 24/7 and was able to self-calibrate. *Source 16, Table 4: A Comprehensive System for Assessing Truck Parking Availability (2017)*
- Minnesota: MnDOT has noted the need for continued resources, including both funding and staffing, to operate and maintain existing TPIMS sites. *Source 4, Table 4: North/West Passage Truck Parking Information Management System Assessment (2023)*
- Washington: WSDOT noted the need for continued resources, including both funding and staffing, to operate and maintain the state's planned TPIMS network. *Source 4, Table 4: North/West Passage Truck Parking Information Management System Assessment (2023)*

6.2.10 Maintenance Funding

The following bullet, as cited in the reports reviewed for this project, describes maintenance funding with truck parking detection.

- Florida: FDOT's approach to maintenance is providing funding based on prescribed formulas at the device level, allowing for effective benefit cost analysis by other states to include long-term maintenance. The innovative use of sponsorship signs, which was approved by the FHWA, offsets maintenance costs of the system. *Source 11, Table 4: Florida DOTs Truck Parking Availability System – Case Study (January 2019)*

6.3 Other Industries with Vehicle Counting Detection Systems

Other industries outside of truck parking that utilize vehicle counting detection were identified during the literature search. The table below lists the resources reviewed. These industries include parking lots, drive-throughs, car washes, toll booths, commercial real estate locations, and parks. Additional details on each industry are provided following the table.

Table 8: Other Industries with Vehicle Counting Detection Resources Reviewed

Source #	Source	Year	Use(s) Referenced
25	Vehicle Counting	N.d. (website)	Parking lots
26	Top 4 Uses for Vehicle Counters	2019	• Parking lots • Drive-throughs • Car washes • Toll booths
27	Why are Car Traffic Counts Important?	2023	Commercial real estate locations
28	Parks and Nature	N.d. (website)	Parks and nature

The following bullets highlight additional details, as cited in the reports reviewed for this project, found on each industry.

Parking Lots

- Parking management companies use vehicle counting systems for parking space occupancy in parking lots and garages. This enables efficient management of parking resources and reduces congestion. *Source 25, Table 8* *Vehicle Counting*
- Large metropolitan areas are home to some of the bigger, more frequently used parking lots. Monitoring the traffic in these parking lots is a big deal for the owners. Varying rates from lot to lot and availability during certain times of the day or even specific days can fluctuate. Owners need to know how much traffic they're receiving in order to understand and properly manage and maintain the lots. *Source 26, Table 8* *Top 4 Uses for Vehicle Counters (2019)*

Drive-throughs

- Thousands of people go through a drive-thru each day, monitoring this traffic is pertinent to the management of these businesses. We commonly think of fast food restaurants when we think of a drive-thru but pharmacies and other item-specific stores like coffee shops also offer drive-through windows for their patrons. *Source 26, Table 8* *Top 4 Uses for Vehicle Counters (2019)*

Car Washes

- The weather can vary from place to place, which is often a trigger for people to bring their cars to the car wash. Owners need to know just how much traffic they're receiving and which seasons or times of day are the busiest. Having this information helps to maintain the facility and keep it running smoothly throughout the year. *Source 26, Table 8 Top 4 Uses for Vehicle Counters (2019)*

Toll Booths

- Toll booths see a lot of traffic on a daily basis. The government needs to know exactly how much traffic they are receiving to keep the booths properly staffed and to maintain the roads. The data collected through toll booths helps to determine the cost of the toll each year, as well as allowing the state to make necessary repairs to the roads and properly forecast any future maintenance that may be needed. *Source 26, Table 8 Top 4 Uses for Vehicle Counters (2019)*

Commercial Real Estate Locations

- Traffic counts provide useful information about the volume and flow of traffic at a location, including peak and off-peak periods, directional flows, and the potential number of passers-by who could become customers for a business situated there. *Source 27, Table 8 Why are Car Traffic Counts Important? (2023)*
- Car traffic counts are an essential benchmark for Commercial Real Estate (CRE) investors and brokers as they assist with assessing the accessibility and profitability of a commercial location. *Source 27, Table 6.3 Why are Car Traffic Counts Important? (2023)*
- Car traffic data is also integral to trade area analysis. *Source 27, Table 8 Why are Car Traffic Counts Important? (2023)*
- Choosing the right location for a retail property is a crucial business decision that can have direct impacts on profitability. Since retail properties rely on good volumes of footfall and walk-ins, car traffic count could be a potential indicator of how many customers a specific location will receive. *Source 27, Table 8 Why are Car Traffic Counts Important? (2023)*
- Commercial real estate property owners can use promising car traffic levels to attract and retain high-quality retail tenants. *Source 27, Table 8 Why are Car Traffic Counts Important? (2023)*

