Creating a roadmap for successfully planning, implementing and administering complex multi-jurisdictional transportation technology projects.

Davonna Moore[1*], Gretchen Ivy[2], Brian Comer[3], Michael DeMent[4], Matthew Junak[5], Charles Miller[6]

1. Kansas Department of Transportation, United States
   Dwight D. Eisenhower State Office Building
   700 S.W. Harrison Street, Topeka, KS 66603-3745
   (785) 296-0346; davonna@ksdot.org
2. HNTB Corporation, 715 Kirk Dr., Kansas City, MO 64105 – givy@hntb.com
3. HNTB Corporation, 715 Kirk Dr., Kansas City, MO 64105 – bcomer@hntb.com
4. HNTB Corporation, 715 Kirk Dr., Kansas City, MO 64105 – mdement@hntb.com
5. HNTB Corporation, 715 Kirk Dr., Kansas City, MO 64105 – mjunak@hntb.com
6. HNTB Corporation, 715 Kirk Dr., Kansas City, MO 64105 – cmiller@hntb.com

Word count: 3,535 words text + 1,000 word equivalents (4 tables and figures)

Submission Date: July 31, 2018

Abstract

Eight Midwestern states united in creating a first-of-its-kind Regional Truck Parking Information Management System (TPIMS) to reduce the incidence of commercial truck drivers injuring themselves and other drivers due to fatigue-related crashes and unauthorized parking along the interstate highways. The core ITS technologies used for the system are not complex - monitoring available parking at authorized public and private truck facilities in real time, and then relaying the information to truck drivers and dispatchers through roadside dynamic truck parking signs (DTPS), mobile applications and state traveler information websites such as 5-1-1. However, deployment of a regional project across multiple agencies and state lines is complex, no more so than in the need to accommodate the organizational policy and technology needs and preferences of the eight partner states (Indiana; Iowa; Kentucky; Michigan; Minnesota; Ohio; Wisconsin; and Kansas, the lead agency for the $25 million federal TIGER grant which underwrites much of the initiative). This paper explores the lessons learned in developing and implementing a complex, multi-jurisdictional technology initiative as it nears full operational status in January 2019 and begins producing results that expect to reduce crashes while improving the efficiency and profitability of the regional freight system. It also highlights how those lessons can be more broadly applied to major multi-jurisdictional transportation projects of all kinds.

Keywords: ITS, Freight, Truck Parking, Technology

Introduction

Safe, convenient parking is essential for long-haul truck drivers, the lifeblood of the U.S. freight transportation network. Yet many drivers often struggle for up to an hour each day to find areas to safely rest - putting themselves and other drivers at risk when searching while fatigued. *(1)*

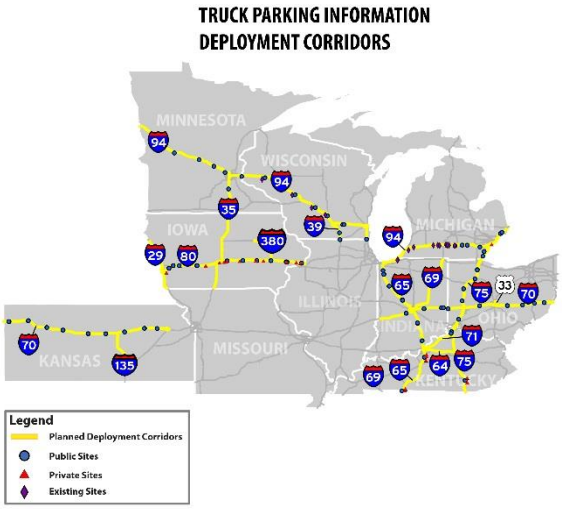
That's why eight states – Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, Ohio and Wisconsin – joined together to develop a real-time, multi-state Truck Parking Information Management System (TPIMS). (*2*)

When fully operational in January 2019, TPIMS will improve the safety and efficiency of America's freight network by providing real-time parking availability information to truck drivers through dynamic message signs, smart phone applications, traveler information websites and other means.

