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# Overview

## Introduction

The freight and logistics system that supports the US economy predominately runs on trucks. Truck parking facilities play a key role in ensuring trucker and public safety by providing safe parking facilities with available parking and direct corridor access. This report provides a review of the research on truck parking as well as pilot projects developed and implemented to assess truck parking systems. These studies and pilot projects have focused on how agencies can provide adequate parking at appropriate locations and ensure that parking opportunities are clearly known by operators. The provision of parking spaces, coordination with private sector parking facilities, and Intelligent Transportation Systems (ITS) and telecommunications practices to detect, monitor, and communicate parking availability dominate the literature and field of practice.

## Rationale for Truck Parking Management Systems

### Increasing Truck Volumes and Tonnage

Increasing truck traffic volumes carrying a growing amount of freight tonnage on existing infrastructure increases the need for truck parking management systems (TPMS). More stringent hours of service regulations also create more demand for available truck parking. Efforts to expand the number of parking spots, increase communication about and awareness of existing parking spots, and work with private sector providers have dominated operational and policy approaches to truck parking management.

The need for truck parking will only increase in the future. In 2012, trucks moved more than 13 million tons of freight, or 67 percent of all freight by tonnage (Table 1). The Federal Highway Administration (FHWA) projects that freight tonnages will increase by 38 percent to more than 18 million tons per year by 2040. Most of this freight is expected to continue to be moved by trucks (BTS, 2013).

**Table 1: FHWA Reported Freight Tonnages**

| | Truck-exclusive Shipments (millions of tons) | All Shipments (millions of tons) |
|---|---|---|
| 2012 | 13,182 | 19,662 |
| 2040 | 18,786 | 28,520 |

There are an estimated 1.6 million heavy and tractor trailer truck drivers in the United States (BLS, 2015). These drivers work for about 1.2 million companies, many of which are independent or small businesses. The trucking industry also employs an additional 7 million people in related fields (ATA, 2015).

Just-in-time (JIT) freight logistics also adds to the truck parking demand as drivers queue at parking facilities near large metropolitan areas to time their deliveries to crowded facilities or to match gate times. This creates two kinds of truck parking needs: open-road/rural parking and urban/suburban parking to address central city logistics and access patterns. Both short- and long-haul moves are increasing. During the past decade, local and short-haul shipments grew 41 percent by value, 16 percent by weight, and 19 percent by ton-miles. Shipments traveling more than 250 miles grew faster—51 percent by value, 34 percent by weight, and 36 percent by ton-miles (BTS, 2004).

### Safety as a Function of Fatigue and Parking Availability

Safe operation of vehicles and illegal parking are both concerns when limited information on available spaces or actual space limitations impact truck operator decision-making. The Federal Motor Carrier Safety Administration (FMCSA) publishes data on truck crashes but there is less information about the degree to which driver fatigue—and its relationship to available truck parking— was potentially related to the crashes. Between 2002 and 2012 (FMCSA, 2012):

- The number of large trucks involved in fatal crashes decreased from 4,587 to 3,802, a drop of 17 percent.
- The number of large trucks involved in injury crashes decreased from 94,000 to 77,000, a drop of 18 percent.
- The number of large trucks involved in property damage only crashes decreased from 336,000 to 253,000, a drop of 25 percent.

As truck volumes rebounded after the 2007 economic downturn, truck crashes also increased. Between 2011 and 2012 (FMCSA, 2012):

- The number of large trucks involved in fatal crashes increased by 5 percent, from 3,633 to 3,802, and the vehicle involvement rate for large trucks in fatal crashes (vehicles involved in fatal crashes per 100 million miles traveled by large trucks) increased by 4 percent.
- The number of large trucks involved in injury crashes increased by 22 percent, from 63,000 to 77,000, and the vehicle involvement rate for large trucks in injury crashes increased by 22 percent.
- The number of large trucks involved in property damage only crashes increased by 14 percent, from 221,000 to 253,000, and the vehicle involvement rate for large trucks in property damage only crashes also increased by 14 percent.

While making a causal link between parking availability, driver fatigue, and crashes is difficult, analysis linking truck crashes with fatigue has been completed in at least three studies and reviewed in several more. A study for the California Highway Patrol analyzed 2,203,789 accidents between 1995 and 2005 (Banerjee et al., 2009). Truck collisions constituted 4.4 percent of the total number of collisions. Fatigue contributed to a higher percentage (1.9 percent) of truck collisions than to collisions of all vehicle types (1.3 percent). In this analysis, fatigue was only indicated on the crash record when it was apparent the driver fell asleep or could be assumed to be fatigued. Based on an expanded definition that includes the factors of single driver, single vehicle collision, driver at fault, driver not intoxicated or speeding, no defect in vehicle, vehicle either crossed into opposing lane or ran off road preceding the collision, the vehicle struck another moving or parked vehicle, fatigue contributed to 11.3 percent of truck collisions compared with 9.7 percent of collisions of all vehicle types.

The authors of the The Large Truck Crash Causation Study found that approximately 12 percent or 9,000 of the 78,000 crash cases were related to “driver non-performance.” This category of critical crash elements incudes fatigue, as well as other possible causes such as a heart attack, or the failure of other causes to explain the crash. Michigan’s assessment of this data found that between 1996 and 2001 fatigue was associated with 2.6 percent of large truck operators involved crashes, 3.6 percent of for-hire drivers, and 14.4 percent of the less-than-truckload (LTL) drivers (FMCSA, 2007).

Similarly, the Insurance Institute for Highway Safety (IIHS) found that truck operators behind the wheel for more than eight hours are twice as likely to be involved in a crash (IIHS, 2015). IIHS reports that operator work cycles in trucking can result in sleep deprivation, disruption of normal sleep/rest cycles, and fatigue. IIHS researchers found that truck drivers reporting hours-of-service violations are more likely to report having fallen asleep behind the wheel during the past month. IIHS also reports that a truck driver's hours-of-service violations and logbook violations, which result in the driver being placed out of service, increased the likelihood that the truck driver would be determined to have precipitated the crash. IIHS researchers concluded that "[t]he proportion of large truck crashes for which fatigue is a contributing factor is uncertain."

Other studies suggest that fatigued driving is similar to drunk or drugged driving. The authors of an Australian study found that 20 percent of all road accidents involve fatigue and that a person awake for 17 hours has the same crash risk as a person with a blood alcohol content (BAC) of .05 g/100mL. A person awake for 24 hours has same performance as someone with a BAC of .1 g/100mL (Transport Accident Commission, 1998). A truck-specific study in New Zealand suggested that fatigue was factor in 3 percent of truck crashes (New Zealand Ministry of Transport, 2014).

An examination of the critical role of public rest areas and fatal crashes involving cars and trucks found that fatigue-related crashes account for 2.2-2.6 percent of all fatal crashes in the United States. Through further modeling the researchers determined that "proximity of a road segment to the nearest rest area significantly influences crash frequencies on both freeways and two-lane highways" (McArthur et al., 2013). In Michigan, study results showed a positive relationship between rest area spacing and fatigue-related truck crashes with a significant increase in crashes "when rest area spacing exceeded 50 miles" (Taylor et al., 1999). A similar study in Minnesota showed that single truck crash densities increased at all times of the day with rest area distances greater than 30 miles (SRF, 2007). Both studies concluded that increased crash rates were related to overcrowded or insufficient truck parking. Factors related to fatigued operations and parking limitations demonstrate the importance of rest areas and their use:

- The studies conclude that freeway segments greater than 30 miles from a rest area experienced disproportionately more single vehicle truck crashes than segments less than 30 miles from a safety rest area.
- There is a relationship between high levels of commercial motor vehicle (CMV) parking and incidence of single-vehicle nighttime truck crashes.
- Single-vehicle truck crashes occur at a disproportionate rate to truck volumes during nighttime hours.
- 39 percent of single-vehicle truck crashes occurred between 10PM and 6AM, despite only 21 percent of truck volume occurring during these hours.
- Single-truck nighttime crashes are considered to be a proxy for fatigued driving.
- The highest single-truck crash rate occurred when the hourly truck rate was lowest.

There are methodological as well as data collection challenges with understanding the role of access and availability of rest area parking on truck operator fatigue, performance, and crashes. Overall, the data presented indicates that based on a strict definition of fatigued driving, fatigued driving accounts for 2.2-2.6 percent of all fatal crashes and approximately 1.9 percent of all fatal truck crashes. However, when the definition of a fatigued event is expanded to include a broader range of possible proxy factors such as a single vehicle crash or leaving the road with no other causation, the rate of truck crashes attributed to fatigue expands to more than 11 percent. The rest area proximity studies also suggest that unavailable or inconvenient parking is linked to increased crash rates.

## Truck Parking Availability

Truck operators use both public and private facilities for short- and longer-term truck parking. In addition to actual limits on available spaces, other factors also affect parking spot utilization. In some cases parking is available but not easily located. In other cases operators perceive the parking to be unreliable due to past experiences with limited spaces. According to a 2002 study on truck parking facilities, spaces provided by public agencies constituted just 10-16 percent of the total truck parking spaces, or just over 31,000 spaces (FHWA, 2002). Estimates on the number of parking spots at private facilities place the number between 167,534 and 284,601 spaces. This report documents 1,771 public lots and 3,382 private facilities. With more than 80 percent of the spaces and more than 60 percent of the facilities in private hands, understanding truck parking services and strategies at these facilities will be crucial to creating a successful and far-reaching approach to truck parking systems.

In 2002, demand for spaces on highways with greater than 1,000 average annual daily truck traffic (AADTT) outstripped availability. Demand was estimated at 287,000 spaces while only 31,000 spaces were available (FHWA, 2002). This estimated demand was based on an annual truck freight tonnage in 2002 of 11,539 million tons (FHWA, 2007). Using this same simple estimation method, 327,865 parking spaces were needed in 2012 to support 13,182 million tons of truck freight (FHWA, 2012). The authors provide a simplified demand model for truck parking spaces.

