Intelligent Transportation Systems and Truck Parking

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U.S. Department of Transportation
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Volpe National Transportation Systems Center

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Foreward

The Federal Motor Carrier Safety Administration (FMCSA) intends to issue a Broad Agency Announcement for proposals to implement a project to demonstrate a system for conveying real-time information on parking availability for truckers on the road. This report outlines some of the issues in using intelligent transportation systems (ITS) technologies to better match drivers to available parking spaces. It provides background for the Broad Agency Announcement.

Although the report can be helpful to the general public in understanding ITS technologies, the report is targeted towards prospective proposers of concept papers on technologies for truck parking management.

This publication is considered a final report and does not supersede another publication.

Notice

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
In	inches	25.4	millimeters	mm
Ft	feet	0.305	meters	m
Yd	yards	0.914	meters	m
Mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
Ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	ml
Gal	gallons	3.785	liters	l
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		MASS		
Oz	ounces	28.35	grams	g
Lb	pounds	0.454	kilograms	kg
T	short tons (2000 lbs)	0.907	megagrams	Mg
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celsius temperature	°C
		ILLUMINATION		
Fc	foot-candles	10.76	lux	lx
Fl	foot-Lamberts	3.426	candela/m2	cd/m2
		FORCE and PRESSURE or STRESS		
Lbf	pound-force	4.45	newtons	N
Psi	pound-force per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	Yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
ml	milliliters	0.034	fluid ounces	fl oz
l	liters	0.264	gallons	gal
m^3	cubic meters	35.71	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg	megagrams	1.103	short tons (2000 lbs)	T
		TEMPERATURE (exact)		
°C	Celsius temperature	1.8 C + 32	Fahrenheit temperature	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m2	candela/m2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	pound-force	lbf
kPa	kilopascals	0.145	pound-force per square inch	psi

* SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.

Intelligent Transportation Systems and Truck Parking

1 Objective

The Federal Motor Carrier Safety Administration (FMCSA) intends to issue a Broad Agency Announcement to solicit concept papers to implement a project to demonstrate a system for conveying real-time information on parking availability for truckers on the road. The objective of this report is to provide background information and lay out the issues for prospective offerors responding to the solication in the Broad Agency Announcement.

2 Introduction

For at least the past decade, truck driver fatigue has been thought to be a contributing factor in a number of heavy truck accidents. One issue contributing to commercial motor vehicle fatigue may be the lack of safe, available truck parking on or near Interstate highways. As a result, drivers may drive for longer than is safe, or may find themselves unable to obtain undisturbed sleep during a rest period.

This report provides a brief introduction to the problem, and outlines some of the issues in using intelligent transportation systems (ITS) technologies to better match drivers to available parking spaces. This report seeks to answer the following questions:

- Is there a shortage of parking (Section 4)? Answering this question involves assessing the types of parking that truck drivers use, the types that they prefer, and whether there is a shortage of desirable parking spaces.
- Is the shortage likely to worsen (Section 5)?
- What are potential solutions (Section 6)?
- What can be done to better match available supply and demand (Section 7)? In particular, what role can ITS technology play?

3 Background

FMCSA has determined that fatigue accounts for 8.15% of all fatal truck crashes in its "Regulatory Impact Analysis and Small Business Analysis for Hours of Service [HOS] Options" prepared in December 2002. The analysis is available at "HOS Regulatory Evaluation" under Reference Documents at

www.fmcsa.dot.gov/Home_Files/revised_hos.asp. The analysis is also available in Docket Number FMCSA-1997-2350-23302 at the U.S. Department of Transportation, Dockets Reading Room, 400 Seventh St., SW, Washington, DC.

Research in 1994 by the National Highway Traffic Safety Administration (NHTSA) suggests that truck driver fatigue may be a contributing factor in 30 to 40% of all heavy truck crashes. A National Transportation Safety Board (NTSB) study in 1990 estimated that 31% of crashes fatal to truck drivers are fatigue-related.

Congress directed the NTSB in July 1998 to review the causes of truck- and bus-related crashes. In its review, NTSB found a major issue was the lack of safe, available truck parking on or near Interstate highways. The NTSB review culminated in May 2000 special investigation report recommending that the Federal Motor Carrier Safety Administration (FMCSA) create a guide (both in paper and electronic forms) to inform truck drivers about locations and availability of parking.

Furthermore, Congress mandated, in Section 4027 of the Transportation Equity Act for the 21st Century (TEA-21), a study on the adequacy of truck parking facilities. The Federal Highway Administration (FHWA) carried out a study and published it in 2002[1]. In it, FHWA documents a common complaint of truck drivers—the difficulty of obtaining information on truck parking availability. This complaint was mirrored by similar ones from privately-owned truck stop operators that they often have available spaces nearby where truck drivers are parking on exit ramps and road shoulders. The FHWA study recommended developing "Intelligent Transportation Systems deployments to provide commercial motor vehicle drivers with real-time information on the location and availability of parking spaces."