Parks

- Crowd counting in parks and open spaces offers numerous advantages to local and regional authorities, city planners, companies, and associations involved in ecological and social development. *Source 28, Table 8 Parks and Nature*
- Benefits for parks and nature include building planning, resources allocation, prevention of overcrowding, preparing for emergencies, event planning, and maintenance. *Source 28, Table 8 Parks and Nature*

Chapter 7: Summary and Implementation

More demand for truck parking than available capacity is a challenge facing state transportation agencies. When this occurs, trucks may choose to park on roadway shoulders. Many states have deployed systems to automatically monitor/detect truck parking availability and communicate this information to truckers as they are approaching truck parking facilities. This is typically accomplished through in/out systems that monitor/detect vehicles as they enter and leave truck parking lots or by space-by-space systems that monitor/detect individual truck parking spaces. This project provided ENTERPRISE members with a better understanding of these truck parking detection technologies, components, and dissemination mechanisms by documenting examples through outreach with ENTERPRISE member states and a literature review.

7.1 Key Findings

Key findings from the review of truck parking detection methods and components are provided below.

- Private rest areas may provide truck parking availability for their locations. This may occur through rest area staff manually updating available spaces on an online system. It is understood that a technology detection system is not deployed typically at these locations.
- There are private mobile applications available where truckers, through crowdsourcing, update how many truck parking spots are available at a location and what time the parking information was updated.
- There are private mobile applications available where truck parking predictions are provided based on how full a lot is typically for a selected day of the week and time.
- ENTERPRISE Members (Illinois, Iowa, Kansas, Michigan, Minnesota, Texas, and Wisconsin) have all deployed or will deploy truck parking detection systems. In addition, some of the member states are involved in regional or multi-state truck parking detection efforts to improve commercial vehicle freight safety and efficiency in a coordinated effort.
- Key findings by category from the literature search of truck parking detection systems are provided in Table 9.

Table 9: Literature Search Key Findings

Category	Literature Search Key Findings (as cited in the reports reviewed for this project)
Truck Parking Detection Components	• There were 19 projects with in/out components and 17 projects with space-by-space components identified. • Overall, there were 12 in/out truck parking detection components found in the sources reviewed and 7 space-by-space detection components. In-pavement puck sensors were utilized the most for both in/out detection and space-by-space detection.

Category	Literature Search Key Findings (as cited in the reports reviewed for this project)
What Worked Well with Truck Parking Detection	• Pole-mounted, wide-angle cameras with open-source video analytics • DMS placed a maximum of 30 minutes or 30 miles upstream from the farthest destination on the sign • Side scanner combined with doppler radar
What did not work Well with Truck Parking Detection	• In-ground sensors/pucks • Reservation system • Manually counting spaces using cameras
Lessons Learned	• Demand an agnostic solution with an API. This will not tie you to one provider. • Replace static cameras with PTZ cameras (reduce the number of cameras needed). • Not all sites can be designed the same. • Place devices in an area where they cannot be blocked by a truck.
Dissemination Mechanisms of Truck Parking Information	• DMS is the most useful. • Mobile application usage would increase if the data integrates with applications already in use.
Calibration of Truck Parking Detection Systems	• Calibration typically needs to be performed once a day. • Need to view entire parking facility to perform calibrations. • Manual calibrations are needed when drivers park in front of sensors, park in unmarked spaces, etc.
Safety Issues with Trucks Illegally Parking or Improperly Parking	• Crash trends in terms of time-of-day, day of week, and month of year follow the time periods drivers stated having trouble finding safe and adequate parking. • Three (3) crashes from 2007-18 on US-97 in Oregon were caused by a large truck being improperly parked. • Truck strikes are infrequent but are often fatal. • Trucks parked on shoulders and ramps can reduce visibility, damage pavement, and result in crashes.
Roadway Maintenance Issues with Trucks in Undesignated Parking Locations	• Undesignated truck parking locations are not designed to support the weight of a truck.