This simplified model predicts the demand (*D*) for commercial truck parking spaces along a highway segment based on total truck-hours of travel per day (*THT*) on that segment and the average parking time per truck-hour of travel ($P_{avg}$).

$$D = THT \cdot P_{avg} \qquad (1)$$

The average truck-hours of travel per day for a segment is estimated from:

$$THT = P_t \cdot AADT \cdot L/S \qquad (2)$$

where $P_t$ is the percent of vehicles that consists of commercial trucks, *AADT* is the annual average daily traffic, *L* is the length of the segment, and *S* is the speed limit or average truck speed. The term $P_{avg}$ is a parameter that is estimated during the calibration step to best fit the calibration data.

The authors point out that estimating parking demand is complicated and not only relates to truck volume but is geographically specific and also dependent on operator preferences, the percentage of short- and long-haul trucks, the time of day, delivery schedules, rural or urban setting, team driving, and regulatory issues.

## Truck Operator Attitudes and Parking Practices

Understanding how truck operators locate and select parking opportunities provides useful information about implementing truck parking systems. Based on research from 2002, about 98 percent of drivers choose parking locations at their own discretion, and most of these drivers have difficulty finding parking (FHWA, 2002). A survey conducted by the Mississippi Valley Freight Coalition (MVFC) found that 53 percent of drivers reported problems finding parking on more than 70 percent of their trips, and another 23 percent indicated they had problems finding parking on 30-70 percent of their trips (Adams et al., 2009). This lack of parking extends across the nation: an earlier FHWA study found that 90 percent of drivers experienced some sort of difficulty finding parking (FHWA, 2002).

The problem of parking shortages is exacerbated by truckers' lack of knowledge about nearby available parking spots: the MVFC study found that 63 percent of drivers had no awareness of nearby truck stops (Adams et al., 2009). Drivers often perceive that parking areas are full, even when they may not be. The Utah Department of Transportation (UDOT) found that 70 percent of drivers mentioned “no empty spaces at commercial stops or public rest areas” as a reason for parking on shoulders and on-ramps. Thirty percent of the truckers interviewed by UDOT also mentioned that not knowing the availability of parking spaces was a reason for parking on shoulders and on-ramps. These drivers claimed they would plan their parking better if they knew where facilities were located (UDOT, 2012). An earlier study by the FHWA confirms this perception: 84 percent of drivers mentioned they would like to receive real-time information about parking facilities along their route (FHWA, 2002).

The lack of information that leads drivers to unsafe or unsatisfactory parking spaces is often a product of their travel planning processes. Parking decisions are usually made in transit: 66-89 percent of truckers decide where to park once they are driving (Smith et al., 2005). For drivers, time is money, and they do not have time to deviate from their route to see if specific stops have spaces. Even so, according to recent in work in Michigan, 83 percent of drivers spend more than 30 minutes looking for parking, and 39 percent claimed they took longer than an hour to find parking. Long-distance drivers who are likely to be in need of a ten-hour break may not be familiar with the area as a whole. Better truck parking information while in transit, but without distraction, will allow truck drivers to make better parking choices.

Since the early 2000s, Intelligent Transportation Systems (ITS) technology has been considered the best way to solve this information asymmetry. A 2003 survey of transportation planners found that among a number of alternatives, “use of ITS to expand amount of information available to truckers” was ranked first and is believed to be the most effective and feasible solution (Trombly, 2003). A National Freight Advisory Committee report also recommends technological/ITS solutions to truck parking issues (recommendation C17) and also mentions fatigue prevention to stem accidents in the transportation sector (recommendation C16) (NFAC, 2014).

## Regulatory influence

Both historic trends and recent changes in hours-of-service regulations are designed to keep fatigued operators off the road to increase safety. Table 2 shows regulations governing hours of operations from 1938 to 2013 (Wikipedia, 2015). Operators must log hours spent driving and working, resting, and the times of change in duty status.

**Table 2: History of Hours of Service**

| Year Enforced | Driving Hours | On-Duty Hours | Off-Duty Hours | Minimum Duty Cycle | Maximum Hours On-Duty Before 30 Minute Rest Break |
|---|---|---|---|---|---|
| 1938 | 12 | 15 | 9 | 24 | None |
| 1939 | 10 | None | 8 | 24 | None |
| 1962 | 10 | 15 | 8 | 18 | None |
| 2003[1] | 11 | 14 | 10 | 21 | None |
| 2013[1] | 11 | 14 | 10 | 21 | 8 |

FMCSA (2014) also provides a summary of the hours of service rules for property-carrying drivers:

- **11-hour driving limit.** May drive a maximum of 11 hours after 10 consecutive hours off duty.**14-hour limit.** May not drive beyond the 14th consecutive hour after coming on duty, following 10 consecutive hours off duty. Off-duty time does not extend the 14-hour period.

- **Rest Breaks**: May drive only if 8 hours or less have passed since end of driver's last off-duty or sleeper berth period of at least 30 minutes. Does not apply to drivers using either of the short-haul exceptions in 395.1(e). [49 CFR 397.5 mandatory "in attendance" time may be included in break if no other duties performed].
- **60/70-Hour Limit.** May not drive after 60/70 hours on duty in 7/8 consecutive days. A driver may restart a 7/8 consecutive day period after taking 34 or more consecutive hours off duty.[1]

Trucking companies and associations followed suit after the regulations and worked to ensure the new rules were easy to follow. The American Trucking Associations (ATA) published a summary of FMCSA's changes to hours of service regulations and categorized the new rules as: maximum driving hours (11); restart (34 hours with two overnight periods); driving window (14 consecutive hours); mandatory rest break (not permitted to drive if over 8 hours since last 30 minute break): off-duty, oilfield exemption (waiting time can be recorded as off duty), and egregious violations (exceeding driving time window by three hours or more) (ATA, 2013).

Other groups such as the American Transportation Research Institute (ATRI) examined the rules critically and found that the hours service rules and 34-hour restart rule could actually result in increased accidents by moving some loads from late night and early morning to more congested daytime deliveries (Murray and Short, 2015). These same polices can also result in a concentration in the need of parking facilities to support compliance with hours of service, breaks, and restarts, especially in the case of staging for last-mile deliveries to urban areas.

MAP-21 includes new freight regulations and authority that support or instruct states as to the relevance of truck operations and available rest areas (FHWA, 2013). At the planning level, state DOTs are encouraged to develop a comprehensive plan for immediate and long-range freight-related planning and investment [§1118]. While truck parking is not explicitly mentioned in the freight planning compliance area, it clearly falls under alignment with national goals: system strength and weakness, performance, and safety. There are also changes in funding eligibility that directly reflect truck parking systems. According to the FHWA, changes in freight eligibility, and specifically truck parking, under grant and loan programs include:

- **Surface Transportation Program**. Provides eligibility for truck parking and surface transportation infrastructure improvements in port terminals for direct intermodal interchange, transfer, and port access. [§1108; 23 USC 133]
- **Highway Safety Improvement Program**. Offers eligibility for truck parking. [§1112; 23 USC 148]
- **Congestion Management Air Quality**. Allows use of funds for a project or program to establish electric vehicle charging stations or natural gas vehicle refueling stations. [§1113; 23 USC 149]
- **Projects of National and Regional Significance (PNRS)**. Continues program with some changes. [§1120; SAFETEA-LU §1301]
- **Transportation Infrastructure Finance and Innovation Act**. Restricts use of loans for freight rail projects to direct intermodal transfer. [§2002; 23 USC 601(a)(12)(D)(i)(I)]

Additional efforts under MAP-21 were directed towards understanding the extent of truck operations and parking across the United States. Included in this area are Jason's Law and the Truck Size and Weight study. Jason's law is summarized as:

[1] The Consolidated and Further Continuing Appropriations Act of 2015 was enacted on December 16, 2014, suspending enforcement of requirements for use of the 34-hour restart.

Makes construction of safety rest areas, commercial motor vehicle (CMV) parking facilities, electric vehicle and natural gas vehicle infrastructure eligible for Federal funding. Requires DOT to survey States within 18 months of enactment regarding their CMV traffic and capability to provide CMV parking. DOT must periodically update this survey, and must post the results on DOT's website. [§1401]

Similarly the directives for the Compilation and Study of Truck Size and Weight Limits (CSTSW) also proscribe an inventory and survey of the trucks operating on the system as well as the guiding regulations. The directions with CSTSW include:

- Requires DOT, in consultation with States and other relevant Federal agencies, to report to Congress within two years of enactment on a comprehensive study of truck size and weight limits. [§32801]
- Requires DOT to report to Congress within two years of enactment on a compilation of State limitations on the size and weight of trucks that may travel on the National Highway System. [§32802]

These regulatory changes and the emphasis on freight can be expected to continue as the realization of the importance of freight movement to the economy and overall transportation system is better understood.

In summary, increasing freight loads further stress an already limited truck parking system. Truck operators often have difficulty finding adequate and safe parking. The state and national emphasis on freight and the safe operation of trucks—especially concerning available rest areas for truck parking—will help focus resources to address fatigued drivers. And increased scrutiny on the role of hours of service regulations designed to ensure rested and safe operators can be expected to drive the need for not only for more truck parking but also for truck parking management systems (TPMS). These systems not only offer parking, but maximize available resources for agencies, ensure awareness of parking options to operators, and provide a means to communicate the information to operators.

# TPMS Projects and Implementation

This section reviews recent efforts to develop and operationalize truck parking management systems (TPMS) in the MAASTO region, across the United States, and in Europe. This review details the components of the systems including corridor coverage, telematics, partnerships, and costs.

With the increasing freight loads, truck volumes, and safety concerns, managing and maximizing both the awareness and availability of rest area parking for truck operators is of paramount concern for state transportation agencies. States have truck parking management systems—with varying degrees of automation—to manage and maximize the available parking on major freight corridors. These truck parking systems generally consist of four components:

1. Provision of parking spots and partnerships to leverage parking with private providers.
2. Telematics that support the assessment or detection of available parking spots.
3. Communication of the availability of the spaces.
4. Operation and management of these systems.