As part of the FHWA study, surveys were distributed to several thousand truck drivers, through site visits to truck stops and mailings to truck stops.[2] A total of 2,046 completed surveys were collected. Distribution sites were spread among 27 States in all parts of the country. The vast majority (97%) of respondents were long haul drivers. Topics of the survey included parking availability and usability, parking patterns and preferences, and parking solutions.

Drivers perceive a shortage of available parking. For truck stops, only 34% of drivers stated they "almost always" or "frequently" find available parking, 51% "sometimes" find available parking, and 16% "rarely" or "never" find available parking. For rest areas, only 11% "almost always" and "frequently" find parking, 41% "sometimes" find parking, and 48% reported "rarely" or "almost never" finding available parking. Drivers commented that more parking is needed during overnight hours and near metropolitan areas. Certain regions of the country, such as the northeast, the northwest and southern

1 *Study of Adequacy of Commercial Truck Parking Facilities*, FHWA-RD-01-158, 2002

2 During the survey pilot, drivers indicated that they would not have time to participate in the study while they were at public rest areas, but would have time while they were taking longer breaks at private truck stops. Therefore, the surveys were distributed to truck stops.

California, were perceived to need more parking.

Motor carrier firms also perceive there is a problem, in terms of both safety and driver satisfaction. With current parking shortages, drivers are sometimes left with the choice between driving while fatigued or parking illegally. Both practices may expose the carrier to significant liability should a crash occur. Furthermore, the need to search for parking, or to stop driving early in the evening in order to find available parking, can lower driver productivity. Finally, the poor choices given to drivers (parking illegally or driving while fatigued) may lead to increased job dissatisfaction; this is an industry with high driver turnover.

4 Is there a Shortage of Parking?

Four types of areas are most often used by truck drivers for overnight parking: public rest areas, private truck stops, other privately owned parking areas and along public right-of-ways. Table 1 reports results from the FHWA study, in which truckers were asked where they last slept (respondents were primarily long haul drivers).

TABLE 1 Locations where Long Haul Truckers Last Slept

Public Rest Area	Truck Stop	Loading Dock	Ramp	Home	Other	No Response
8%	56%	10%	4%	9%	11%	4%

Due to rounding, percentages may not sum to 100.

The remainder of this section discusses the types of spaces used, the balance between supply and demand, and driver preferences.

4.1 Types of Spaces Used

Public rest areas have limited services (typically, bathrooms, only limited food and no shower facilities) and limited truck parking capacity. They tend to be preferred for short breaks. Private truck stops often have extensive facilities and services, such as bathrooms, food and showers. Other privately owned parking locations may include loading docks, but typically have no facilities. Finally, trucks may be found parked along the shoulder of a highway or ramp. Both truck stops and public rest areas are generally located along major highways. Table 2 summarizes the types of parking typically used:

TABLE 2 Types of Overnight Truck Parking

Attribute	Public Rest Area	Private Truck Stop	Other Private Location	Roadside
Ownership	Public	Private	Private	Public
Legal parking time	Typically, a few hours	Unlimited	Unlimited	Often, zero (illegal to park)
Number of locations	1,800[3]	3,400	Unknown	Undefined[4]
Spaces per location	Typically less than 20[5]	Typically 80 or more	Unknown	Undefined
Total number of spaces	28,400-Interstate 2,900-Other	254,000-Interstate 24,000-Other	Unknown	Unknown
Location convenience	High	Moderate	Varies	High
Parking convenience	Varies	Varies	Varies	High
Safety from crime	Varies	Varies	Varies	Varies
Safety from crashes	Safe	Safe[6]	Safe	Not as safe[7]

4.2 Supply and Demand of Parking

On a national level, the overall supply of public and private spaces appears sufficient to meet demand (Table 3). Values are rounded to the nearest thousand.

TABLE 3 Summary of National Supply and Demand (From National Cooperative Highway Research Program (NCHRP) Synthesis 317)

	Daily Parking Demand			Parking Supply		
Roadway System	**Public**	**Private**	**Total**	**Public**	**Private**	**Total**
Interstate	56,000	189,000	245,000	28,000	254,000	282,000
Other	10,000	32,000	42,000	3,000	24,000	27,000
Total	66,000	221,000	287,000	31,000	278,000	309,000

However, such aggregate figures do not tell the whole story. First, in certain parts of the U.S., there are regional shortages of parking, with the northeast, the northwest, and

3 Interstate Highways and National Highway System (NHS) routes with over 1,000 trucks/day. From NCHRP Synthesis 317.

4 According to FHWA, there are approximately 47,000 miles of Interstate highways, with approximately 14,000 - 15,000 interchanges.

5 From Garber, Teng and Lu, 2004.

6 In surveys, some drivers expressed a concern about low-speed crashes, due to the large number of trucks in close proximity to each other.