This regional system will enable truck drivers, dispatchers and others to see and benefit from a consistent, cohesive parking availability system that crosses state lines, benefitting regional and national freight movements.

The planning, design and deployment of TPIMS followed the systems engineering process. An appropriate level of up front planning and documentation was completed to insure stakeholder needs were met in a manner that can be efficiently implemented and operated by each state.

Figure 1: TPIMS Geographical Reach



TPIMS is being deployed along the region's high-volume freight corridors using existing ITS infrastructure and emerging vehicle detection and data collection technologies. Locations were selected based on factors such as trucking volume, parking demand and site capacity for improvements.

In the process, TPIMS also provides important lessons for successfully developing and delivering complex, multi-jurisdictional technology projects of all types while integrating individual and collective agency goals and needs.

Addressing regional problems through technology

The MAASTO Regional TPIMS initiative was established in recognition that commercial trucks move nearly two-thirds of North America's almost $1.2 trillion in freight shipments annually. (*3*) How and when these long-haul truck drivers will find safe spots to rest are logistical details often overlooked, however. That's why truck drivers consistently report issues finding safe, legal parking places along their routes. In one study conducted for the Kansas Department of Transportation (KDOT), 78 percent of drivers reported that on average it takes them longer than 30 minutes to find parking. (*4*)

The longer a fatigued truck driver is on the road looking for a spot to park, the higher the risk of a crash happening. Eighty-five percent of truck drivers surveyed said that they occasionally or regularly found themselves fatigued while driving and had an unsafe feeling because they were not able to find safe truck parking. (*5)* When fatigued, drivers cannot find legal spots to park, they often park on freeway ramps or in unauthorized lots, putting at risk themselves and other motorists.

Having identified the issue, the TPIMS partner states (Partnership) developed and agreed to a set of goals for the initiative based on multilateral discussions, availability and robustness of data and collection methods to underpin performance measurements, and other factors. The project goals that emerged included:

1. Improve safety
    a. Reduce crashes (fatigue related)
    b. Reduce illegal/informal parking on ramps
    c. Improve personal safety and security for commercial drivers
2. Provide timely, reliable and accurate truck parking availability information
3. Provide harmonious and consistent operations between states
    a. Regional consistency and branding
    b. Seamless across state lines
    c. Universal data interface (API) with private industry helping to provide innovations for data dissemination
4. Maximize usage of existing parking assets
5. Add value to the trucking industry
6. Implement in a sustainable way
    a. Show return on investment with clear, measurable public benefit
    b. Mitigate long-term O&M costs – potential transition of system to private industry or others
7. Allow some state-specific flexibility (procurement and truck parking monitoring technologies)

Figure 2: Lesson 1

FOCUS ON OUTCOMES

Focusing on outcomes – safety, ease of use, consistent regional access to parking information – was critical for success. Agreed-to goals enabled the Partnership to reframe discussions about technological solutions in terms of end-user benefits rather than agency custom. It mooted potential conflicts about how each state delivered those benefits since each one could achieve the goal in its own way, reflecting its operational, regulatory and statutory preferences and constraints.

Such a commitment to a common approach can be challenging for cross-jurisdictional technology projects.

Partner agencies typically will have a broad range of options to consider when they undertake a technology-related initiative. Narrowing the potential options is made significantly easier when research springs from clear project goals and quantifiable performance measures.