Because close to 80 percent of truck parking spaces on major highways are privately held, many of these state-level efforts are working towards a public-private approach to leverage private infrastructure. MAASTO states are also working towards a regional approach to truck parking along multistate freight corridors to ensure the service and facilities support the business of trucking and logistics. Truck operations are without state administrative borders, so multistate, corridor-level approaches aim to provide continuity in services to match the continuity of freight movements.

## US Models of Implementation

Table 3 outlines the truck parking management systems implemented and tested to date. Work in Michigan, Minnesota, Tennessee, and along the I-95 corridor represents the state of the art in the United States. Efforts in the European Union (EU) were also captured to provide for the assessment of similar systems and operational issues.

**Table 3: US Models for Implementation**

| State | Michigan | Minnesota | I-95 Corridor | Tennessee |
|---|---|---|---|---|
| Project Link | Link | Link | Link | Link |
| Partners | Michigan DOT, FHWA, Truck Smart Parking Services (TSPS) | Minnesota DOT, University of Minnesota, ATRI, PeopleNet, OOIDA, Pilot Travel Centers | FHWA, MdDOT, Virginia DOT, Maryland DOT, I-95 Coalition, Telvent Farradyne | FMCSA, TnDOT, Gannett Fleming |
| Project Type | Parking space detection, communication, and management. | | | |
| Project Goals | Reduce illegal truck parking, improving highway safety | Improve truckers' decision making | Improving communication of parking availability | Reduce illegal and dangerous parking practices |

| State | | Michigan | Minnesota | I-95 Corridor | Tennessee |
|---|---|---|---|---|---|
| Facility Bounds | | 130 miles of I-94 between Kalamazoo and Jackson | 116 miles of I-94 northwest of Minneapolis | I-95 at MD-32 and between Richmond, VA and Washington, DC | I-75 in eastern Tennessee |
| Facility Count | Public | 5 | 4 | 2 | 2 |
| | Private | 5 | 1 | 0 | 0 |
| Components | Public Involvement | | | | |
| | Studies | | UMN study of video tech | | FMCSA SmartPark Demo |
| | Detection | Video, magnetic | Video | Video, thermal | Laser, radar |
| | Communications | VMS, web, apps | VMS, web, in-cab signals (PeopleNet) | VMS, web, cell phone, radio | VMS, web, apps, phone reservations |
| Project Cost | Detection | $1,711,055.00 | | | |
| | Communication | $616,450.00 | | | |
| | Other | $2,080,719.00 | | | |
| | Total Cost | $4,408,224.00 | $2,040,940.00 | $4,871,688 | |
| Maintenance Cost (annual) | Detection | $247,500.00 | | | |
| | Communication | $20,315.00 | | | |
| Cost sharing agreements | | TSPS maintains collection equipment in private stops. | | | |
| Data sharing agreements | | License to use data collected at private stops | UMN collects and shares data with MNDOT | | |
| Evaluation of project | | Pending, due fall 2015 | Pending, due fall 2015 | | |

There have been several proof-of-concept projects and smaller pilot projects to develop and implement components of truck parking systems. Michigan, Minnesota, Tennessee, Maryland, and Virginia have provided implementation leadership with truck parking management systems, often partnering with some combination of FHWA, FMCSA, and private-sector vendors. As shown in Table 3, three of these examples include multiple public and private partners, multiple rest areas, incorporate ITS technology, and are geared towards parking space detection, communication, and management. Project goals are predominantly aligned with increased operator and public safety through better communication of available parking, improved decision-making concerning parking, and reduced illegal parking or parking avoidance. These partnerships generally involve both private and public rest areas. In Michigan, five public and five private rest areas have been included so far. In Minnesota, four public and one private rest area are included. There are two public facilities in operation on the I-95 corridor. In Tennessee, two public rest areas are operational on I-75. Truck Smart Parking is providing private sector leadership in developing parking awareness and real-time parking systems.[2] While Michigan's public-private implementation of the system provides a real-time innovation example, the Truck Smart Parking business is mapping and providing rest area information for rest areas across the country with an apparent trajectory towards real-time monitoring, as well as notification systems for available spaces through the web, phone, and variable-message signs (VMS). Their locations in Michigan, developed in coordination with the Michigan DOT, are the first to provide real-time information about available parking spots.

The detection of available and filled parking spots is most commonly fulfilled using video detection, but magnetic, induction, thermal, and on-site observation is also used. Each of these approaches has its own advantages as well as limitations. Video detection seems most desirable due to its ability to be located out of traffic lanes, and it is less susceptible to damage, detection errors, and vandalism. Variable message signs provide the most direct access to truck operators without device or system intrusion into the cab and work space. Web applications, in-cab signals, cell phone, radio information and reservations are also used to communicate with truckers. In the I-95 model, incoming calls can be arranged to provide parking updates.

The costs to implement these truck parking management systems ranged between $2.04 million (Minnesota) to $4.4 million (Michigan) and $4.8 million (I-95 corridor). Figures 1, 2, and 3 show the user interfaces of these systems.