7 According to NTSB (2000), only a small number (0.3%) of large truck accidents involved illegally parked vehicles on shoulders. However, these accidents have a high risk of fatality or injury. Furthermore, illegal roadside parking may restrict sight distances for other drivers and may cause road shoulder damage.

southern California being perceived as the areas with the worst shortages. For example, a surplus of spaces in Iowa does little good to a driver who has just run out of allowable driving hours[8] in Cincinnati, with Ohio, Kentucky, and Indiana all having shortages of spaces. Furthermore, statewide aggregate figures do not indicate whether there are shortages or surpluses of parking along specific corridors or at particular locations within corridors. For example, although the FHWA study found the overall parking supply in Virginia to be "sufficient", a closer look at major corridors in the state revealed shortages in some of those corridors (Wang and Garber, 2003). For example, I-81, I-95 and certain rest areas on other Interstate routes had parking shortages, while I-64 did not.

Spaces need to be available at the right time and place, namely close to the time and place where the driver has run out of hours for the day. In the absence of strict enforcement and monitoring of hours-of-service, the driver might simply choose one of the truck stops, and then make creative entries to his or her logbook to deal with the long day of driving. However, with strict enforcement and monitoring, this may no longer be an option.

4.3 Driver Preferences

For long term rests, drivers typically used truck stops (most desirable), rest areas, and loading docks (see Table 1). Desired attributes of long term rest locations include food, fuel, restrooms, phones, showers, convenience to the highway and well- lighted parking lots. Drivers also mentioned that they value big parking spaces that allow trucks to maneuver in and out. However, for short naps, rest areas were preferred (Table 4)[9].

TABLE 4 Driver Preferences for Overnight Stops and Short Naps

	Overnight Stops	Short Nap
Truck stop	78%	19%
Rest area	6%	45%
No preference	16%	36%

The survey asked respondents to speculate on why truck drivers sometimes choose to park on ramps and shoulders. Reasons given include the following, with the fraction of drivers reporting the reason given in parentheses[10]:

- No empty spaces at nearby truck stops or rest areas (94%)
- No nearby parking facility is available (83%)
- Nearby parking spaces have time limits that are too short (approximately 50%)

8 Federal hours-of-service rules dictate the maximum number of hours a driver may drive in a day or week before taking an extended rest.

9 Data for this survey were collected at truck stops.

10 Approximately 2,000 responses to the survey were received. Responses add up to more than 100% because drivers were permitted to check multiple items.

- Nearby spaces were blocked by other vehicles (approximately 50%)
- The ramp/shoulder is convenient for getting back on the road (approximately 33%)
- Interruptions by strangers (e.g., drug dealers, prostitutes) were less likely (approximately 33%)
- Difficult to drive around congested parking lots (18%)
- Ramps/shoulders have better lighting than the lots. (4%)

4.4 Summary

For overnight rests, most drivers preferred truck stops. Although the current nationwide supply of truck stops appears to be adequate, there are regional shortages (some of which may lie in certain corridors). Furthermore, given the desire to maximize productivity (i.e., drive as much as possible in a day) while remaining legal under the hours-of-service rules, a driver may find that he or she has run out of available driving hours with no legal parking available nearby. As a result, drivers sometimes park on the shoulder of a highway or ramp, creating a safety hazard.

5 Is the Shortage Likely to Worsen?

Demand for overnight parking is influenced by the overall size of the trucking industry and the fraction of that industry with overnight parking needs. The spatial and temporal distribution of the demand for parking is influenced by the locations of major truck routes, pickup and delivery locations, pickup and delivery times, and hours-of-service rules.

5.1 Industry Growth

Between 1993 and 1999, intercity truck ton-miles increased from 861 billion to 1,093 billion. Between 1999 and 2001, there was a slight decline to 1,051 billion (American Trucking Associations' (ATA) American Trucking Trends, 2003). However, the long distance trucking industry has two primary segments: truckload (TL) and less-than-truckload (LTL).[11] An LTL operation is structured much like an airline hub and spoke network where multiple shipments are consolidated into large trucks, just as airline passengers are consolidated into large aircraft. LTL is characterized by regular routes where drivers either are able to return home or stay in motels. In fact, LTL tractors often do not have sleeper berths. The truckload segment, on the other hand, operates more like a taxi service, where routes are irregular, the shipment fills the trailer, and is taken

11 The term "less-than-truckload" comes from the size of the shipment, which does not occupy an entire trailer.

directly from origin to destination.[12] It is primarily in the truckload segment that drivers are away from home for long periods. The truckload segment is the segment of the trucking industry that has the greatest need for overnight parking. According to an ATA trucking activity report (December 2003), the truckload segment experienced substantial growth between 1993 and 2003. The ATA truckload traffic index (January 1993 = 100) was up 81% for loads, and 56% for miles in October 2003. Meanwhile, LTL indices over the same 10+ year period showed increases in tonnage of 24% and 35% for large and small carriers, respectively.