Table 1: TPIMS Core Functions Matrix

Functions	Type	Iowa	Ohio	Michigan	Kentucky	Wisconsin	Indiana	Kansas	Minnesota
Procurement	Public	DBOM	DBOM	DBB	DBB	DBB	DBB	DBB	DBB
	Private		N/A	DBOM		N/A	N/A	N/A	N/A
Data Collection Method	Public	Functional Requirements	Functional Requirements	In/Out	In/Out	In/Out	In/Out	Space-by-Space	Space-by-Space
	Private		N/A			N/A	N/A	N/A	N/A
Data Collection Technology[6]	Public	Functional Requirements	Functional Requirements[1,2]	Video	Magnetometer	Magnetometer	Magnetometer	Video[2]	Magnetometer
	Private		N/A	Video		N/A	N/A	N/A	N/A
Operations & Maintenance	Public	Third Party	Third Party	Internal[3]	Third Party[4]	Third Party	Internal	Third Party	Internal
	Private		N/A	Third Party		N/A	N/A	N/A	N/A
	Sign Operations	N/A	Internal	Internal	Internal	Internal	Internal	Internal	Internal
Data Analytics & Sharing	Processing	Third Party	Third Party	In-House ATMS[7]	In-House ATMS	Third Party	In-House ATMS	In-House[8]	In-House ATMS
	Software	Not Developed	Not Developed	Current	Not Developed	Current	Not Developed	Not Developed	Needs Additional Development
	Sharing Format	XML Data Feed	XML Data Feed	XML Data Feed	XML Data Feed	XML Data Feed	XML Data Feed	XML Data Feed	XML Data Feed
Information Dissemination	Signs	No Signs	DTPS	DTPS	DTPS	DTPS	DTPS	DTPS	Full-Matrix Color DMS
	Website	State and Third Party[5]	State and Third Party[5]	State and Third Party[5]	State and Third Party[5]	State and Third Party[5]	State and Third Party[5]	State and Third Party[5]	State and Third Party[5]
	Mobile Website/ Mobile App	State and Third Party[5]	State and Third Party[5]	State and Third Party[5]	State and Third Party[5]	State and Third Party[5]	State and Third Party[5]	State and Third Party[5]	State and Third Party[5]

Successfully completing regional technological initiatives may necessitate reconciling different, perhaps conflicting, agency technical preferences and requirements as seen in this Core Functions Matrix. These can be deeply embedded in an individual agency's business rules or typical practice. The Matrix provided a way for participant agencies to better visualize where conflicts and commonalities might arise during TPIMS planning.

Development of the project's core functions, represented in the figure, are discussed further below.

Defining end user needs and expectations

A powerful tool for further refining choices a technology partnership must make involves being very clear about expectations and requirements of internal and external end users. This helps strengthen the project team's understanding of the opportunities and limitations of each technology being considered for a given task.

The TPIMS partners did considerable internal and external outreach to improve the proposed system and mitigate or eliminate potential threats to project success. This engagement involved a mix of workshops, surveys and face-to-face meetings conducted throughout the implementation region.

By engaging with trucking associations, for example, the Partnership could identify when drivers start planning where to park and, by extension, where TPIMS signage and marketing needed to occur. It also underscored the importance of providing parking information electronically through smart phone applications or in-cab navigation systems that are increasingly the hub through which drivers make and document their driving decisions. Meanwhile, external end users had expectations and statutory requirements that necessitated delivering accurate, real-time parking information in an electronic format, regardless of other delivery methods used. Finding a technology solution that could satisfy all these requirements helped rapidly narrow the field of potential answers.

As a result, the partnership reached out third-party application developers such as Google, Waze and Truck Specialized Parking Services, among others, to engage them in using TPIMS parking data in their apps.

To help measure whether this goal would be achieved, the TPIMS Partnership developed three broad categories of performance measures:

1. Parking utilization and demand involves measuring driver perceptions of how full MAASTO truck stops are and how often. Parking utilization and demand cycle data will be collected through system statistics as well as yearly through a driver survey conducted by the American Transportation Research Institute (ATRI).
2. Corridor safety reflects the number of fatigue-related crashes on TPIMS corridors. Corridor safety data - including fatigue-related truck crash rates, types and patterns - will be analyzed and reported by the Mid-America Freight Coalition (MAFC).
3. System reliability will show how well the system is operating. System reliability will be measured by total system downtime, number of user complaints and the difference in the number of spots that the system says are open and that are available.

Figure 3: Lesson 2

LINK GOALS AND PERFORMANCE

The ability to rule particular technology in or out of consideration based on agreed-to goals and performance measures reduces opportunities for delay.