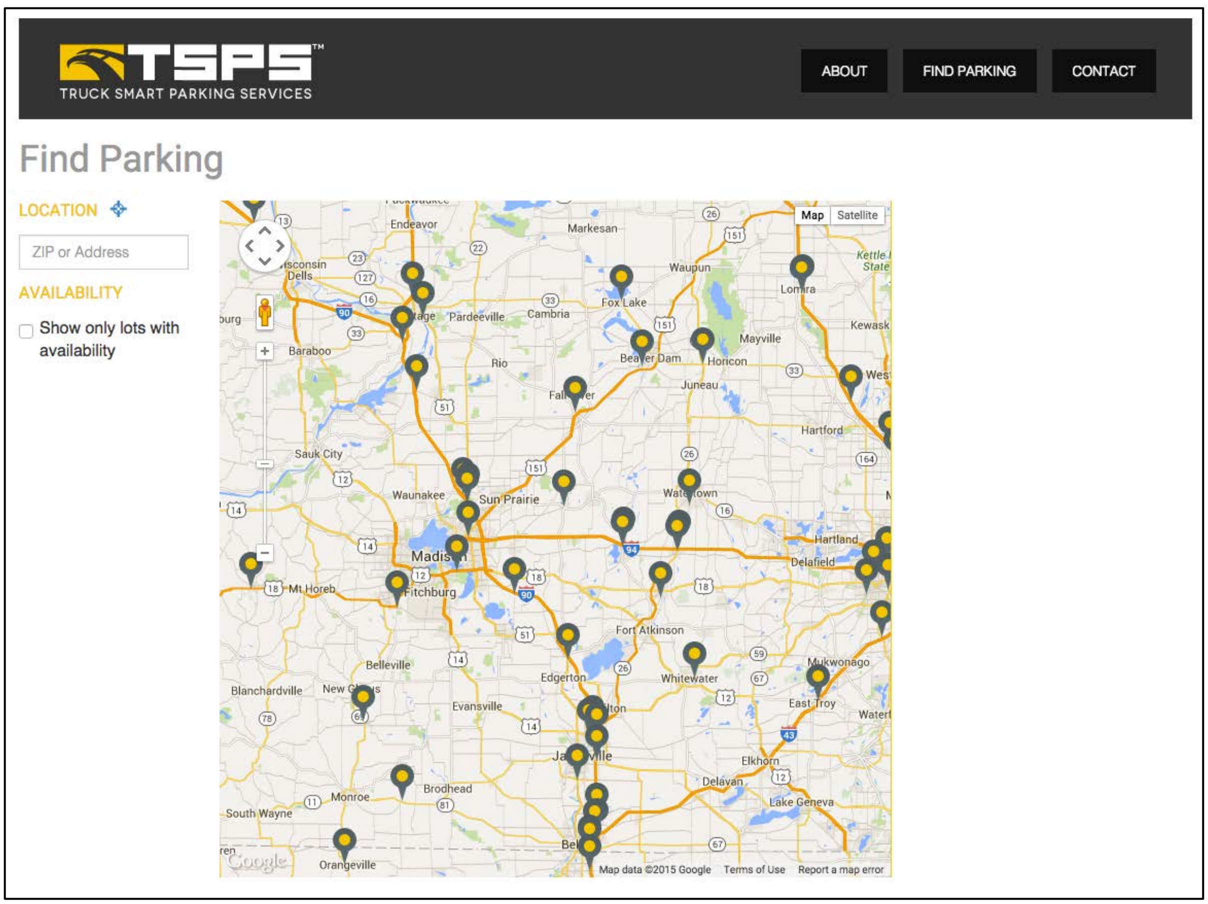



**Figure 1: Michigan Truck Smart Parking System (onlineparkingnetwork.net/map)**

[2] http://trucksmartparkingservices.com/


**Figure 2: Minnesota VMS Parking Alert (cts.umn.edu/research/featured/truckparking)**

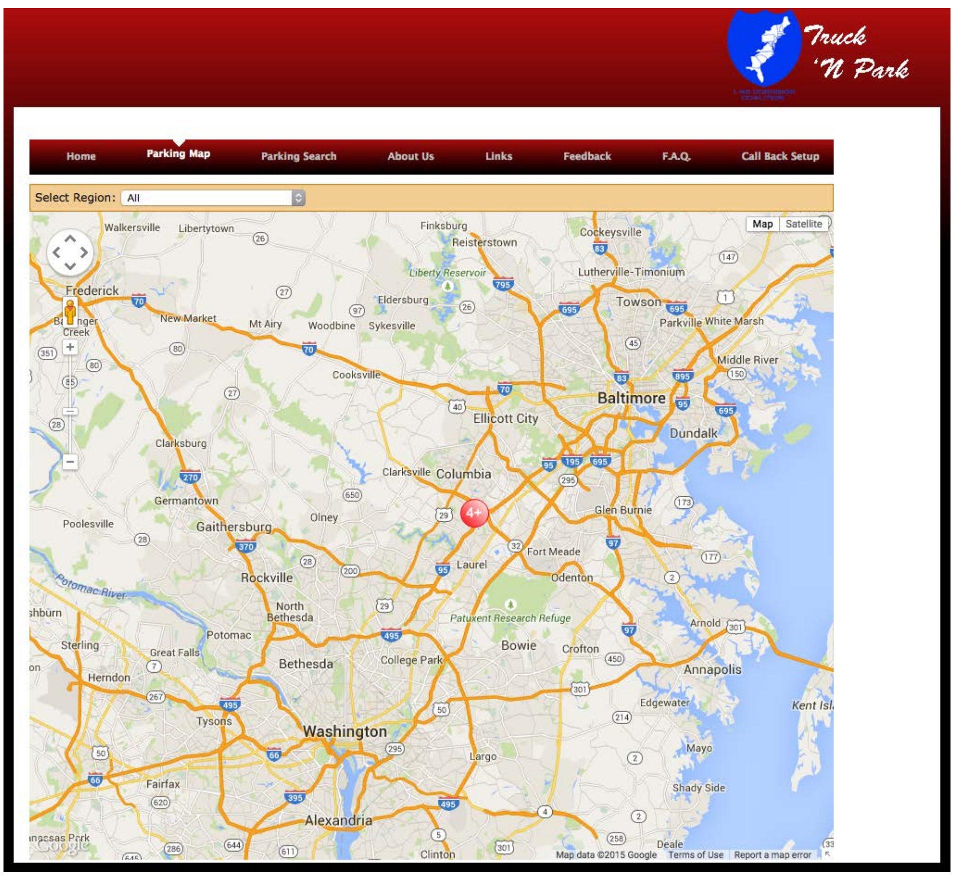
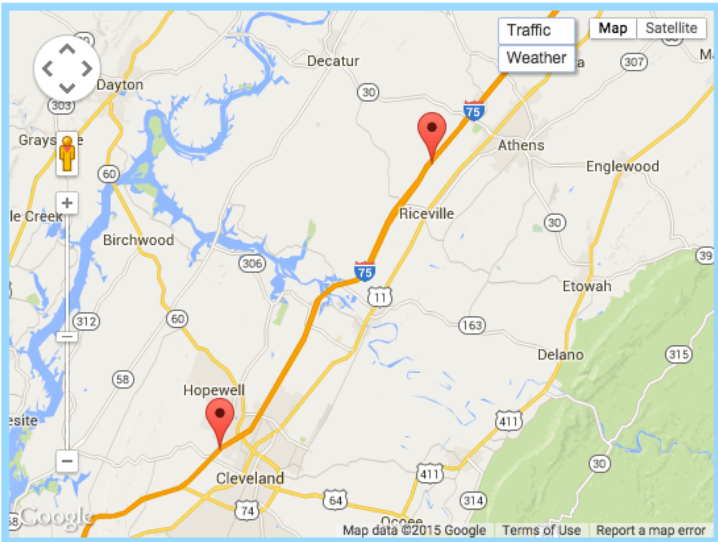



**Figure 3: Maryland I-95 Truck N Park with Call Back Option (trucknpark.com/tnp/ParkingMap.aspx)**

Click on marker for current parking, or use table below.
Click here for a project overview and answers to frequently asked questions




| Parking Area | Current Availability |
|---|---|
| Tennessee I-75 NB at MM 23 | Available |
| Tennessee I-75 NB at MM 45 | Available |

**Figure 4: Tennessee Smart Park Application (smartparkingusa.com)**

## Private Sector Implementation

Private truck facilities are also providing advanced parking services. TA/Petro travel centers provide general first come/first park, as well as Reserve-It Parking and Preferred Parking.[3] Depending on location and demand, an operator can pay between $13-$20 per 24 hour period to park. In limited locations, preferred parking is available with secure gates and parking discounts based on expenditures at the travel center. For example, an operator can receive 24 hours of free parking with every $50 in fuel purchased or $20 spent at the facility. Reservations require a credit card and are non-refundable.

## International Models of Implementation

In the European Union, the TruckInform system operates in 40 countries with more 2,800 parking spots.[4] TruckPArking Europe has pooled parking areas with more than 249,000 spaces.[5] This system acts as a clearinghouse that uses truck operator input to catalogue parking locations. The service also offers a mapping tool that can identify parking areas and available bays based on the operator's anticipated truck route. At the time of writing, both of these systems are nonviable.

Table 4 lists a variety of detection methods used in the EU including induction loops, magnetic sensors, video, ground radar, laser detection, overhead detectors, parking stall sensors, and pay-at-entry. Variable message signs (VMS) are the predominant form of communication with

[3] http://www.ta-petro.com/amenities/parking.
[4] http://www.truckinform.eu/. Note: At the time of writing, this website is inoperable.
[5] https://www.truckparkingeurope.com/

truck operators. Radio, smartphone applications, traffic message channels, and websites are also used. In some cases, to increase efficiencies per spot, VMS are also used to guide trucks to spots and manage parking locations based on expected departure times. The EU provides a well-documented deployment guide for truck parking: *Freight and Logistics Services. Intelligent Truck Parking and Secure Truck Parking* (EasyWay, 2012).

Table 4 highlights work in Germany, Italy, and the Netherlands, where limited truck parking management systems have been implemented.

**Table 4: International Models of Implementation**

| Nation | Area | Number of Sites | Detection Technology | Communication Technology |
|---|---|---|---|---|
| **Denmark** | E20 between Odense and Copenhagen | 1 parking area | Infrared | VMS |
| **Germany** | A5 at Hartheim | 5 rest areas | Magnetic sensors at entrance / exit | VMS, website |
| | A2 at Börde | 1 rest area | Induction loops in parking spaces | VMS |
| | A2 at Krahenberge | 1 rest area | Video network | VMS |
| | A1 at Buddikate | 1 rest area | Ground radar | VMS |
| | A8 near Aichen | 1 rest area | Magnetic sensors at entrance / exit | VMS |
| | A9 between Munich and Nuremburg | 21 lots | Laser and ground radar at entrance and exit | Radio, smartphone, Traffic Message Channel |
| | Port of Hamburg | 3 lots | Induction loop | N/A |
| | Montabur | 1 parking area | Paid entrance, gate and laser at exit | VMS guide to row (telematics controlled) |
| | A3 near Jura - Complete in 2015 | 1 parking area | Overhead detectors in each bay | VMS above each bay with departure time |
| **Italy** | A22 between Modena and Bolzano | N/A | Pay station for entry | VMS to be installed by 2015 |
| | A22 between Modena and Bolzano | N/A | Pay station for entry | VMS to be installed by 2015 |
| **Netherlands** | Eindhoven A67/E34 | 1 service area | Flush-mount sensors in each stall | Parckr software |

## Continuum of Implementation

In Figure 5, a TPMS operational continuum was developed based on levels of parking detection, communication, and management of truck parking systems based on the public- and private-sector work reviewed. The axes on the TPMS continuum represent varying levels of parking spot detection, and a step-wise approach to communication with truck operators. The projects on the continuum are also keyed to the level of public-private sector partnership on the project. The vertical axis represents the continuum of parking space detection; the scale ranges from direct observation, in/out accounting, laser, in-pavement, and video. Video detection is presumed to be optimal solution at this time based on the widespread adoption and reliability of these systems. The horizontal axis presents the continuum of communication with truck operators, characterized from passive to active. Passive communication is represented by the use of static signs, such as “Rest Area 34 miles” and does not provide additional information, or make an effort to reach operators with the information. The active end of the continuum includes variable message signs, connected technologies, and reservation systems. This scale reflects the level of active effort to reach consumers and provide advanced opportunities for operators to secure parking. The projects reviewed in this synthesis are then classified based on the level of partnership between the public and private sectors. Taken together, detection practices, communication practices, and partnership practices provide a snapshot of innovative approaches to truck parking management systems.

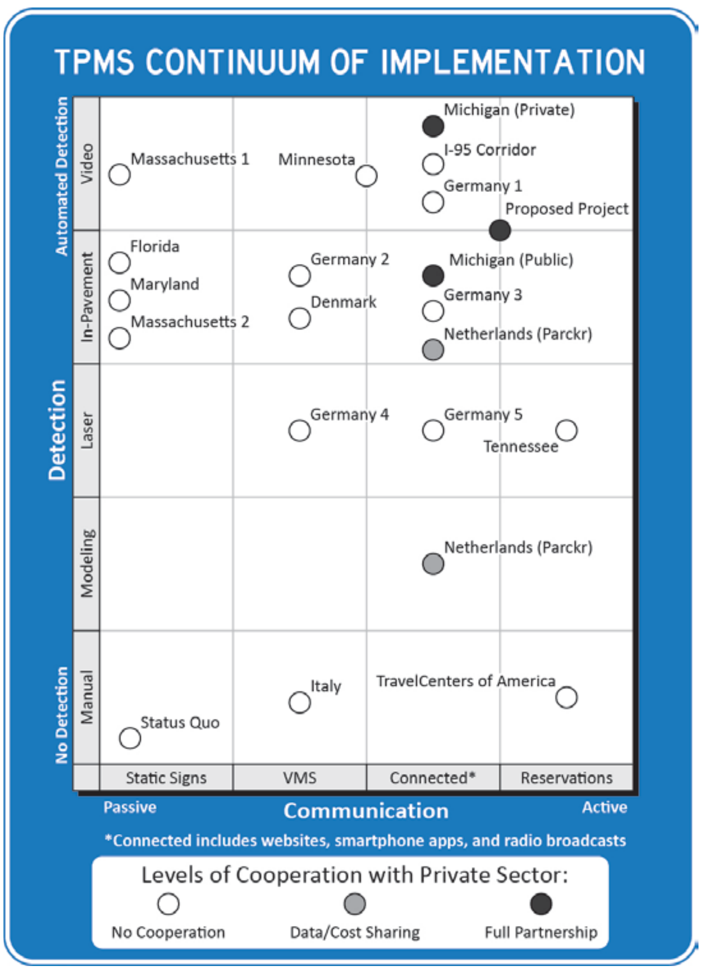



**Figure 5: Continuum of Implementation**

In addition to ITS-based truck parking systems, alternate approaches have also been piloted and implemented across states to increase truck parking availability. These techniques are not exclusive of ITS use and include reuse of existing parking areas, partnerships with the private sector, and improved communication of parking policies.