Category	Literature Search Key Findings (as cited in the reports reviewed for this project)
Technology Maintenance with Truck Parking Detection Systems	• Any error from parking detectors compounds over time. Detectors must be calibrated once a day. • If no human interaction is required for calibrations, cameras are needed. • Funding is needed for staff to operate and maintain sites.
Other industries with Vehicle Counting Detection Systems	• Parking lots (including large employers) • Drive-throughs • Car washes • Toll booths • Commercial real estate locations • Parks

7.2 Implementation Plan

This research results in several resources that ENTERPRISE members can use to inform staff about truck parking detection:

- Private Sector Truck Parking Availability Mechanisms (Chapter 3)
- Multi-State or Regional Truck Parking Detection Projects (Chapter 4)
- ENTERPRISE Member Agencies Truck Parking Efforts (Chapter 5)
- Literature Search (Chapter 6)

Transportation agencies can implement the results of this research in several ways. Recommended implementation steps could include the following actions:

1. Distribute the report to freight and ITS staff at ENTERPRISE agencies as well as others within the agency that maintain and design truck parking detection systems.
2. Review the resources found through the literature search of individual state and multi-state/regional truck parking efforts to understand what has worked well, what didn't work well, lesson learned, dissemination mechanisms, calibration, safety, and maintenance of truck parking detection systems.
3. As transportation agencies continue to deploy and improve truck parking detection systems, ENTERPRISE could consider conducting a follow-up project to continue to monitor advancements with truck parking detection systems.

Overall, the research conducted for this project provided ENTERPRISE member agencies with numerous examples of truck parking detection components and systems in many different states giving members a better understanding of these systems.

Appendix A
Literature Search: Summary

Table A1 Truck Parking Detection Literature Search Summary

Project Description and Experience	Detection Type	Location	Dissemination	Status	Source (See Table 4)
SmartPark Technology Demonstration Project • Phase I tested laser scanning and light curtain technology to determine if either was appropriate for use in truck parking applications. In Phase II, side-fired laser scanners were implemented at the ingress and egress points of the truck parking areas used for the project to monitor vehicles entering and exiting the site. Phase II also expanded the system to include traveler information dissemination. • The most optimal configuration of technologies is a side scanner combined with Doppler radar at both the ingress and egress points of the selected truck parking area. • The reservation concept relied on an honor system; truckers simply did not use it. • The system must be calibrated at least once per day to maintain acceptable accuracy levels. • DMS was the most useful. Mobile applications usage would be far more widespread if the data integrates with other applications that are already in use. • Future deployments will ideally replace all the static cameras with pan/tilt/zoom (PTZ) cameras, also reducing the number of cameras needed. There is an ongoing need, however, to be able to view the entire parking facility in order to perform calibrations and identify issues on site.	In/out • Side laser scanners combined with Doppler radar • Light curtains combined with Doppler radar • Overhead laser scanners combined with Doppler radar	Tennessee • 1 site – Phase 1 • 2 sites – Phase 2	• DMS • Mobile application • Public website • Interactive voice response system (IVR)	Operational Test	Source 7: ATRI Truck Parking Information Systems: Truck Driver Use and Perceptions (2021) Source 13: SmartPark Technology Demonstration Project Phase II (2018) Source 18: SmartPark Technology Demonstration Project Phase 1 (2013)

Project Description and Experience	Detection Type	Location	Dissemination	**Status**	Source (See Table 4)
• Cameras provided surveillance and provided a single image for storage when triggered by a detector.					
Florida DOTs Truck Parking Availability System • Florida DOT's (FDOT's) Regional Transportation Management Centers (RTMCs) integrate and disseminate the Truck Parking Availability System (TPAS) information. • Future stages of the project will include historical data analysis and predictive parking availability (at both public and private parking facilities) to further enhance route and logistics planning for freight management. • FDOT's approach to maintenance is providing funding based on prescribed formulas at the device level, allowing for effective benefit cost analysis by other states to include long-term maintenance. The innovative use of sponsorship signs, which was approved by the Federal Highway Administration (FHWA), offsets maintenance costs of the system.	Space-by-Space • In-ground (rest areas and welcome centers) In/out • Microwave (weigh stations) • CCTV	Florida • 74 public facilities	• Roadside-embedded DMS • Florida 511 (FL511.com) website • Third-party data feeds	Deployed	Source 7: ATRI Truck Parking Information Systems: Truck Driver Use and Perceptions (2021) Source 11: Florida DOTs Truck Parking Availability System – Case Study (2019) Source 14: National Coalition on Truck Parking: Technology and Data Working Group - Truck Parking Availability Detection and Information Dissemination (2018)
Commercial Truck Parking Detection Technology Evaluation for Columbia County Rest Areas, FL • The objective of this project was to evaluate three different vehicle detection technologies (SENSIT, Sensys, and CivicSmart) as applied to commercial truck parking areas of interstate rest areas.	Space-by-Space • Magnetic and infrared • Microwave radar	Florida • 2 rest areas	• Not demonstrat-ed	Evaluation	Source 17: Commercial Truck Parking Detection Technology Evaluation for Columbia County Rest Areas (2016)