Another factor contributing to the increased demand for parking, cited in NCHRP Synthesis 317, is the increased use of "just-in-time" delivery, which requires drivers to deliver their shipments in a narrowly specified time window. Furthermore, some ports (e.g., Port of Oakland, CA) have implemented an appointment reservation system for trucks at some marine terminals in order to improve coordination between vessels and trucks while reducing congestion and truck idling.

The 2002 FHWA Study assumed an average 2.7% annual increase in truck traffic, which corresponds to a 31% increase over 10 years. This increase is somewhat lower than what has been historically observed for truckload traffic.

5.2 Likely Responses to Increased Parking Demand

Likely responses to the increased demand for truck parking include the following:

- Additional truck stop expansion. However, this may be limited in metropolitan areas (where the parking is needed the most) due to local resistance and high land values.

- Use of reservations. It is logical to expect that, as demand increases, some truck stops may move towards allowing driver reservations, much as hotels and motels do now.

- Increased parking on shoulders and ramps, potentially creating safety hazards.

5.3 Summary

Continued growth in the truckload industry will lead to increased demand for truck parking.

12 In a few cases, a carrier may run relays, passing the trailer from one driver to the next, thus keeping each driver closer to home. A carrier may also partner with a railroad to run intermodal service, which also may keep the carrier's drivers closer to home. However, the typical mode of truckload operation is for the driver to stay with a shipment from origin to destination. This means that the driver may be away from home for an extended period.

6 What are Potential Solutions?

In 1999, FHWA sponsored a two-day Rest Area Forum, where stakeholders were invited to present issues and recommendations. Recommendations included the following:

- Improve safety and security at public rest areas and commercial truck stops
- Provide financial support (e.g., low interest loans) to support development of commercial truck stops
- Improve financial support for improving and expanding public rest areas, and make this a safety-related issue
- Change time limit policies in public rest areas (eliminate time limits to make rest areas more useful for overnight stops, or enforce time limits to free up spaces for short rests as needed)
- Use alternative sites such as weigh stations and park and ride lots
- Increase driver education and information on the causes of fatigue and on the availability and location of available parking spaces.

In 2000, NTSB made the following recommendations:

- Provide a comprehensive guide (in paper and electronic format) for truck drivers that provides information on the locations and space availability in both private and public parking areas
- Make appropriate modifications to time limits at public rest areas, or else re-direct drivers to parking facilities where they can obtain adequate rest.

6.1 Parking Related Improvements Identified by State Officials

State highway maintenance engineers were surveyed to identify potential options for addressing problems with commercial vehicle parking (NCHRP Synthesis 317). They were asked to rate improvements in terms of both feasibility and effectiveness, where a value of 1 was assigned to a rating of “low,” 2 to “medium” and 3 to “high.”

Interestingly, average ratings on both feasibility and effectiveness ranged between 1 (low) and 2.08 (medium). Highest ranked items include the following (the effectiveness and feasibility ratings are given in parentheses after each item):

- Use ITS to expand the amount of information available to truckers (2.04, 1.96)
- Expand existing rest areas for truck parking by providing more truck spaces (2.00, 1.79)
- Permit the use of weigh stations for parking (1.71, 1.92)
- Establish Federal assistance program targeted at truck parking (2.08, 1.50)
- Encourage the development of public-private partnerships (2.08, 1.48)

- Build new rest areas for autos, trucks and RVs (1.79, 1.54)
- Elimination of parking time enforcement was rated very low (1.15, 1.00).

Although NCHRP Synthesis 317 indicated a favorable view of ITS, a report from the State of Connecticut concluded that ITS would not be effective at reducing overcrowded parking at public rest areas in that State (ConnDOT, 2001). The major concern expressed in the Connecticut report was that by the time the truck driver reached the rest area, the parking availability information would be out-of-date and incorrect.

6.2 Parking Related Improvements Identified by Drivers

In the FHWA survey, drivers were asked to identify the five top improvements from a list of some 17 possible improvements. The most popular items were:

- Build more truck stop parking spaces (79%)
- Build more rest area parking spaces (66%)
- Stop enforcement officers from waking drivers (57%)
- Eliminate time limits (49%)
- Improve parking layout/configuration (e.g., more pull through) (46%)
- Separate truck, car, and RV parking (42%).

The improvements related to parking information were less popular:

- Improve signs and roadway information for parking facilities (28%)
- Up-to-the-minute information on parking availability (18%)

6.3 Summary

Approaches to solving the truck parking shortage fall into three major areas: a) making underutilized spaces more attractive, b) increasing the supply of spaces, and c) better matching supply and demand. Examples of making underutilized spaces more attractive include better lighting to reduce crime and improvements to parking layouts. Examples of increasing the supply of spaces include construction, using weigh stations and park and ride lots, and relaxing time limits. Examples of better matching include technologies that provide up-to-the minute information on parking availability.