One trend in rest area management is recognizing and leveraging the private sector role in providing parking. Some states have explored public-private partnerships for the maintenance and operation of rest areas, but federal law prohibits privatization of rest areas on interstate highways (with some exceptions). In response, states like Vermont and Utah have experimented with closing publicly-owned rest areas and giving special recognition to local truck stops. In exchange for this recognition, the private stops must agree to provide a certain level of free parking and services. Another option is to create incentives for businesses, malls, and warehouse locations to allow truck parking especially in the case of warehouse facilities where there are large parking lots and truck traffic specific to the facility. More publicly-oriented alternatives to improving parking include reopening closed rest stops and weigh stations or relaxing parking time limits at existing rest stops and weigh stations.

## Performance Measures

A truck parking management system addresses a number of different areas of transportation, including public safety, trucking efficiency, and customer satisfaction. Performance measures are familiar and effective management tools used by state DOTs and should be incorporated into truck parking systems. Recommended measures identified in the literature include: level of awareness of facilities; acceptance and use of parking information system; changes in search time and difficultly in locating parking; changes in truck-related crashes; changes in illegal parking; and changes of utilization of parking facilities. Table 5 compares the major performance measures, their importance, data requirements, and difficulty of collection (Garber et al., 2004).

**Table 5: Truck Parking Performance Measures**

| Measure | Importance | Data Requirement | Collection Strategy | Difficulty |
|---|---|---|---|---|
| Level of awareness, acceptance and use of TPMS | ★★★★ | Truck drivers' attitudes toward system | Questionnaires at parking facilities | ★★★★ |
| Change in parking search time and difficulty | ★★★★★ | Parking search time | Questionnaires at parking facilities | ★★★★ |
| Changes in truck-related crashes and fatalities | ★★★★ | Truck-related crash and fatality records | Police crash reports | ★★ |
| Changes in amount of illegal parking | ★★★ | Number of illegally-parked trucks | On-road observations | ★★★ |
| Change in utilization of facilities in system | ★★★ | Count of trucks parked | Automatic counting via detection tech | ★★★★ |

★★★★★–most important or difficult, ★–least important or difficult

A review of performance measurement practices across state agencies regarding truck parking revealed limited inclusion of truck parking metrics thus far. Most states only collect data about crashes and fatalities. The handful of states that already collect customer satisfaction information could easily develop a customer segmentation approach to address truck operator satisfaction and use with a TPMS.

Optimally, states wishing to pursue a TPMS should establish measures prior to system design and implementation, and such measures should be common across the MAASTO region. Baseline levels for these measures should be collected before a system is implemented.

## Estimating Future Costs and Benefits

Comparing fatigue-related accidents before and after the provision of parking provides a useful way to measure TPMS performance. A robust framework can be developed for evaluation of the costs and benefits of parking availability and awareness using crash data, vehicle operating costs, and fixed and operating costs of parking systems. Cost of installation and operation of the system is straightforward, but a careful quantification of the benefits of a TPMS will require knowledge of avoided crashes and avoided search time. States must also establish baseline rates for crashes and driver search time and mileage as they develop these practices and measures.

Research in this area demonstrates that crash likelihood increases significantly between 20 and 30 miles away from a rest area, suggesting that rest areas reduce fatigue-related crashes for up to 20 miles downstream (Gates et al., 2012). A Michigan study found that each rest area reduced fatigued-related crashes within a 20-mile radius on the route by 3.37 crashes per year (Gates et al., 2012) but the number of CMV-only crashes reduced was not calculated. Since a TPMS improves driver information about available parking, it should equalize parking occupancy over the route, and reduce the likelihood truckers will choose to keep driving when they should stop. Baseline and post-implementation rates of parking space utilization and downstream crashes could be used to determine how many more truckers are stopping rather than continuing driving. These estimations will also help estimate the monetary value of avoided crashes.

The estimated cost of a commercial motor vehicle (CMV) crash (adjusted to 2015 dollars) is about $20,000 for property damage only, $362,000 for injury, and $7.9 million for fatal crashes (FMCSA, 2010). States could collect baseline crash statistics, particularly 20-30 miles downstream of TPMS-equipped corridors, and compare them against downstream and pre-implementation crash statistics. Avoided or reduced severity crashes that can be attributed to use of the TPMS can then be assigned the monetary values. Gates et al. (2012) concluded that providing adequate rest area truck parking reduced costs related to highway crashes, with a cost savings ratio of 1.61.

Vehicle operating costs can also be used to calculate the potential TPMS benefits. As mentioned before, drivers can spend significant portions of their driving time searching for parking. Baseline and post-implementation surveys of truckers could identify time and mileage wasted while searching for parking spaces, and reductions in search time and mileage could be quantified as a benefit using FMCSA and FHWA estimates of CMV operational costs. Measures of reduced mileage could also be used to estimate the benefits of avoided greenhouse gas emissions. Properly quantifying TPMS benefits will require establishment of baseline levels for these performance measures and careful statistical control for exogenous factors like weather and increasing truck volumes.

Freight movement by trucks continues to grow and in response, travel centers, state agencies, and federal initiatives are supporting approaches to providing and managing truck parking. There are several important trends in the deployment of these truck parking management systems.

- Parking spot detection is trending toward real-time information using video detection.

- Systems should include a range of communication tools to ensure customers can find reliable and valid information on parking availability.
- The efforts should recognize the significant role of private sector facilities and should encourage and support additional efforts to align public and private efforts.

Based on these criteria, innovative and useful truck parking management systems should provide real-time information that is commonly available across a spectrum of media, but is non-intrusive in the cab. Successful efforts will also leverage the predominance of parking available at private facilities, provide greater levels of feedback from consumers, and ensure safe facilities for the truck operator. The MAASTO states—Michigan and Minnesota in particular—as well as Tennessee, Maryland, and Virginia, and their private sector counterparts should be provided continued support through federal initiatives. These initiatives should also advance and encourage public-private partnership strategies.

# Supporting Research and Proof of Concept

This section of the TPMS synthesis provides an overview of parking systems component issues and research that have framed truck parking strategies across the United States. Currently available technological solutions for collecting and communicating parking information will be described, as will individual research efforts to implement ITS components and truck parking. Ultimately, this synthesis should help the MAASTO states fully understand the breadth of work in this area and better inform their own multistate initiatives.

## Corridor Identification for Parking Systems Implementation

The identification of appropriate freight corridors to include in truck parking systems development tends to be based on several combined factors:

- Identification of major freight corridors.
- Observation of full truck lots.
- Increased occurrence of illegal or unsafe parking.
- Collateral increases in accidents involving trucks.

This approach is part anecdotal and part data-driven. As multistate truck parking systems are developed, other data sources and factors should be included to supplement these observations. The relevance of the selected freight corridors for TPMS projects can be further developed using data and corridors from the recently defined National Freight Network, MAFC Regional Freight Study corridors, as well as through corridors identified in the individual freight plans of MAASTO states (FHWA, 2014a; MAFC, 2014). Including these resources supports the identification of the appropriate corridors for implementation of truck parking systems. This approach will also drive home the systems approach and a holistic understanding of state and regional freight movement and operator parking needs.

Various freight data sources can also be included to substantiate and reinforce the selected corridors. The Freight Analysis Framework, BTS commodity flow data, and state-collected HPMS data can all support the identification through assessment of truck volumes, freight tonnages and values, and corridor-level freight movements (FHWA, 2015; BTS, 2012; FHWA, 2014b). This list reflects publicly available data. Additional refined freight and corridor data can be purchased from a range of vendors, such as Transearch (IHS, 2015).

In addition to other state-collected data such as monitoring illegal and unsafe parking, states should consider developing customer surveys of truck operators regarding parking preferences and experiences.

## MAASTO State Studies

In addition to the resources cited throughout this report, a brief summary of recent completed work from the MAASTO region provides a overview of the issues and strategies involved with implementing truck parking in this region.

### Iowa: Commercial Vehicle Study (1999)

This study formed a task force of state planners and trucking industry stake holders to analyze the effects of public policy on truck parking. This brief study laid out some potential goals for future research, including investigating the use of ITS to inform drivers of available spots. No specific problems were identified (CTRE, 1999).

## Illinois: Trucker's Park and Rest Facility Study (2008)

This study focused on the Chicago area and examined how truck parking problems affect the region's infrastructure and economy. The research team interviewed stakeholders such as truckers, trucking companies, and local authorities and surveyed parking areas. This study identified two major sources of problems. Local company drivers were parking in areas designed for over-the-road trucking and on on-ramps. Over-the-road drivers, in turn, were responsible for illegally parking in residential, commercial, and insecure areas. The authors recommended creation of additional parking, and consideration of a system for communicating parking availability to drivers (Beltemacchi et al., 2008).

## Minnesota: Interstate Truck Parking Study (2008)

This study examined what role the state should play in providing parking, what parts of truck parking will provide the most benefit to Minnesota's economy, and what can be done to improve traffic safety. The study identified a number of sites where parking shortages were acute, but also found that all of the state's interstate highways lacked capacity, and parking was generally needed around large cities. The authors did not make specific recommendations but instead set forth plans for evaluation of public private partnerships, capacity additions, parking policy revisions, and applications of ITS (Wilbur Smith Associates, 2008). The early work in Minnesota then resulted in a demonstration project that combined parked vehicle detection monitoring with communication to operators. This project continues to collect truck parking data but is not actively communicating with operators (CTS, 2015).

## Wisconsin: Low-Cost Strategies to Increase Truck Parking in Wisconsin (2010)

An offshoot of the *Low-Cost Strategies for Short-Term Parking on Interstate Highways of the MVFC*, this report sought to understand Wisconsin's parking trends in relation to stops for breaks, operational issues creating parking needs, specific locations where problems exist, and solutions for specific areas. The study found that parking problems were most often related to insufficient capacity during peak hours, safety concerns, and that parking area geometry was sub-optimal, resulting in reduced driving capacity (Adams et al., 2009).