Project Description and Experience	Detection Type	Location	Dissemination	**Status**	Source (See Table 4)
• Video data were collected by the research team to use as the ground-truth data. Overall, it was found that all three technologies performed well, with accuracy rates of 95%.					
TTI Helps TxDOT Evaluate Technologies to Facilitate Truck Parking • Preliminary evaluation indicated that both systems seem to be working well, keeping accurate tallies of the number of trucks versus the number of spaces.	In/Out • Side laser (LiDAR) Space-by-Space • In-pavement infrared/ magnetic sensors	Texas • 2 rest areas	• Changeable message signs	Evaluation	Source 8: Making Space for Big Rigs: TTI Helps TxDOT Evaluate Technologies to Facilitate Truck Parking (March 2021)
Truck Specialized Parking Services (TSPS) • Originally used TSPS. In the process of doing an RFP for a new contract, it may change. • Broadcasted at roadside signs and utilizing TSPS but working to develop a system with an Application Programming Interface (API) to make this available through the traffic management website and approved vendors. • There are system challenges in bad weather (continually worked to enhance the hardware to accommodate). • In-ground detection sensors can be a problem for snowplow damage.	In/Out and Space-by-Space • Combination of loop systems and video detection	Colorado • 6 sites – Phase 1	• Roadside signs • Mobile apps • XML feed	Deployed	Source 1: ARDOT Truck Parking Survey Results (2024) Source 7: ATRI Truck Parking Information Systems: Truck Driver Use and Perceptions (2021)

Project Description and Experience	Detection Type	Location	Dissemination	**Status**	Source (See Table 4)
• Demand an agnostic solution with an API. This will allow companies in the private sector to help you share the information that is being collected and not tie you to one provider.					
MAASTO TPIMS • MAASTO, which represents Iowa, Indiana, Kansas, Kentucky, Michigan, Minnesota, Ohio and Wisconsin, received a TIGER grant to develop and implement a regional TPIMS. The TPIMS involves the development of a coordinated truck parking management solution in the Midwest region. • Means of detection and notification are uniquely defined within each State, but the information from each State will be collected through standard extensible markup language (XML) feeds and shared through a common API via dynamic message signs (DMS), traveler information websites, and a smart phone app. • The system will be recalibrated once a day, and the information will be automatically updated to the system every 15 minutes to appear on DMS. DMS would be installed approximately 15 miles before the truck parking area and would include not only the amount of parking spaces for the closest parking area, but also for the one or two parking areas after that. • Indiana is installing cameras that oversee the parking areas to aid the TMC as a backup confirmation on the number of trucks in the parking lot.	In/out • Magnetometers (in-ground wireless pucks)	Indiana • 20 public sites	• DMS • 3rd Party • 511	Deployed	Source 14: National Coalition on Truck Parking: Technology and Data Working Group - Truck Parking Availability Detection and Information Dissemination (2018)

Project Description and Experience	Detection Type	Location	Dissemination	**Status**	Source (See Table 4)

Truck Parking Stall Occupancy Sensor Accuracy Study
• The goal was to determine which technology or combination of technologies would best provide accurate parking lot information to TrucksParkHere.com. The University analyzed data from several different types of sensors from October 2020 through May 2021.
• Recommendation for pole-mounted wide-angle cameras with an open-source video analytics software system (Solution 1) to pull images by the central server or push from the cameras over a public or private network.
• In-pavement detection was found to be accurate but was determined to have a prohibitively high failure rate resulting in unrecoverable errors and additional maintenance and replacement costs.
• Entrance and exit over-height sensors were found to be accurate and economical but had too many intractable issues.
• One commercial off-the shelf video analytics system (Solution 2) was easy to set up and configure, however it required a head-on-view of the parking lot which needed to be placed far away for a narrow field-of-view and made it much more sensitive to adverse weather.
• Accuracy Results
  ○ Video Analytics Solution 1: 96%
  ○ In-pavement (measured after repairs, 22% failed with the first year of use): 88%
	In/Out
	• Overheight
	
	Space-by-Space
	• In-pavement sensors
	• Camera video
		Illinois
		• 1 site
			• Not included in test	Test	Source 9: Truck Parking Stall Occupancy Sensor Accuracy Study (2021)