It shifts the focus from "how we do it" to "will it help achieve the end results." In the process, partner agencies can better accept differing agency approaches if they see they don't affect the ultimate delivery of services and results.

Finally, it is simpler to address late-breaking project questions or changes by analyzing them in light of whether they improve or degrade results under agreed-upon performance measures.

Innovative technologies for building a safer network

Thoroughly understanding end user needs coupled with well-articulated actionable and measurable goals helped simplify decisions underpinning three important categories of technology deployment that make TPIMS possible:

- Detection of available parking
- Collection and storage of parking availability data and
- Communication of parking data to drivers

Detection of available parking

The number of designated spots differs facility to facility, and there are many ways to count the number of spots occupied or available. The level of vehicle detection accuracy and how availability level is communicated are critical for DOTs to build trust among truck drivers such that they can rely on using the system to make productive routing and parking decisions. A TPIMS baseline survey had revealed that system reliability is the most important concern for truck drivers followed closely by system accuracy. Therefore, the Partnership created performance standards to monitor both. For example, small parking facilities (less than 15 spots) will need to meet an 85% accuracy threshold. A 90% threshold will be the benchmark for large parking facilities (15 or greater spots).

Having agreed to performance measures and a commitment to end user needs enabled the Partnership to identify and deploy two different methodologies for monitoring available parking that best fit agency and local user needs. The two approaches involved counting flows in and out of a truck parking area or detecting space occupancy.

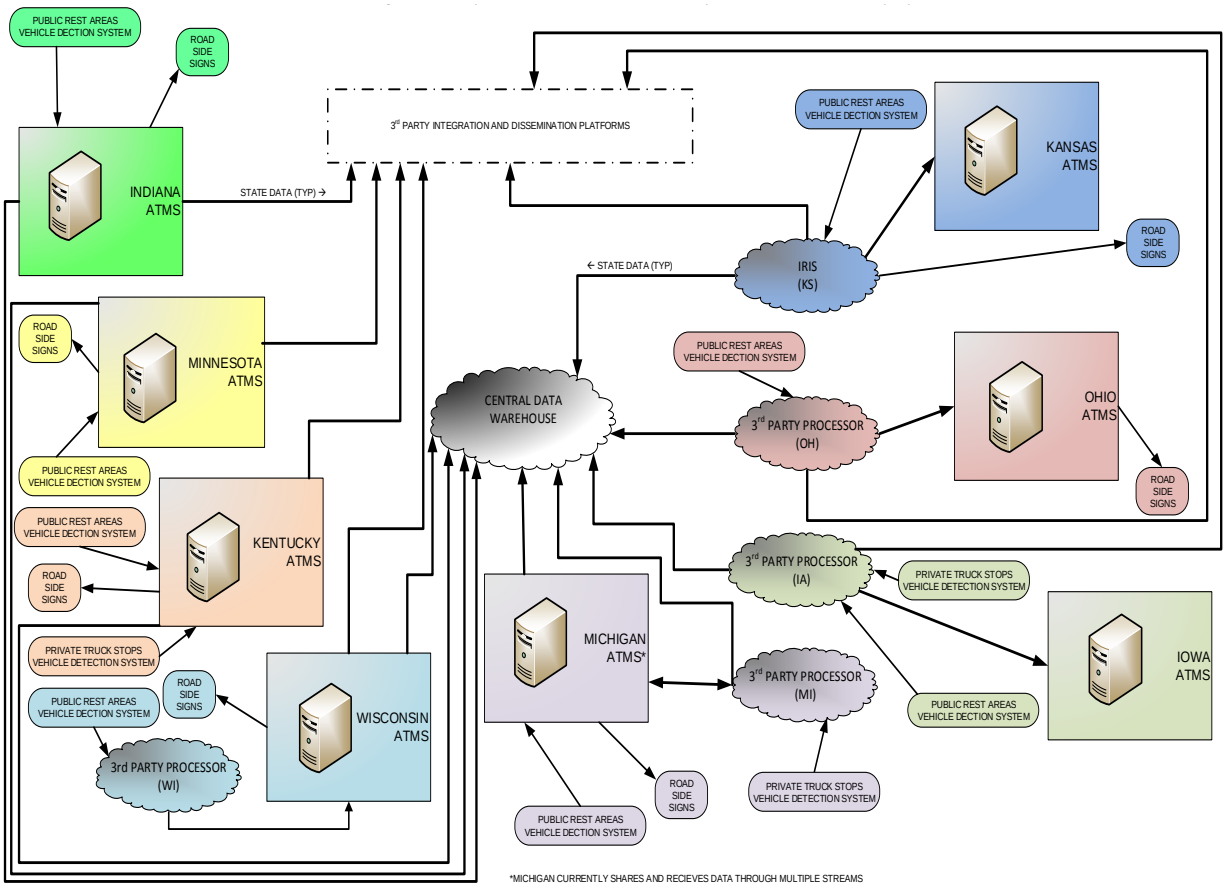
Several Partnership states have chosen to use the "one in and one out" method for estimating available spots. This method requires a parking facility with designated entrances and exits. When a truck enters a facility, the system is triggered to account for one less spot. Likewise, when a truck exits the parking facility the system refreshes to reflect another parking spot becoming available. The benefit of this methodology is cost effectiveness for larger parking areas and the ability to accommodate informal parking beyond marked parking spaces. The downside is that truck counting errors can accrue until manually corrected, so the available space count must be verified and reset by operators regularly and periodically. With this methodology, either magnetometer-based sensors or video detection is being used to count trucks entering and exiting parking areas.