## Low-Cost Strategies for Short-Term Parking on Interstate Highways of the MVFC (2009)

This project used GIS to document parking problems in the ten states that made up the Mississippi Valley Freight Coalition (now the Mid-America Freight Coalition). Stakeholders such as highway patrol officers, freight planners, and truckers were interviewed to identify problematic parking facilities. The study's found that many parking problems are found at the fringes of metro areas, parking shortages occur in the early evening or late at night, these shortages are caused by a lack of information about parking availability, and poorly-designed parking areas further reduced capacity. The areas with most severe shortages of parking were Chicagoland, Indianapolis, Gary, IN; the Twin Cities, Davenport, IA; Janesville, WI; Rockford, IL; Milwaukee, Kansas City, Louisville, Detroit, Toledo, and St. Louis. Advanced parking information on road signs, and further exploration of ITS were recommended as potential solutions to parking shortages in the Midwest (Adams et al., 2009).

## Other Studies

Kansas DOT has also initiated a truck parking study on the state's major freight corridors to be completed in the fall of 2015.

Further, much of the initial research was based on findings of earlier report from the FHWA: *Study of the Adequacy of Truck Parking Facilities–Final Report* (FHWA, 2002).

The following section describes the work and issues revolving around the major system components in truck parking; detection and monitoring of trucks in parking spaces, data management and modeling from truck data, and communication technologies.

## Truck Parking Detection Systems

There are a number of technological solutions available to states and regions interested in adopting ITS for truck parking. Detection technology refers to systems to count or estimate the occupancy of a given parking area, while communication technology is required to relay gathered information to truckers. The major detection systems tested so far are in-pavement systems and video cameras, however alternatives like light curtains, lasers, Doppler radar, observation, and entry/exit traffic counts have also been considered as possible detection tools.

### In-Pavement Systems

In-pavement systems include technologies such as induction sensors, magnetic sensors, and infrared sensors. These systems are a tried-and-true transportation technology that may be well-suited to use in truck parking. These systems consist of magnetic or induction sensors embedded in the pavement, sometimes combined with infrared sensors for greater accuracy with high-clearance trucks. Sensors could be installed in each stall of a parking area, or at the entry and exit points of a limited access area, such as those found at state-owned highway rest stops (Bayraktar et al., 2012). In-pavement solutions have a number of advantages. They are well-developed and widely-used in other transportation applications, easy to install, flexible in design, and allow for relatively easy data processing with a low bandwidth requirement. FHWA tests of magnetic systems show that they are able to classify vehicles, albeit with varying rates of success (Fallon, 2011). In-pavement systems do have downsides. Since sensors must be embedded in the pavement, wire loops and hardware are subject to temperature and traffic stress, and parking areas must be closed during installation and maintenance. These types of systems are not reliable when trying to monitor a wide range of vehicles, such as pickups to tractor-trailers (Fallon, 2011), and may not be able to cope with uncontrolled driving behavior (failure to park within stalls). Given current technology, any system that relies primarily on in-pavement detection will require daily or weekly ground-truthing to ensure accuracy.

### Video

A possible alternative to in-pavement systems is machine vision, or video counting. A series of video cameras are installed around the parking area, parking stalls are marked in the video feed, and software is programmed to detect whether the designated stalls are empty or occupied. Raw video or processed counting information can be forwarded to a state DOT, depending on bandwidth restrictions. Video cameras could be used in both limited-access and more open parking areas (Modi et al., 2011). Video systems have a higher degree of flexibility. They can easily be remotely reconfigured and reprogrammed to accommodate new parking patterns, one unit can monitor multiple lanes or zones of a given area, and cameras can be networked to cover a large area with few units. Ground-truthing is made easy by remote access to system cameras. Video cameras are easier to install and maintain than in-pavement sensors. However, video systems can be adversely affected by inclement weather and wind, and must be mounted high up for optimum detection (Gertler and Murray, 2011). Truckers have also expressed concerns about privacy with video systems.

### Light and Laser Detection

Light and laser systems are a potential solution for limited-access truck parking areas, as they count ingress/egress instead of stall occupancy. Panels of laser or light detectors are installed on gantries next to and across the top of entry and exit lanes for truck parking areas. Light and laser systems may be combined with Doppler radar and video feeds for added accuracy (Lopez-Jacobs et al., 2013). When the FWHA tested video, magnetic, and laser systems, it found that lasers produced the most reliable results. A laser system combined with Doppler radar was very accurate at correctly counting ingress and egress, but was less accurate at classifying vehicles. There are a number of downsides to light and laser systems. Like cameras, laser panels are vulnerable to inclement weather, particularly snow and ice. Detectors may be vulnerable to vandalism, and only work at parking areas with strictly controlled entrances and exits, such as those found at on-highway rest stops. They are also more capital intensive, requiring the installation and maintenance of an overhead gantry at both entrances and exits (Lopez-Jacobs et al., 2013).

### Summary: Detection Systems

Support for detection systems strongly favors in-pavement detection and video feeds. Each system has its own strengths and weaknesses, and it may be best left to each state to determine which system, or combination of systems best fits their parking detection needs. For example, Michigan has installed magnetic detection at its state-owned rest stops, but relies on video data collected from privately-owned truck stops, which have less-controlled parking areas and would not benefit from in-pavement systems. Minnesota has thoroughly tested video detection and reports an accuracy rate of more than 95 percent (MnDOT, 2014).

## Data Management, Modeling, and Spot Management

In addition to the benefits of communicating parking availability to operators, parking data including volume, times and duration can be used to estimate future parking needs and services. Germany and the Netherlands have already implemented truck parking ITS systems that include data modeling systems. Similar work could be completed in the MAASTO region to validate parking system investments, and help predict future demands for parking on multistate corridors.

### Modeling with Floating Vehicle Data (FVD)

Parking needs can be estimated based on data external to the parking facility. GPS vehicle data and driver feedback on the capacity of rest areas can be modeled to provide demand and duration estimates. The number of GPS or smartphone-equipped trucks on a given portion of highway at a specific time can be used to predict parking needs. Given enough observations, collected data can be used to predict current and future occupancy rates of parking areas. Data would then be relayed to truckers who have a smartphone application. Drivers have the option of correcting occupancy estimates while onsite, improving the system's accuracy in the future (van de Ven et al., 2012). FVD modeling is advantageous in that it can replace onsite detection equipment like cameras or pavement detectors entirely and coverage can be expanded at virtually no cost. Many large trucking fleets already use vehicle tracking technology and may already have a substantial amount of collected data. This technology is still in its infancy and the accuracy of its predictions remains limited.

### Telematics Controlled Parking

Germany has developed a novel solution to increase parking capacity without using additional land through telematics controlled parking. Truck stops are equipped with an overhead gantry that spans all available stalls. Variable signs above each stall indicate the time when each stall should be vacated, so truckers can choose when to leave. This system allows trucks to park two deep in each stall, effectively doubling capacity without the construction of additional spaces. Departure times are usually stacked earliest to latest from the exit to the entrance, so even if a trucker does not leave on time, a truck parked behind them can still exit. This system may not work in the United States since laws on vehicle length are not as strict, and two trucks may not fit in stalls at state-owned rest areas (Kleine and Lehmann, 2014).

## Communication Technologies

After truck parking data has been collected and modeled, information about parking availability must be communicated to truckers. Communication systems should reflect operator planning windows, media preferences, and safety issues such as in-cab intrusion, while providing reliable parking information. The most frequently used communication options are variable message signs (VMS), websites, and smartphone applications but other technology such as 511 services, reservation systems, and radio broadcasts may be available to ensure that truckers easily receive correct information about available truck parking.

### Variable Message Signs (VMS)

A tested, reliable technology, VMS have the benefit of providing real-time information to drivers with minimal distraction. Previous research indicates that truckers have identified VMS with parking information as a desirable resource, and VMS have received broad support from both truckers and transportation planners (Adams et al., 2009). In an environment where minimizing distraction is key to ensuring safety, VMS are a strong option for safe and easy real-time communication of parking information. The main weakness of VMS systems is their relatively high expense compared to other communication systems.  They require a substantial amount of capital and labor of install and maintain. And where advanced parking planning is preferred, they do not provide for remote access to information. Given their usefulness for more than just truck parking information, states may find that benefits of installation and maintenance of VMS outweigh costs, particularly since VMS infrastructure may already be in place and can be used for other message types.

### Smartphone applications

Smartphone applications have the benefit of much lower cost relative to VMS and are widely available. And for the most part, in-cab intrusion can be limited. In Michigan, a pilot project found the entire cost for a smartphone application to be roughly the same as the installation of two variable message signs.  As implementation of parking detection increases, the marginal cost of expanding smartphone applications is significantly less than installing new or modifying existing message boards. Applications also have the benefit of potentially synthesizing additional information relevant to truckers like traffic and weather. Applications do have a major downside of potential in-cab intrusion. Creative use of advanced functions like voice command and response, motion deactivation, and geo-fencing may ameliorate some of these potential conflicts. Also, information provided by application would only be available to those with smartphones with data plans and cellular service along the route.

### Websites

While drivers do most of their parking planning on the road, website access in downtime can support route planning and parking options. Long-distance drivers already mention that they have little information about parking on their route, and easily accessible information about parking capacity prior to driving could support decision making along the road. Web publication of truck parking sites and information is a relatively inexpensive endeavor, and one that lays the groundwork for implementation of more advanced smartphone applications. Utah and Michigan have excellent examples of how websites publishing truck parking information may be implemented. Similar to smartphone issues, access to websites could be controlled through motion deactivation and geo-fencing. Radio broadcasts and 511 services are also viable options for communicating with truck operators and have demonstrated performance with passenger vehicles.

In addition to these methods, a clearinghouse for truck parking information could provide a useful way to merge and maintain the information from various sources.

## Conclusion

Public agencies—especially MAASTO state DOTs—have vetted numerous parking detection and communication technologies. Video and in-pavement detection techniques appear to be the forerunners in adopted approaches. VMS and smartphone applications appear as the leading communications technologies. Implementation of these technologies on multistate highway corridors should be reviewed. The national and regional freight networks should be evaluated, along with freight movement data to ensure efficient implementation of truck parking information systems.