Project Description and Experience	Detection Type	Location	Dissemination	**Status**	Source (See Table 4)
○ Overheight (97% accurate without the presence of maintenance vehicles): 42% ○ Video Analytics Solution 2 (required head-on view of vehicles): 12%					
MAASTO TPIMS • MAASTO, which represents Iowa, Indiana, Kansas, Kentucky, Michigan, Minnesota, Ohio and Wisconsin, received a TIGER grant to develop and implement a regional TPIMS. The TPIMS involves the development of a coordinated truck parking management solution in the Midwest region. • Means of detection and notification are uniquely defined within each State, but the information from each State will be collected through standard XML feeds and shared through a common API via DMS, traveler information websites, and a smart phone app. • The in-pavement sensors have failed at a very high rate. To better monitor sensor failures, a real-time alert system based on visual sensing is also developed. • Iowa was unique in that there were not any roadside signs installed, but rather used data feeds. Resources were focused on instrumenting more public and private sites.	In/out • Video (For areas with more than 25 stalls) Space-by-space • In-pavement (for areas with less than 25 stalls)	Iowa • 14 public sites • 10 private sites	• 3rd Party • 511	Deployed	Source 1: ARDOT Truck Parking Survey Results (2024) Source 3: Evaluation of Iowa Truck Parking Information and Management System Phase 2: Performance Measures and Data Analysis (2023) Source 15: National Coalition on Truck Parking: Technology and Data Working Group - Truck Parking Availability Detection and Information Dissemination (2018)

Project Description and Experience	Detection Type	Location	Dissemination	Status	Source (See Table 4)
MAASTO TPIMS • MAASTO, which represents Iowa, Indiana, Kansas, Kentucky, Michigan, Minnesota, Ohio and Wisconsin, received a TIGER grant to develop and implement a regional TPIMS. The TPIMS involves the development of a coordinated truck parking management solution in the Midwest region. • Means of detection and notification are uniquely defined within each State, but the information from each State will be collected through standard XML feeds and shared through a common API via DMS, traveler information websites, and a smart phone app. • KDOT is using a "computer vision" system that uses cameras to build a 3D image of the parking area so available spaces can be automatically detected. Most rest areas will have two camera poles installed near the truck parking area and each pole will have three cameras mounted on it to produce the 3D image.	Space-by-space • Computer vision	Kansas • 16 public sites	• DMS • 3rd Party • 511	Deployed	Source 1: ARDOT Truck Parking Survey Results (2024) Source 15: National Coalition on Truck Parking: Technology and Data Working Group - Truck Parking Availability Detection and Information Dissemination (2018)
MAASTO TPIMS • MAASTO, which represents Iowa, Indiana, Kansas, Kentucky, Michigan, Minnesota, Ohio and Wisconsin, received a TIGER grant to develop and implement a regional TPIMS. The TPIMS involves the development of a coordinated truck parking management solution in the Midwest region. • Means of detection and notification are uniquely defined within each State, but the information from each State will be collected through standard XML	In/out • Radar	Kentucky • 9 public sites • 14 private sites	• DMS • 3rd Party • 511	Deployed	Source 1: ARDOT Truck Parking Survey Results (2024) Source 15: National Coalition on Truck Parking: Technology and Data Working Group - Truck Parking Availability Detection

Project Description and Experience	Detection Type	Location	Dissemination	**Status**	Source (See Table 4)
feeds and shared through a common API via DMS, traveler information websites, and a smart phone app. • System Design and Construction ○ Not all sites can be designed the same. Different/ complementary technologies could be used to compensate. Consider implementing a testbed to try multiple technologies with various conditions, such as driver behavior or weather and technology comparison. • Integration and Testing (burn-in) ○ Integrate low-cost verification cameras for the roadside DMS/signage. ○ Calibration was modified to take snapshots for manual counting. On-site cameras take multiple snapshots of their respective lot(s) for full coverage. This modification was implemented during the burn-in. ○ Web-based power switches were installed to remotely reset devices due to geographically dispersed locations. This modification was implemented during Operations and Maintenance (O&M). • Operations and Maintenance ○ Operations - Determine how to reduce the time required for manual intervention to correct the accuracy of spaces available in the lots. ○ Drivers park in front of the sensors, park in unmarked spaces, enter or exit in the wrong direction, etc. Some software changes were made,					and Information Dissemination (2018)