The second methodology senses vehicle occupancy in defined parking spots to determine how many spaces are being used. Two different technologies will be used to monitor parking stall occupancy – video analytics and wireless magnetometer sensors in the pavement. Both technologies determine if a defined parking stall is occupied. This methodology requires less effort to monitor and correct inaccuracies because trucks are only counted when they occupy or leave parking slots in a manner sufficient to trigger sensors. Thus, errors are "reset" when the vehicles move and do not accrue over time. However, since each parking stall must be monitored, the cost increases as the number of spaces increases. This methodology also cannot adapt as easily to informal parking and when vehicles park in undefined spaces, such as when snow covers the ground.

Collection and storage of parking availability data

The TPIMS Partnership states will collect and send their data to a central data warehouse operated by the Mid-America Freight Coalition. From there it will be provided to other partner states and third-party vendors for use. Each state will determine how it will collect and transmit its data within the common standards the Partnership created to promote interoperability across state lines. The result is that users of the system will see no difference in how it operates from state to state, despite each state taking a different path towards integrating its parking information efforts with its existing ITS network and software platforms and vendors.

Figure 4: TPIMS Data Collection and Storage



A commitment to a common user experience means that they will see no difference in how the system operates from state to state, despite each state taking a different path towards integrating its parking information efforts with its existing ITS network and software platforms and vendors.

Communication of parking data to drivers

Websites, mobile applications and DTPS will provide truck parking data to truck drivers. Dynamic messaging signs will include information on where the truck parking facility is located and how many spots are available. Parking information for up to three of the nearest parking facilities will be displayed on each DTPS.

Figure 5: TPIMS Dynamic Messaging Signs

Roadside signs will display real-time parking information because the actual number of available spots may change by the time a driver reaches the reported facility. To minimize this being an issue, roadside signs and data streams will be required to refresh at a rate of no less than one time every five minutes; and, DTPS design requirements recommend signs be placed at a maximum distance of 60 miles from the next truck parking facility so that drivers can make efficient, timely

The intent is to enable a truck driver to evaluate whether to stop at the next available facility or continue to another facility where more parking may be available or could get them further towards their destination within their legal hours of service.