With 70 percent of the total freight loads moved on our nation's highways and a 38 percent increase in tonnage anticipated; with more than 11 percent of truck crashes related to fatigue; with a 1.61 ROI on truck parking investments; and considering that there are 1.6 million truck operators, a multistate approach to parking information systems on major freight corridors presents a substantial opportunity to increase safety of truck operators and the general public while providing safe and convenient parking. Additionally, with nearly 80 percent of truck parking spaces in private hands, these systems should include and leverage private sector efforts. Finally, performance measures related safety, facility and investment efficiency, convenience, and operator preferences and planning windows should be established to support and validate these multistate truck parking efforts.

## Works Cited


Adams, Teresa, Praveen Srivastava, Bruce Wang, and Libby Ogard (2009). Low-Cost Strategies for Short Term Parking on Interstate Highways of the MVFC. Technical Report. National Center for Freight and Infrastructure Research and Education. http://wisdotresearch.wi.gov/wp-content/uploads/08-28increasetruckparking-f.pdf. Accessed June 29, 2015.

American Trucking Associations (2013). ATA Summary of FMCSA's Changes to the Hours of Service Regulations. http://www.trucking.org/Safety/042013_ATA%20Summary%20of%20Final%20HOS%20Rules.pdf. Accessed June 30, 2015.

American Trucking Associations (2015). Reports, Trends & Statistics. http://www.trucking.org/News_and_Information_Reports_Industry_Data.aspx. Accessed June 30, 2015.

Banerjee, Ipsita, Joon ho Lee, Kitae Jang, Swati Pande, David Ragland (2009). Rest Areas—Reducing Accidents Involving Driver Fatigue. University of California, Berkeley Traffic Safety Center. http://www.dot.ca.gov/newtech/researchreports/reports/2009/2009-05_design_and_construction.pdf. Accessed June 29, 2015.

Bayraktar, Mehmet, Yinmin Zhu, and Farrukh Arif (2012). Commercial Vehicle Parking Trends at Rest Areas and Weigh Stations. Florida International University. http://www.dot.state.fl.us/research-center/Completed_Proj/Summary_TE/FDOT-BDK80-977-14-rpt.pdf. Accessed June 30, 2015.

Beltemacchi, Peter, Laurence Rohter, Jac Selinksky, and Terry Manning (2008). Truckers' Parking/Rest Facility Study. Technical Report. Illinois Institute of Technology. https://www.ideals.illinois.edu/bitstream/handle/2142/12034/FHWA-ICT-08-018%20truck%20parking.pdf?sequence=2. Accessed June 30, 2015.

Bureau of Labor Statistics (BLS) (2015). 53-3032 Heavy and Tractor-Trailer Truck Drivers. US Department of Labor. http://www.bls.gov/oes/current/oes533032.htm. Accessed June 30, 2015.

Bureau of Transportation Statistics (BTS) (2012). 2012 Commodity Flow Survey. US Department of Transportation. http://www.census.gov/econ/cfs/2012/ec12tcf-us.pdf. Accessed June 30, 2015.

Bureau of Transportation Statistics (BTS) (2013). Freight Facts and Figures 2013. US Department of Transportation. http://www.ops.fhwa.dot.gov/freight/freight_analysis/nat_freight_stats/docs/13factsfigures/pdfs/fff2013_highres.pdf. Accessed on June 30, 2015.

Bureau of Transportation Statistics (BTS) (2004). Length of Haul. US Department of Transportation. http://www.rita.dot.gov/bts/programs/freight_transportation/html/length_of_haul.html. Accessed June 30, 2015.

Center for Transportation Research and Education (CTRE) (1999). Commercial Vehicle Parking. Iowa Department of Transportation. http://www.intrans.iastate.edu/reports/truckpar.pdf. Accessed June 30, 2015.

Center for Transportation Studies (CTS) (2015). Truck Parking Availability Study. University of Minnesota. http://www.cts.umn.edu/research/featured/truckparking. Accessed June 30, 2015.

EasyWay (2012). Freight & Logistics Services: Intelligent and Secure Truck Parking. Deployment Guideline. European Commission. http://www.rits-net.eu/uploads/media/EW-DG-2012_FLS-DG01_IntelligentAndSecureTruckParking_02-00-00.pdf. Accessed June 30, 2015.

Fallon, John, and Kareem Howard (2011). SmartPark Truck Parking Availability System: Magnetometer Technology Field Operational Test Results. Technical Report. VehicleSense. http://ntl.bts.gov/lib/51000/51300/51359/SmartPark-Magnetometer.pdf. Accessed June 30, 2015.

Federal Highway Administration (FHWA) (2002). Study of Adequacy of Commercial Truck Parking Facilities. US Department of Transportation. http://www.fhwa.dot.gov/publications/research/safety/01158/3.cfm. Accessed June 29, 2015.

Federal Highway Administration (FHWA) (2007). Freight Facts and Figures. US Department of Transportation. http://www.ops.fhwa.dot.gov/Freight/freight_analysis/nat_freight_stats/docs/07factsfigures/pdf/fff2007.pdf. Accessed June 29, 2015.

Federal Highway Administration (FHWA) (2012). Commercial Motor Vehicle Parking Shortage. US Department of Transportation. http://ops.fhwa.dot.gov/freight/documents/cmvrptcgr/index.htm. Accessed June 30, 2015.

Federal Highway Administration (FHWA) (2013). MAP-21 Significant Freight Provisions. US Department of Transportation. http://www.fhwa.dot.gov/map21/factsheets/freight.cfm. Accessed June 30, 2015.

Federal Highway Administration (FHWA) (2014a). National Freight Network. US Department of Transportation. http://ops.fhwa.dot.gov/freight/infrastructure/nfn/index.htm. Accessed June 30, 2015.

Federal Highway Administration (FHWA) (2014b). Highway Performance Monitoring System (HPMS). US Department of Transportation. http://www.fhwa.dot.gov/policyinformation/hpms.cfm. Accessed June 30, 2015.

Federal Highway Administration (FHWA) (2015). Freight Analysis Framework. US Department of Transportation. http://www.ops.fhwa.dot.gov/freight/freight_analysis/faf/index.htm. Accessed June 30, 2015.

Federal Motor Carrier Safety Administration (FMCSA) (2010). Commercial Motor Vehicle Facts. US Department of Transportation. https://cms.fmcsa.dot.gov/sites/fmcsa.dot.gov/files/docs/Commercial_Motor_Vehicle_Facts_December_2010.pdf. Accessed June 30, 2015.

Federal Motor Carrier Safety Administration (FMCSA) (2014) Summary of Hours of Service Regulations. US Department of Transportation. http://www.fmcsa.dot.gov/regulations/hours-service/summary-hours-service-regulations. Accessed June 30, 2015.

Federal Motor Carrier Safety Administration (FMCSA) (2007). The Large Truck Crash Causation Study - Analysis Brief. US Department of Transportation. http://www.fmcsa.dot.gov/safety/research-and-analysis/large-truck-crash-causation-study-analysis-brief. Accessed June 30, 2015.

Federal Motor Carrier Safety Administration (FMCSA) (2012). Large Truck and Bus Crash Facts. US Department of Transportation. http://www.fmcsa.dot.gov/safety/data-and-statistics/large-truck-and-bus-crash-facts-2012#Tables from Chapter 2. Accessed June 29, 2015.

Garber, Nicolas, Hualiang Teng, and Yuan Lu (2004). A Proposed Methodology for Implementing and Evaluating a Truck Parking Information System. Technical Report. University of Virginia. http://trid.trb.org/view.aspx?id=740705. Accessed June 30, 2015.

Gates, Timothy, Peter Savolainen, Tapan Datta, Ryan Todd, and Stephanie Boileau (2012). Evaluating the Appropriate Level of Service for Michigan Rest Areas and Welcome Centers Considering Safety and Economic Factors. Michigan Department of Transportation. http://www.michigan.gov/documents/mdot/MDOT_Research_Report_RC1570_387400_7.pdf. Accessed June 30, 2015.

Gertler, Judith, and James Murray (2011). SmartPark Truck Parking Availability System: Video Technology Field Operations Test. Technical Report. Waltham: Foster-Miller, Inc. ftp://www.mdt.mt.gov/research/LIBRARY/FMCSA_RRT_10_002.PDF. Accessed June 30, 2015.

IHS (2015). Transearch. https://www.ihs.com/products/transearch-freight-transportation-research.html. Accessed June 30, 2015.

Insurance Institute for Highway Safety (IIHS) (2015). Large Trucks. http://www.iihs.org/iihs/topics/t/large-trucks/qanda. Accessed June 29, 2015.

Kleine, J., and R. Lehmann (2014). Intelligent Controlled Compact Parking for Modern Parking Management on German Motorways. http://trid.trb.org/view/2014/C/1320202. Accessed June 30, 2015.

Lopez-Jacobs, Von, Jason Ellerbee, and Michael Hoover (2013). SmartPark Technology Demonstration Project. Technical Report. Gannett Fleming. http://ntl.bts.gov/lib/51000/51400/51423/13-054-SmartPark-Demonstration-Project-508slim.pdf. Accessed June 30, 2015.

McArthur, Adam, Jonathan Kay, Peter T. Savolainen, and Timothy J. Gates (2013). Effects of Public Rest Areas on Fatigue-Related Crashes. Transportation Research Record No. 2386: 16-25. http://trrjournalonline.trb.org/doi/pdf/10.3141/2386-03. Accessed June 29, 2015.

Mid-America Freight Coalition (MAFC) (2014). Corridor Profiles. National Center for Freight and Infrastructure Research and Education. http://midamericafreight.org/rfs/network-inventory/corridors/profiles/. Accessed June 30, 2015.

Minnesota Department of Transportation (MnDOT) (2014). Press Release: MnDOT's parking availability system helps truckers. http://www.dot.state.mn.us/newsrels/14/08/27parking.html. Accessed June 30, 2015.