Project Description and Experience	Detection Type	Location	Dissemination	**Status**	Source (See Table 4)
and manual calibrations are used to compensate for these scenarios. ◦ Too much ground truthing (manually counting spaces using camera snapshots) is needed with the current technology (radar sensors) in order to keep counts accurate.					
Space-by-Space Detection Evaluation • Kentucky DOT is evaluating space-by-space detection using existing CCTV and Multiview cameras as well as AI video analytics technology based on deep-neural networks. • AI analytics technology is combination with in/out is also being evaluated.	In/Out • AI analytics Space-by-Space • CCTC and Multiview cameras • AI video analytics	Kentucky	• Unknown	Evaluation	Source 1: ARDOT Truck Parking Survey Results (2024)
MAASTO TPIMS • MAASTO, which represents Iowa, Indiana, Kansas, Kentucky, Michigan, Minnesota, Ohio and Wisconsin, received a TIGER grant to develop and implement a regional TPIMS. The TPIMS involves the development of a coordinated truck parking management solution in the Midwest region. • Means of detection and notification are uniquely defined within each State, but the information from each State will be collected through standard XML feeds and shared through a common API via DMS, traveler information websites, and a smart phone app.	In/out • In-ground sensors • Camera-based detection	Michigan • 8 public sites • 22 private sites	• DMS • 3rd Party • 511	Deployed	Source 1: ARDOT Truck Parking Survey Results (2024) Source 7: ATRI Truck Parking Information Systems: Truck Driver Use and Perceptions (2021) Source 14: National Coalition on Truck

Project Description and Experience	Detection Type	Location	Dissemination	**Status**	Source (See Table 4)
• With the TIGER funding, Michigan is expanding their TPIMS along I-94 and into other corridors. Michigan may expand their in-ground sensors with camera-based detection at the TPIMS sites.					Parking: Technology and Data Working Group - Truck Parking Availability Detection and Information Dissemination (2018)
TPIMS • In 2014, prior to the TIGER grant Michigan DOT installed TPIMS. • The DMS are placed a maximum of 30 minutes or 30 miles upstream from the farthest destination on the sign. This spacing standard is used to minimize the likelihood that the number of available spaces would change significantly prior to a trucker's arrival at the parking facility. The data on the signs updates approximately every 3 to 5 minutes. Private truck parking locations are displayed on the sign only by their exit number to remove perception of advertising.	In/out • Wireless magnetometers Space-by-space • Video cameras	Michigan • 15 public and private sites	• DMS • Smartphone apps • In-cab displays • Multiple websites	Deployed	Source 14: National Coalition on Truck Parking: Technology and Data Working Group - Truck Parking Availability Detection and Information Dissemination (2018)
MAASTO TPIMS • MAASTO, which represents Iowa, Indiana, Kansas, Kentucky, Michigan, Minnesota, Ohio and Wisconsin, received a TIGER to develop and implement a regional TPIMS. The TPIMS involves the development of a coordinated truck parking management solution in the Midwest region. • Means of detection and notification are uniquely defined within each State, but the information from	Space-by-space • In-pavement puck sensors	Minnesota • 7 public sites	• DMS • 3rd Party • 511 • Static and dynamic feed on the MAASTO TPIMS website	Deployed	Source 4: North/West Passage Truck Parking Information Management System Assessment (2023) Source 14: National Coalition on Truck Parking: Technology

Project Description and Experience	Detection Type	Location	Dissemination	**Status**	Source (See Table 4)
each State will be collected through standard XML feeds and shared through a common API via DMS, traveler information websites, and a smart phone app. • MnDOT has noted challenges with the longevity and performance of the puck technology used to detect truck parking availability. A combination of technology and operating condition challenges, including inclement weather like ice and freezing rain, have led to battery performance and puck failure issues. MnDOT is currently evaluating the potential to upgrade its sensing technologies.					and Data Working Group - Truck Parking Availability Detection and Information Dissemination (2018)
University of Minnesota Pilot Study • The University of Minnesota conducted a pilot study from 2012-2017. • All three notification mechanisms (e.g., DMS, internet/website information portal) were evaluated during the field test. • Overall, the system tested provided accurate 24/7 information about truck parking availability to drivers. • System proved to be 95 percent accurate with discrepancies of ±1-3 counts. Accuracy slightly lower at night. • System operated 24/7 and was able to self-calibrate. • From a post-implementation survey and assessment from drivers and carriers. • Drivers prefer receiving information via an onboard computer and 20 miles in advance.	Space-by-space • Video cameras with stereoscopic Video analytics	Minnesota • 3 sites	• DMS • Internet/ website information portal • Onboard geolocation application	Deployed	Source 4: North/West Passage Truck Parking Information Management System Assessment (2023) Source 7: ATRI Truck Parking Information Systems: Truck Driver Use and Perceptions (2021) Source 14: National Coalition on Truck Parking: Technology and Data Working Group - Truck Parking