7 What Can Be Done to Better Match Available Supply and Demand?

Of the three approaches mentioned above, the first of making underutilized truck stops or rest areas more attractive may not be sufficient in those areas where truckers are unable to find a truck stop with any available space. The second approach of adding parking

capacity is capital intensive, and may be resisted by local residents. This is especially true in metropolitan areas, where land prices are high. The most practical and cost-effective of the three approaches is to start with the better matching of existing supply and demand in an area where a parking shortage exists.

Before discussing specific technologies, it is important to review the process in choosing a location for an overnight rest. This involves reviewing both who makes the decision and when the choice of an overnight rest location is made.

According to the FHWA survey, it is the truck driver (and not the carrier) who makes the decision on where to rest in nearly all cases. Conceptually, the driver's decision-making can be viewed as taking place in three stages:

1. The previous evening (12 to 24 hours in advance), the driver may be planning activities for the next day, including the location of the next long rest (which may be hundreds of miles away). At this point, the driver is reasonably likely to have internet access (and thus can make use of online directories).
2. During the work day, a driver completes a shift and needs to rest in the next hour or so. At this point, the driver may wish to choose from several rest areas or truck stops within a 100-mile radius.
3. At the end of the work day, the driver is approaching a particular rest area or truck stop, and is deciding whether to pull in or not.

Section 7.1 discusses what can be done to help the driver when he or she is planning the next day's activities. Section 7.2 discusses real-time tools that are used while the driver is on the road.

7.1 Planning Tools

One NTSB recommendation was to "create a comprehensive guide, available both on paper and in electronic format, for all truck drivers to use that will inform drivers about the locations of all parking areas (both private and public) and the space availability." Since then, a number of directories have been developed, both by private industry and government. Examples include the following:

- NATSO (National Association of Truck Stop Operators) online guide
  http://www.natso.com/for_drivers/truckstops.php3

  According to NATSO, this guide contains 1,100 truck stops in the United States. It only includes basic information (name, location, phone, web site) on each stop.

- Trucker's Friend
  http://www.truckstops.com

  This is a web site sponsored by TR Information Publishers. It is a paid site ($10 for

100 searches) and claims to include several thousand truck stops with information on the facilities and amount of parking provided at each truck stop. They also publish a printed directory of truck stops.

- State of Maryland truck map and motor carrier handbook
  http://www.sha.state.md.us/SHAServices/mapsBrochures/maps/OPPE/maps.asp

  The handbook contains a list of private truck stops, park and ride lots, and weigh stations that have overnight parking.

There is no single source for all parking areas (private truck stops and public rest areas) nationwide. The sources mentioned above vary in the amount of detail provided, with Trucker's Friend providing the most detail. No historical information is provided on when parking is likely to fill up each evening.

Two ways to make the driver's planning process more effective include using historical occupancy data and incorporating the process for rest stop selection into the same process that some carriers and drivers use to select refueling stops.

While enroute, a tractor trailer may have to be refueled once every two days. The choice of refueling location can have a significant impact on fuel costs and thus the carrier's bottom line. Accordingly, some carriers are using decision support software to plan where their drivers should refuel. Since the refueling locations are generally the same as the rest locations, any proposed process for rest location planning should consider the process currently employed by carriers and drivers for fuel stop planning.

Although existing truck stop directories provide helpful information, an enhancement would be to inform the driver which stops are likely to have parking spaces available, given an arrival time and date. To facilitate this provision of information, any technology that is deployed to assess real-time parking occupancy should also have an archival function, so that a historical record of parking availability can be constructed. Because many segments of the trucking industry have seasonal peaks, any historical record should be maintained for at least one year.

7.2 Real-Time Tools

The effectiveness of the real-time provision of parking availability information depends on four factors:

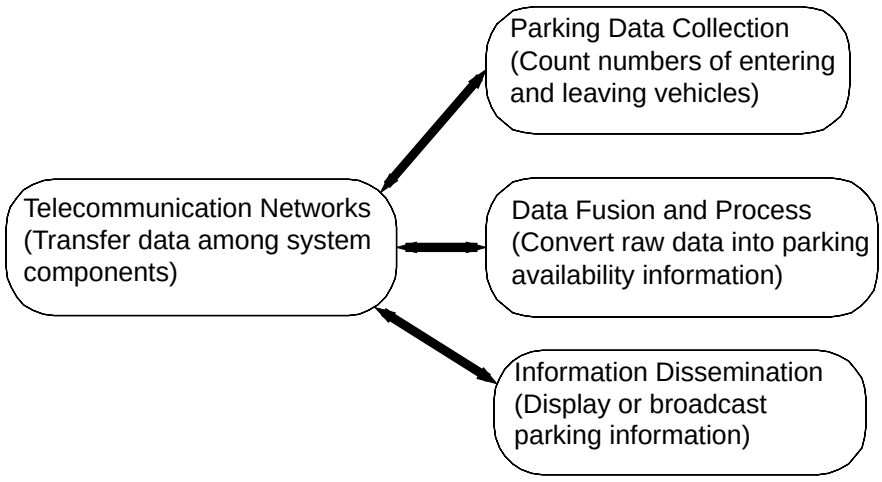
1. Is the fundamental problem one of better matching drivers to available spaces, or that there is in fact an overall shortage of spaces in the corridor? If the latter is true, it may be more productive to focus efforts on either increasing the number of spaces or reducing the demand for them. A real time information system that simply informs the driver that all the legal spaces are full will not add much value.
2. How accurately can entering and exiting trucks be detected? In other words, does the ITS technology accurately and reliably "know" whether a parking area is full, and if