Additionally, when parking facilities begin to reach capacity the number of available spaces tends to be volatile, and some lots accommodate informal parking beyond the striped parking spaces. Therefore, the MAASTO TPIMS Partnership has agreed to display the word "LOW" on signs and within data streams when the calculated availability drops below a pre-determined threshold. Due to the differing technology preferences and number of spots available per site, each agency determines what the threshold for "LOW" will be at each of its sites.

Websites and mobile applications - official agency-supported platforms like 511 as well as third-party platforms – also will be options. For data shared through third-parties, the interface and how the truck drivers receive the data will be primarily left to developers and how they interface with their customers (mobile application, fleet logistics partners, on-board telematics providers, etc.). Regulations prohibit drivers from using hand-held devices while in-route, so third-party

Figure 6: Lesson 3

COMMUNICATE EARLY AND OFTEN

Team members may differ regarding the manner of system design and testing. But common standards for testing and communication increase the likelihood of success. Early in TPIMS design, for example, it became clear that moving parking facility utilities could require more coordination than expected. Sharing this enabled agency partners to adapt construction and testing approaches, eliminating potential delay. For TPIMS, as each state was completing final design and installation prior to testing, monthly project team meetings coupled with individual WebEx conference calls combined to make sure that work was proceeding on schedule and that partner agencies could benefit from each other's experiences.

vendors and commercial fleets will be tasked with finding a way to integrate TPIMS data with the hands-free technologies currently used for fuel efficiency, supply chain management, and driver logging.

Evolution of TPIMS regional collaboration

Members of the TPIMS Partnership originally came together to make it easier for truck drivers to reliably find safe places to park through use ITS technology. The system they envisioned would be designed to provide over-the-road truck operators with accurate, actionable truck parking information that would save them from wasting their limited legal hours of service searching for places to park for their Federal Motor Carrier Safety Administration mandated rest periods (*6*) or from using unsafe informal or illegal parking locations, jeopardizing their safety and that of other motorists on the roads they share.

Figure 7: Lesson 4

DEFINE ROLES CLEARLY

As the lead applicant for this project, KDOT administers the TIGER grant; manages the group's activities in support of monthly and milestone progress; and facilitates group and stakeholder meetings designed to ensure that the system meets partner and end-user needs and expectations. This frees up each state to focus on only its own implementation plan, schedule and budget.

What is pioneering about TPIMS is that state agencies have collaborated to ensure that the truck parking system on an interstate corridor does not stop at the state boundary. Each of TPIMS Partnership states recognized that the need for a truck parking system is not simply a state issue, but a regional issue, as drivers can cover up to 600 miles of roadway in one shift.

There was also the realization that addressing this issue would require ensuring that each agency had the flexibility to work out for itself the technical details of its state truck parking system - with the understanding that the overall system must appear seamless to the truck operator when moving from state to state and must adhere to the same levels of performance.

TIGER grants require demonstrating close adherence to budget and schedule requirements. This put a premium on clearly defining roles and expectations to avoid unanticipated delays or budget risks that might arise from developing an architecture flexible enough for each state to create an individual parking information system integrated into its existing ITS network and software platform - yet still capable of regional interoperability.

In this environment, each state committed to its own implementation budget and schedule that supported those of the overall project. Three partner states that had begun deploying precursor TPIMS projects served as technical resources. The Mid-America Freight Coalition was brought on board to serve as the project's data warehouse and to assess performance after the system goes live.

So far, this approach has worked smoothly and efficiently as evidenced by the fact that the original $25 million TIGER grant has grown to a total of nearly $35 million in additional state and federal funding. The project has moved on to Phase Two (Final Design and Deployment) after successfully completing Phase One in the 4Q of 2016 (Concept of Operations and 30% Design). The system-wide go-live date of January 4, 2019 still holds.

With full implementation, the use of ITS technology in TPIMS is expected to significantly reduce the amount of fatigue-related accidents that occur on interstates every year. In the three years after system launch, the system will be evaluated to determine if the performance measures are being met and if truck operators are reporting a positive experience using the system.