Project Description and Experience	Detection Type	Location	Dissemination	**Status**	Source (See Table 4)
• The ideal parking information system would utilize highly accurate, automated cameras to count available truck parking spaces. Digital imaging cameras is highly accurate but relatively expensive, the Minnesota's project cost increased due to the use of 3D cameras. • Video systems do not impact the pavement and substructure of the parking surface which is important to government agencies when freeze/thaw cycles exist.					Availability Detection and Information Dissemination (2018) Source 16: A Comprehensive System for Assessing Truck Parking Availability (2017)
MAASTO TPIMS • MAASTO, which represents Iowa, Indiana, Kansas, Kentucky, Michigan, Minnesota, Ohio and Wisconsin, received a TIGER to develop and implement a regional TPIMS. The TPIMS involves the development of a coordinated truck parking management solution in the Midwest region. • Means of detection and notification are uniquely defined within each State, but the information from each State will be collected through standard XML feeds and shared through a common API via DMS, traveler information websites, and a smart phone app.	In/out • In-ground sensors	Ohio • 18 public sites • 33 private sites	• DMS • 3rd Party • 511	Deployed	Source 12: State DOTs Are Provided Parking Software for Trucks at Rest Stops (2019) Source 14: National Coalition on Truck Parking: Technology and Data Working Group - Truck Parking Availability Detection and Information Dissemination (2018)

Project Description and Experience	Detection Type	Location	Dissemination	Status	Source (See Table 4)
MAASTO TPIMS • MAASTO, which represents Iowa, Indiana, Kansas, Kentucky, Michigan, Minnesota, Ohio and Wisconsin, received a TIGER to develop and implement a regional TPIMS. The TPIMS involves the development of a coordinated truck parking management solution in the Midwest region. • Means of detection and notification are uniquely defined within each State, but the information from each State will be collected through standard XML feeds and shared through a common API via DMS, traveler information websites, and a smart phone app. • The 2017 deployment of TPIMS as part of the MAASTO project concentrated on expanding truck parking that had been completed in 2016.	Space-by-Space • Video pattern recognition (cameras) In/out • Magnetometer	Wisconsin • 7 public sites	• DMS • 3rd Party • 511	Deployed	Source 1: ARDOT Truck Parking Survey Results (2024) Source 14: National Coalition on Truck Parking: Technology and Data Working Group - Truck Parking Availability Detection and Information Dissemination (2018)
TPIMS • In 2016 Wisconsin deployed TPIMS. The magnetometer counts vehicles entering and the video system analyzes how many parking spaces are occupied in real-time.	In/out • Magnetometer Space-by-Space • Video pattern recognition (cameras)	Wisconsin • 4 sites	• 511 • DMS • 3rd party	Deployed	Source 14: National Coalition on Truck Parking: Technology and Data Working Group - Truck Parking Availability Detection and Information Dissemination (2018)
I-10 Corridor Coalition TPAS • TPAS began in 2020 and is expected to go live in 2024 • A survey of over 500 responses from drivers and dispatchers indicated that the preferred method for	In/out • Indirect sensing (Texas, New	California, Arizona, New Mexico, and Texas (I-10	• DMS • Smartphone and in-cab applications	Deployed	Source 1: ARDOT Truck Parking Survey Results (2024)

Project Description and Experience	Detection Type	Location	Dissemination	**Status**	Source (See Table 4)
receiving real-time information is roadside DMS (43%) and expressed a preference that the signs display at least two or three upcoming sites. They also preferred a sign that shows rest areas within five to 45 miles and the total number of available spaces. • Select the detection technology according to conditions of the site (e.g., fog, weather, reliability of cellular connection service provider especially in rural areas). (California)	Mexico, and California) Space-by-space • Direct sensing (Arizona)	Corridor at 37 public sites)	• Website and traveler information sites		Source 4: North/West Passage Truck Parking Information Management System Assessment (2023) Source 5: TPAS FactSheet (2023) Source 19: I-10 Corridor Coalition Truck Parking Availability System (TPAS) Website
I-5 Joint Regional TPIMS • Project to kick off in late 2024 or early 2025. Project should be complete in 2027.	TBD	Oregon, Washington, and California • I-5 Corridor at 54 sites	• Digital roadside sides • Directly to their cabs, if they have compatible in-cab technology • Via smartphone apps or travel websites	Awarded	Source 2: Truck parking on Interstate 5 will be safer and easier thanks to new grant-funded project (2024)