Modi, Pushkar, Vassilios Morellas, and Nikolaos Papanikolopoulos (2011). Counting Empty Parking Spots at Truck Stops Using Computer Vision. Technical Report. University of Minnesota. http://www.its.umn.edu/Publications/ResearchReports/reportdetail.html?id=2022. Accessed June 30, 2015.

Murray, David C. and Jeffery Short (2015). Technical Memorandum: Quantifying Impacts From the 34-Hour Restart Provisions. American Transportation Research Institute (ATRI). http://atri-online.org/2015/04/29/quantifying-impacts-from-34-hr-restart-provision-april-2015/. Accessed June 30, 2015.

National Freight Advisory Committee (NFAC) (2014). Recommendations to U.S. Department of Transportation for the Development of the National Freight Strategic Plan. US Department of Transportation. http://www.transportation.gov/sites/dot.gov/files/docs/NFAC%20Task%201-Recommendations%20for%20NFSP-Final%286-12-14%29.pdf. Accessed June 29, 2015.

New Zealand Ministry of Transport (2014). Fatigue. New Zealand Government. http://www.transport.govt.nz/assets/Uploads/Research/Documents/Fatigue-2014.pdf. Accessed June 29, 2015.

SRF Consulting Group (2007). Interstate Highway Safety Study. Minnesota Department of Transportation. http://www.dot.state.mn.us/restareas/pdf/raspacingstudyreport.pdf. Accessed June 30, 2015.

Taylor, W.C., N. Sung, K. Kolody, A Jawad (1999). A study of Highway Rest Areas Characteristics and Fatigues Related Truck crashes. Michigan State University, Lansing. http://trid.trb.org/view.aspx?id=618488. Accessed June 30, 2015.

Transport Accident Commission (1998). Fatigue Statistics. State Government of Victoria, Australia. http://www.tac.vic.gov.au/road-safety/statistics/summaries/fatigue-statistics. Accessed June 29, 2015.

Trombly, Jeffrey (2003). NCHRP Synthesis 317 - Dealing with Truck Parking Demands. Synthesis. Transportation Research Board. http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_syn_317.pdf. Accessed June 30, 2015.

Utah Department of Transportation (2012). Utah Interstate 15 Truck Parking Study. Utah Department of Transportation. http://www.udot.utah.gov/truckparking/pdf/Utah%20I-15%20Truck%20Parking%20Draft%20Report%2008082012.pdf. Accessed June 29, 2015.

Van de Ven, Tom, Bram Bakker, De Jong, Eric Koenders, and Gwen van Vugt (2012). Parckr - Estimating and Forecasting Parking Occupancy Based on Floating Vehicle Data. http://trid.trb.org/view/2012/C/1261764. Accessed June 30, 2015.

Wilbur Smith Associates (2008). The Minnesota Interstate Truck Parking Study." Technical Report. Minnesota Department of Transportation. http://www.dot.state.mn.us/ofrw/PDF/MN_TrkParkFnlRpt.pdf. Accessed June 30, 2015.

Wikipedia (2015). Hours of service. http://en.wikipedia.org/wiki/Hours_of_service. Accessed June 29, 2015.

# Further Reading


Bayraktar, Mehmet Emre, Farrukh Arif, Halit Ozen, and Gorm Tuxen (2014). Smart Parking-Management System for Commercial Vehicle Parking at Public Rest Areas. Journal of Transportation Engineering. doi:10.1061/(ASCE)TE.1943-5436.0000756. Accessed June 30, 2015.

Chatterjee, Arun, and Frederick Wegmann (2000). Overnight Truck Parking Along Tennessee's Interstate Highways and Rest Areas. Transportation Research Record: Journal of the Transportation Research Board 1734: 64–68. doi:10.3141/1734-10. Accessed June 30, 2015.

Chen, Kathryn, Kelley Pecheux, John Farbry, and Stephen Fleger (2002). Commercial Vehicle Driver Survey: Assessment of Parking Needs and Preferences. Technical. McLean: Science Applications International Corporation. http://www.fhwa.dot.gov/publications/research/safety/01160/01160.pdf. Accessed June 30, 2015.

Deeter, Dean (2009). NCHRP Synthesis 399 - Real Time Traveler Information Systems. Synthesis. Transportation Research Board. http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_syn_399.pdf. Accessed June 30, 2015.

Deruytter, Michael, Wouter Favoreel, Dzmitry Tsishkou, Sylvain Bougnoux, and Remy Bendahan (2013). Low Costs Stereovision Based Truck Parking Occupancy Detection. http://trid.trb.org/view/2013/C/1320436. Accessed June 30, 2015.

EasyWay (2015). URSA MAJOR ITP Workshop Results. European Commission. http://www.easyway-its.eu/highlights/ursa-major-itp-workshop-results-25-26-march-2015. Accessed June 30, 2015.

Federal Motor Carrier Safety Administration (FMCSA) (2015) SmartParking USA. US Department of Transportation. http://www.smartparkingusa.com/. Accessed June 30, 2015.

Fleger, Stephen, Robert Hass, Jeffrey Trombly, Rice Cross, Juan Noltenius, Kelley Pecheux, and Kathryn Chen (2002). Study of Adequacy of Commercial Truck Parking Facilities. Technical. McLean: Science Applications International Corporation. http://www.fhwa.dot.gov/publications/research/safety/01158/01158.pdf. Accessed June 30, 2015.

Haghani, Ali, Sina Farzinfard, Masoud Hamedi, Farshad Ahdi, and Mehdi Kalantari Khandani (2013). Automated Low-Cost and Real-Time Truck Parking Information System. Technical Report. University of Maryland. http://www.roads.maryland.gov/OPR_Research/MD-13-SP209B4M_TRUCK-PARKING_Report.pdf. Accessed June 30, 2015.

Hawes, Clarissa (2014). Truckers Weigh in on Parking Problems : Hope Rivenburg Releases Truck Parking Survey Highlighting Problematic Areas of the Country. LAND LINE MAGAZINE 39, no. 1. http://trid.trb.org/view/2014/C/1307636. Accessed June 30, 2015.

I-95 Corridor Coalition (n.d.). I-95 Truck Parking Initiative. Technical. US Department of Transportation. http://i95coalition.net/i95/Portals/0/Public_Files/pm/reports/I-95%20Truck%20Parking%20Final%20Proposal%20Only.pdf. Accessed June 30, 2015.

Kvidera, Max (2012). Parking Solutions. Overdrive 52, no. 1. http://trid.trb.org/view/2012/C/1127969. Accessed June 30, 2015.

Mbiydzenyuy, Gideon, Jan A. Persson, and Paul Davidsson (2012). Proposed Core Services for the Deployment of Intelligent Truck Parking. http://trid.trb.org/view/2012/C/1262684. Accessed June 30, 2015.

Morris, Betsy (2015). Too Many Trucks, Too Little Parking. Wall Street Journal. http://www.wsj.com/articles/truck-drivers-face-shortage-of-legal-safe-places-to-park-1421799404. Accessed June 30, 2015.

National Transportation Safety Board (NTSB) (n.d.). Highway Special Investigation Report: Truck Parking Areas. Technical. https://app.ntsb.gov/doclib/safetystudies/SIR0001.pdf. Accessed June 30, 2015.

Nourinejad, Mehdi, Adam Wenneman, Khandker Nurul Habib, and Matthew J. Roorda (2014). Truck Parking In Urban Areas: Application of Choice Modeling Within Traffic Microsimulation. http://trid.trb.org/view/2014/C/1287428. Accessed June 30, 2015.

Parametrix (2005). WSDOT Truck Parking Study - Final Report. Technical. Washington State Department of Transportation. http://www.wsdot.wa.gov/NR/rdonlyres/90A1F589-BB16-48E5-A958-6337018F2912/0/WSDOTTruckParkingStudyFinalReport.pdf. Accessed June 30, 2015.

Pennsylvania State Transportation Advisory Committee (2007). Truck Parking in Pennsylvania. ftp://ftp.dot.state.pa.us/public/pdf/STCTAC/TAC/Reports/Truck%20Parking%20in%20Pennsylvania%20-%20December%202007%20-%20Final%20Report.pdf. Accessed June 30, 2015.

Pfannerstill, Elmar, and Andy Apfelstadt (2012). Telematic Solutions for Overload of Truck Parking Areas. http://trid.trb.org/view/2012/C/1262162. Accessed June 30, 2015.

Shaheen, Susan, and Caroline Rodier (2007). Commercial Vehicle Parking in California: Exploratory Evaluation of the Problem and Possible Technology-Based Solutions. Technical. Research Report. UC Davis Institute of Transportation Studies. http://www.its.ucdavis.edu/research/publications/publication-detail/?pub_id=1096. Accessed June 30, 2015.

Siemens AG (2014). Someone Had to Start. ITS Magazine.

Siemens AG (2014b). Truck Parking Information System Sitraffic Conduct +.. https://www.mobility.siemens.com/mobility/global/SiteCollectionDocuments/en/road-solutions/interurban/infrastructure/outdoor-parking-en.pdf.

Smith, Scott, William Baron, Kevin Gay, and Gary Ritter (2005). Intelligent Transportation Systems and Truck Parking. Technical Report. US Department of Transportation. http://ntl.bts.gov/lib/50000/50500/50595/intelligent-transportation-truckparking.pdf. Accessed June 30, 2015.

Sochor, Jana, Gideon Mbiydzenyuy, and Pia Larsson (2011). Assessing the Benefits of Intelligent Truck Parking. http://trid.trb.org/view/2011/C/1243257. Accessed June 30, 2015.

SWARCO (2014). HGV Parking. https://www.swarco.com/sts-en/Products-Services/Parking/Truck-Parking/HGV-Parking. Accessed June 30, 2015.

U.S. Department of Transportation (2009). 2007 Commodity Flow Survey. Inventory. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2007. Washington D.C.: U.S. Environmental Protection Agency, 2009.

Winter, Ken (2007). Heavy-Truck Accidents Due to Driver Fatigue Can Be Reduced With Simple Measures, However Parking Capacity Must Eventually Be Increased. Synthesis. Virginia Department of Transportation. http://vtrc.virginiadot.org/rsb/RSB15.pdf. Accessed June 30, 2015.