And ultimately, the MAASTO TPIMS Partnership will strengthen America's freight network by helping commercial truckers make safer, more efficient parking decisions through a user-focused information service that consistently provides timely, reliable parking availability information. The MAASTO TPIMS initiative will provide a truly regional ITS-driven system within which truck drivers, dispatchers and others will see a consistent, cohesive parking availability system regardless of when or where they cross state lines.

Figure 8: Other Success Factors

- Verify proposed sign locations to preclude field issues.
- Locate signs to maximize truck driver decision making.
- Market new system internally and externally to maximize acceptance and use.
- Coordinate with other current and proposed truck parking system to ensure consistent regional and national protocols for information distribution.

AUTHOR CONTRIBUTION STATEMENT

The authors confirm contribution to the paper as follows: project conception and design: Davonna Moore, Gretchen Ivy, Brian Comer, Michael DeMent, Matthew Junak, and Charles Miller. The same individuals participated in the preparation and review of the manuscript and approve the final version of the manuscript.

References

1. Jaillet, James. Drivers' parking journals show they lose $5,000 annually to time spent finding parking. *Commercial Carrier Journal*, Dec.14, 2016. https://www.ccjdigital.com/drivers-parking-journals-show-they-lose-5000-annually-to-time-spent-finding-parking/. Accessed July 21, 2018.
2. Mid America Association of State Transportation Organizations. April 20, 2016. http://www.maasto.net/documents/TPIMS-Summary.pdf. Accessed July 22, 2018.
3. U.S. Bureau of Transportation Statistics. March 2018. https://www.bts.gov/newsroom/2017-north-american-freight-numbers. Accessed July 26, 2018.
4. *Kansas Statewide Freight Network Truck Parking Plan*. Kanas Department of Transportation, Topeka, KS. 2016. https://www.ksdot.org/Assets/wwwksdotorg/bureaus/burRail/Rail/Documents/Kansas_Statewide_Freight_Network_Truck_Parking_Plan_2015_2016_Appendices.pdf. Accessed July 12, 2018.
5. Freight Management and Operations, U.S. Federal Highway Administration. Feb. 1, 2017. https://ops.fhwa.dot.gov/freight/infrastructure/truck_parking/jasons_law/truckparkingsurvey/es.htm. Accessed July 223, 2018.
6. Federal Motor Carrier Safety Administration. May 31, 2018. https://www.fmcsa.dot.gov/regulations/hours-of-service. Accessed July 21, 2018.

Reviewer Comments Matrix

"Creating a roadmap for successfully planning, implementing and administering complex multi-jurisdictional transportation technology projects."

Reviewer	Location	Subject	Reviewer Comment	Response
Reviewer #2	Page 1	Edit	"Iowa is duplicated in the abstract."	Deleted.
Reviewer #2	Throughout	General	"The lessons learned while inverting andshpuld be included don't seem to follow standard TRB processes for research/informational papers. This is more informative than research but it will be interesting to hear the report out in a couple of years for how this partnership is working and if there is a a measurable reduction in fatigue related incidents in the trucking industry in these areas."	Noted. No changes to the document were made at this time.
Reviewer #2	Throughout	Format	"There are some formatting issues happening in the paper especially the page with figure 3."	Formatting has been fixed.
Reviewer #3	Throughout	Format	"Lessons Learned graphics are not numbered. They look fine the in paper but cannot be referenced."	Formatting has been fixed.
Reviewer #4	Page 2	Text	"The paper certainly delivers on the title. The weaving of the Lessons Learned and Other Success Factors is nicely done - speaks to the ITS systems engineering philosophy. Certainly not needed or wanted to get into a discussion of ITS systems engineering. Was great to see the authors hit a lot of the ITS systems engineering boxes without getting into the systems engineering jargon. Still, but might be worthwhile to mention it in the first part of the paper if indeed ITS systems engineering was used."	Noted. A short paragraph has been added in the introduction that explicitly confirms the systems engineering process was followed.
Reviewer #4	Throughout	Format	"Other than the comments on Table 1, and Figure 2, I do not have any recommendations for improvement."	Formatting has been fixed.