Project Description and Experience	Detection Type	Location	Dissemination	**Status**	Source (See Table 4)
TPIMS • WSDOT has noted challenges with the performance of the puck technology used to detect truck parking availability, and the state is considering a range of additional sensing technologies, including Omni Sight Radar, video detection using fixed cameras, and Wavetronix lidar, for the expansion. The state is open to combining one or more technologies or using a mix of technologies in a system-agnostic approach. • WSDOT plans to select TPIMS technologies by early fall 2023, with construction and deployment by the end of 2024 and evaluation occurring in 2025. The University of Washington is also refining its existing truck parking availability prediction algorithm for more accurate forecasting.	TBD	Washington • 21 rest areas • 7 weigh stations	• Traveler information map • App • API	Planning	Source 4: North/West Passage Truck Parking Information Management System Assessment (2023) Source 6: Appendix H: Washington Truck Parking Assessment (2022)

TPIMS Pilot Project
• WSDOT partnered University of Washington to pilot a TPIMS in 2019 which included an algorithm to predict future truck parking availability up to four hours in advance with about 12 percent error.
• WSDOT Truck Parking Online Information
  ○ Scatter Creek Safety Rest Area
  ○ Nisqually Weigh Station
	Space-by-Space
	• In-pavement puck sensors
		Washington
		• 2 sites
			• Application
			• Website
				Pilot	Source 4: North/West Passage Truck Parking Information Management System Assessment (2023)
					
					Source 6: Appendix H: Washington Truck Parking Assessment (2022)

Project Description and Experience	Detection Type	Location	Dissemination	**Status**	Source (See Table 4)
TPIMS Pilot Project • Montana DOT is conducting a TPIMS pilot project. • MDT released a Request for Information (RFI) (opened March 2023 and closed April 2023) to inform the assessment and selection of TPIMS technologies and design. • The technology implemented is to be a resilient that will remain accurate through inclement weather, such as snowstorms.	TBD	Montana • 2 sites on I-90	• DMS • 511 website • API	Pilot Project	Source 4: North/West Passage Truck Parking Information Management System Assessment (2023)
Rest Area & Truck Pullout Truck Parking Analysis • Video cameras were placed at each rest area on June 26, 2018, to record the occupancy in truck-only parking spots over a single 24-hour period. Cameras were positioned at strategic locations at each rest area to capture entering/exiting trucks and to provide a view of all truck parking spots. • The project identified which locations truck parking was adequate to accommodate the demand for most hours of the day and which location will exceed capacity for at least one hour.	In/Out • Video cameras Space-by-Space • Video cameras	South Dakota • 30 locations	• Information was not disseminat-ed	Deployed	Source 4: North/West Passage Truck Parking Information Management System Assessment (2023) Source 15: South Dakota DOT Rest Area & Truck Pullout Truck Parking Analysis (2018)
The Eastern Transportation Coalition – Truck Parking • The Eastern Transportation Coalition initially developed systems engineering documents and then turned the system over to Virginia in 2018. • The Eastern Transportation Coalition summary of key lesson learned: need for stakeholder outreach and buy-in, interoperability of systems and technologies ensures	In/out • Pavement puck sensors Space-by-space • Pavement puck sensors	Virginia • 5 sites	• 511 system • XML feed	Deployed	Source 4: North/West Passage Truck Parking Information Management System Assessment (2023)

Project Description and Experience	Detection Type	Location	Dissemination	Status	Source (See Table 4)
flexibility, consider ongoing operations and maintenance costs, balance between consistent regional approach and state flexibility, private sector participation is desirable but hard to achieve, dissemination systems should be diverse and should prioritize safety, sharing lessons learned helps achieve gradual improvements, and need to ensure that there is adequate truck parking capacity.					Source 7: ATRI Truck Parking Information Systems: Truck Driver Use and Perceptions (2021) Source 20: The Eastern Transportation Coalition – Truck Parking (website)
PA Turnpike Installing Truck Parking Technology at 10 Service Areas • Truck parking management system deployed in June 2021. • This data will also be available to drivers through other travel apps and third-party truck parking information systems.	Unknown	Pennsylvania Turnpike • 10 sites	• DMS	Deployed	Source 10: PA Turnpike Installing Truck Parking Technology at 10 Service Areas (2021)
Pilot Test • Tracking state owned parking sites for activity. • Place devices in areas where they cannot be blocked by a truck, otherwise, they do not work correctly.	In/Out • In-pavement	New Jersey	• Broadcasted using electronic signage	Pilot Test	Source 1: ARDOT Truck Parking Survey Results (2024)