it is not full, the number of spaces remaining. What is known about the sizes of the available spaces (a space might accommodate a tractor with a single 53-foot trailer, but would not accommodate a triple combination)?

3. How can this raw information on space occupancy be converted to information usable by approaching drivers? In cases where information is being broadcast over a wide area (for example, to drivers who are still many miles away), is it enough to simply broadcast the current space availability, when that space availability is likely to change by the time the driver arrives? For example, if a truck stop has 5 spaces left, and 30 drivers converge on the truck stop based on a broadcast of that information, 25 of those drivers will be left unsatisfied.
4. How effectively can the information be communicated to the drivers?

Garber, Teng, and Lu present a conceptual framework for a parking information system that addresses points 2 through 4 above (See Figure 1). The conceptual framework contains elements similar to what is depicted in the Parking Facility Management Market Package (ATMS16) in the National ITS Architecture, in that it contains parking surveillance, a parking management subsystem, and a link to the vehicle subsystem. The next three sections discuss each of these points in turn.

FIGURE 1 Parking Information System Framework (from Garber, Teng, Lu, 2004)



7.2.1 Determining whether spaces are occupied

There are essentially two approaches in using automation to determine how many spaces are available at a particular parking area:

1. Vehicle presence detection at each parking space. This requires that sensors be placed in each space or a video pattern recognition system to maintain a current count of available spaces. This approach offers good accuracy but typically costs more in equipment and installation.

2. Count in and count out. By counting the number of trucks entering and exiting a parking area, it is possible to deduce the number of vehicles currently parked. This usually produces less accurate results, because not all vehicles may park in a designated space, some vehicles will take up multiple spaces, and a sensor misread may never be corrected unless the parking area closes periodically or a manual count and correction is performed.

Several commonly-used technologies can be applied to determine how many parking spaces are available at a particular rest area. In the first approach above, an array of vehicle presence detectors must be established. Inductive loop detectors or magnetometers can be placed beneath the surface of the lot. This requires the lot surface to be saw-cut or trenched. Another approach is to use break-beams or ultrasonic presence detectors, but these would need to be placed on poles or in overhead structures, which typically do not exist at each parking space of a given rest area.

The second approach can be accomplished by counting the number of trucks entering and exiting each parking area. This can be easily accomplished through the use of a break-beam inductive loop, magnetometer, infrared or ultrasonic sensor. However, if both cars and truck typically enter the same rest area, which is more common than not, it is important to be able to distinguish between cars and trucks. Pole-mounted break beams, such as those used to warn vehicles of over-height situations, are usually effective at distinguishing between cars and trucks. The same can be said of weigh-in-motion (WIM) technologies, although these tend to carry much higher costs. However, for those rest areas that are co-located with state commercial motor vehicle safety inspection stations, it may be possible to leverage the WIM equipment by making it dual-use.

The second approach also assumes that the entries and exits to the parking area are well organized, so that all vehicles can be counted. Public rest areas are generally located next to the highway, and have a single one way ramp to enter and another one way ramp to exit. The entries and exits to a truck stop may not be as well organized. Therefore, some re-organization and channelization may be required before parking occupancy can be accurately determined via in-and-out vehicle counts.

In either event, it may be helpful to supplement the in-and-out counts with an overhead video image as a backup. It may also be helpful to provide an operator with the ability to manually reset the count, so that errors do not accumulate over many days. The detection technology must function in all weather conditions and must be usable at night, since the peak demand for parking is at night.

The State of Illinois has implemented a pilot system at two rest stops along I-80. Vehicle detection in the rest stop is combined with a sign on the highway that indicates whether the rest stop is full. The counts are performed by inductive loops. The observed error of approximately 1 vehicle per hour can add up significantly over the course of several days. The vendor is now trying to reposition the loops to improve accuracy. Desirable enhancements would include daily calibration along with the ability to set the counter remotely.

Ultimately, the decision on what technology and approach is most appropriate will need to be taken on a case-by-case basis, after weighing factors such as lot size, available infrastructure, budget, and accuracy requirements.

7.2.2 Forecasting space availability

Even a perfectly accurate parking occupancy detection system will only indicate the number of spaces available at a particular point in time. What the driver needs, however, is an indication of whether spaces will be available at the time he or she arrives at the truck stop or rest area. There are several approaches to dealing with this issue:

- Furnish information to the driver just before the entry to the rest area or truck stop. With a less than 1-minute lag, the actual occupancy number is not likely to change significantly. However, this does not help a driver choose among rest locations, where some of them may be many miles down the road. The eventual networking of truck stops and rest areas in a corridor so as to provide information on the nearest parking availability to truckers when a particular truck stop is full would be extremely useful.
- Furnish information on the number of spaces occupied and the number of spaces available, and let drivers do their own estimating as to whether spaces will be available when they arrive. This may be sufficient for a driver who is familiar with the corridor, but may not be helpful to an unfamiliar driver.
- Provide a forecast of space availability, based on historical information (e.g., if 20 spaces are open now at 7 pm, the lot will likely be full by 8 pm).
- Allow drivers to send an inquiry or request for parking to the parking management system (e.g., "I request parking in truck stop xx"), and incorporate this request along with requests from other drivers into the forecasts. Given the added communications needs and the change in driver behavior, this last option may not be practical.

While it may be desirable to provide space availability information far in advance of a rest area, the ability to do so may be more limited than it appears, even when using predictive software that calculates the rate of change in available spaces.

Sudden spikes can occur in the number of occupied spaces, because it is not unusual for drivers to run together for reasons that include safety, companionship, and fuel efficiency.
When trucks travel together, they often rest together as well. This can lead to a sudden decrease in the amount of available parking, which complicates the ability to forecast available parking.

7.2.3 Real-time communication to drivers

Once the number of spaces has been determined, the information must be processed and

delivered to approaching drivers. There are several effective ways to accomplish this:

- Variable message signs—This is probably the simplest and most effective way to deliver current information to drivers. Nearby signs can be hard-wired, while signs located a significant distance in front of the rest area may have a radio-frequency or a cellular telephone interface. Many such signs are commercially available and can be customized if necessary.
- Traveler information radio—The Federal Communications Commission sets aside frequencies, usually on the extreme ends of the AM spectrum, to provide local information to motorists. Establishing an informational radio broadcast is not particularly expensive (equipment often costs less than a variable message sign), and by using the AM radio, it is sure to be available to almost all truckers. While a synthesized voice can provide information on the amount of available parking, some effort may be required to convert the parking availability information into a form suitable for radio broadcast.
- Citizen's band (CB) radio—This technology was ground-breaking in the trucking community when it first became popular in the 1970s, but it still serves a function today. It is an effective way of identifying what other vehicles may be traveling in the vicinity, as well as what nearby hazards may exist. CB radio is not typically used to broadcast information, but there appears to be nothing prohibiting its use in this manner.
- Cellular telephone—Almost all truck drivers carry cellular telephones, and it would be a simple process to set up a telephone information system to provide drivers with parking availability data. However, there are some safety concerns with respect to using a cell phone while driving. Also, similar to radio, the parking availability information needs to be converted to a form suitable for audio broadcast.
- 511 trucker information—A truck-specific menu could be added to an existing 511 traveler information system. This menu would include information on available parking, and could be accessed via either cellular or land-line telephone.
- On-board computers—Many carriers use on-board computers to communicate with drivers. However, due to safety concerns, drivers are instructed not to look at the displays while they are driving. Carriers are beginning to look at text-to-voice conversion.

Safety concerns limit the use of in-vehicle visual displays to very simple messages. Furthermore, roadside variable message signs also have significant limitations, as the passing

motorist needs to be able to read the sign at a glance.[13]

13 An example at the Dallas Fort Worth International Airport (DFW) illustrates the limits of variable message signs. Since American Airlines uses three terminals at DFW, passengers who are driven to the airport need to be informed of their flight gate and terminal before they are dropped off. This was initially done via large variable message signs. The signs were blamed for crashes on the

According to the 2002 FHWA survey, desired means of receiving real-time information include radio in vehicle (73%) and visual display in vehicle (40%). (Roadside display of information was not presented as an option in the survey.) Desired information includes location, features, parking availability, and time limits.

Suffice to say, there are many options regarding the delivery of information to drivers. Technologies, such as roadside signs, information telephone numbers, and local radio broadcasts, should be looked at first as these can be used by the vast majority of drivers.

7.2.4 ITS Architecture and Standards

A national systems architecture for ITS has been established by the United States Department of Transportation (U.S. DOT) in cooperation with industry and other public sector agencies. The National ITS Architecture defines a Parking Management Subsystem, which provides for electronic monitoring and management of parking facilities, as well as links to a corresponding Vehicle Subsystem to allow for electronic collection of parking fees. It also includes the instrumentation, signs, and other infrastructure to provide information on parking lot usage, parking availability, and other parking information such as the ability to accommodate various vehicle types and sizes, cargo restrictions, hours of operation, etc. In addition, the National ITS Architecture provides for regional parking management strategies and coordination among multiple parking lot operators.

The National ITS Architecture is technology neutral in that it merely describes essential data and functions associated with the various subsystems, communication interfaces and data flows among the subsystems, and corresponding data and technical standards. It defines core functional requirements of ITS applications with the expectation that the architecture will be augmented as necessary to achieve specialized capabilities for which national consistency or widespread interoperability is not essential. The National ITS Architecture is not static; rather it is revised and updated as necessary to accommodate and integrate new ITS functions and capabilities in the overall framework.

Associated needs for various standards have been identified and these are being developed by corresponding standards developing organizations. The National ITS Architecture and Standards seek to promote widespread interoperability among ITS applications, so that purchasers of ITS products and services will be able to have seamless access to ITS capabilities throughout the United States where conforming infrastructure and services exist. In addition, the National ITS Architecture and Standards provide a broad market scope to encourage industry development of ITS products and services and market stability to mitigate consumer risk of technological obsolescence. The U.S. DOT requires that public sector ITS deployments made with highway trust funds for highways or transit conform to the National ITS Architecture and Standards.

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airport roadway as motorists slowed to read them. Now, a low power AM radio station is used to broadcast gate and terminal information.

As defined in the National ITS Architecture, parking management functions include monitoring parking space availability, providing information about parking availability and cost to drivers, electronic fee collection, and violation enforcement. Information about parking and space availability is to be provided to: 1) drivers in the immediate vicinity of parking lots via roadside electronic message signs; 2) information service providers via fixed-point to fixed-point communications technologies; and 3) other parking facilities. The information service provider function may be provided in various ways, and serves as an intermediary to provide information to drivers and to arrange parking reservations on behalf of drivers. In the case of commercial vehicles, a large trucking firm may elect to perform the information service provider function for its fleet. Alternatively, an industry group, truck stop operators, or public highway agencies may perform the function for particular parking areas or, more comprehensively, for a geographic area. In addition, parking information may be provided to traffic management and transit management systems to support regional parking management strategies.

Although a real-time parking availability information system for truckers will include many of the components in a managed parking facility (see www.its.dot.gov/aconform/aconform.htm), it will not need to include fee collection and violation enforcement. Most truck stops and rest areas do not charge for truck parking; therefore, in most cases the fee collection function will not be needed.

7.2.5 Real-Time Tools: Summary

A real-time parking information system should include three major components:

- Parking data collection
- Conversion of raw data to parking availability information
- Information dissemination to drivers on the road.

At this point, since historical information on parking occupancy is not available, the forecasting of parking availability based on historical information will be deferred. However, any information technology should include the capability to archive data, so that historical information on parking occupancy can be assembled and used for forecasting. Furthermore, a parking information system should have the ability to accommodate a potential parking reservation function.

The design of the parking information system must be consistent with the National ITS Architecture, in particular those parts of the Parking Facility Management Package (ATMS16) that involve:

- Monitoring the number of spaces available at a truck or rest stop, and
- Providing real-time information on the availability of spaces to drivers on the road as well as to Information Service Providers and other parking facilities.

8 Conclusions

One issue contributing to truck driver fatigue-related crashes is the lack of safe, available truck parking on or near Interstate highways. As a result, drivers may drive for longer than is safe, or may find themselves unable to obtain undisturbed sleep during a rest period. On the issue of safe, available truck parking, this report addressed the following four questions:

- Is there a shortage of parking?
- Is the shortage likely to worsen?
- What are potential solutions?
- What can be done to better match available supply and demand?

Is there a shortage of parking?

Yes, there are regional shortages. Furthermore, given the desire to maximize productivity (i.e., drive as much as possible in a day) while remaining legal under the hours-of-service rules, a driver may find that he or she has run out of available driving hours with no legal parking available nearby. As a result, drivers sometimes park on the shoulder of a highway or ramp, creating a safety hazard.

Is the shortage likely to worsen?

Yes, continued growth in the truckload industry will lead to increased demand for truck parking.

What are potential solutions?

Approaches to solving the truck parking shortage fall into three major areas: a) making underutilized spaces more attractive, b) increasing the supply of spaces, and c) better matching supply and demand. Examples of making underutilized spaces more attractive include better lighting to reduce crime and improvements to parking layouts. Examples of increasing the supply of spaces include construction, using weigh stations and park and ride lots, and relaxing time limits. Examples of better matching include technologies that provide up-to-the minute information on parking availability.

What can be done to better match available supply and demand?

A real-time parking information system should include three major components:

- Parking data collection
- Conversion of raw data to parking availability information
- Information dissemination to drivers on the road.

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