- USING OPTIMIZATION MODELING TO ADDRESS TRUCK PARKING NEEDS -

- ABSTRACT -

Addressing the rest and break needs of the nation's truck drivers through the provision of adequate truck parking has been the focus of national research efforts since the 1990's. In 2012, these needs were specifically addressed within Federal legislation. Previous research and practice have established well documented approaches for evaluating truck parking needs through a combination of qualitative analysis via stakeholder outreach and quantitative analysis using truck traffic counts and GPS data. This paper discusses the use of optimization modeling, a common private sector planning tool for both strategic and operational planning for over three decades. It describes the development of an optimization model for the I-10 Corridor in Texas with the primary objective to minimize the distance that truck drivers must travel to find an authorized parking space when needed, based on the hours-of-service regulations.

Results from a baseline scenario and a constraint-based scenario both identified the Fort Stockton and El Paso areas as the top locations on the Corridor to build additional truck parking capacity. Optimization provides planners with a dynamic, data-driven tool that can be updated with new GPS data and the ability to analyze scenarios related to planned or unplanned closures, regulatory policy, and operational questions. The use of optimization models to aid public sector decisions is an emerging practice with applications beyond truck parking, including traffic signal systems, multimodal freight networks, fleet operations and management, and the siting of non-carbon based refueling and recharging infrastructure.

KEYWORDS: truck parking, optimization, hours-of-service (HOS), GPS data, freight

TRBAM-23-03512

- D A T A -

- Segmentation of the I-10 Corridor -

The highway network used by USDOT to model Freight Analysis Framework flows (FAF Network) was pared down to the I-10 segments within Texas. The 875 FAF I-10 segments ranging in length from 0.001 to 35.464 miles were merged into a single line shapefile and then split into 879 one-mile segments and given a unique ID from 1 to 879, moving west to east. The Lat/Long coordinates of each centroid was derived and recorded. Since the ATRI GPS data employed in the model is a sample, expansion factors were derived by comparing sample data to known truck counts and applied:

- Expansion Factor of 6 for segments within or intersecting a Permian Basin County.
- Expansion Factor of 3.76 for segments that serviced a truck parking facility and were within or intersected a metro area county of Houston, San Antonio or El Paso.
- Expansion Factor of 2.85 for segments that serviced a truck parking facility and were not within or did not intersect a metro area county.
- Expansion Factor of 3.1 to remaining segments that did not service a truck parking facility.

- Truck Parking Supply -

TxDOT inventory of truck stop supply locations (polygons) with attributes related to location, type of facility (e.g., private truck stop or public rest area), source of information, estimate for number of spaces, and others were supplemented with truck parking facilities identified using the following process:

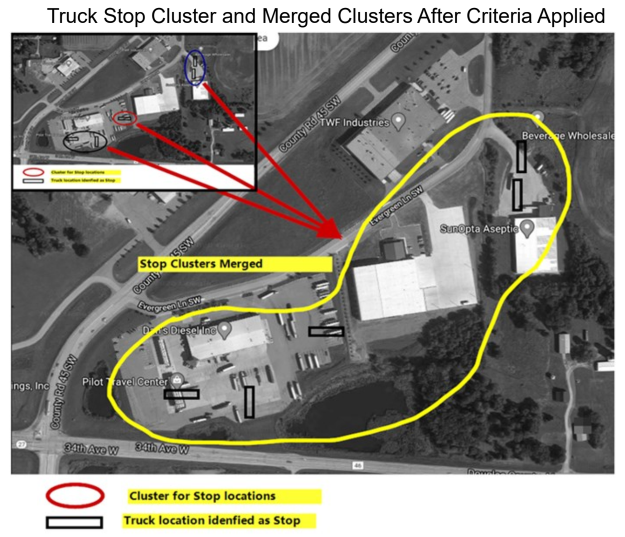
1. Parcels from the Texas Natural Resources Information System (TNRIS) were spatially joined with InfoUSA business data to identify gas stations, and reviewed for the presence of truck parking.
2. For counties with no TNRIS data, areas with high concentrations of overnight stops were reviewed using Google satellite imagery.
3. Sum number of overnight stops for each parcel.
4. Visually check gasoline station parcels with more than 10 stops to identify truck parking facilities.
5. Estimate number of truck parking spaces using satellite imagery.
6. Sum number of spaces per one-mile segment using a geospatially derived crosswalk table.

- Truck Parking Demand -

Estimates for overnight truck parking demand were based on a 62-day sample of ATRI truck GPS data for Texas, as well as eastbound I-10 trips from New Mexico, and westbound I-10 trips from Louisiana and Mississippi. Data processing followed these steps:

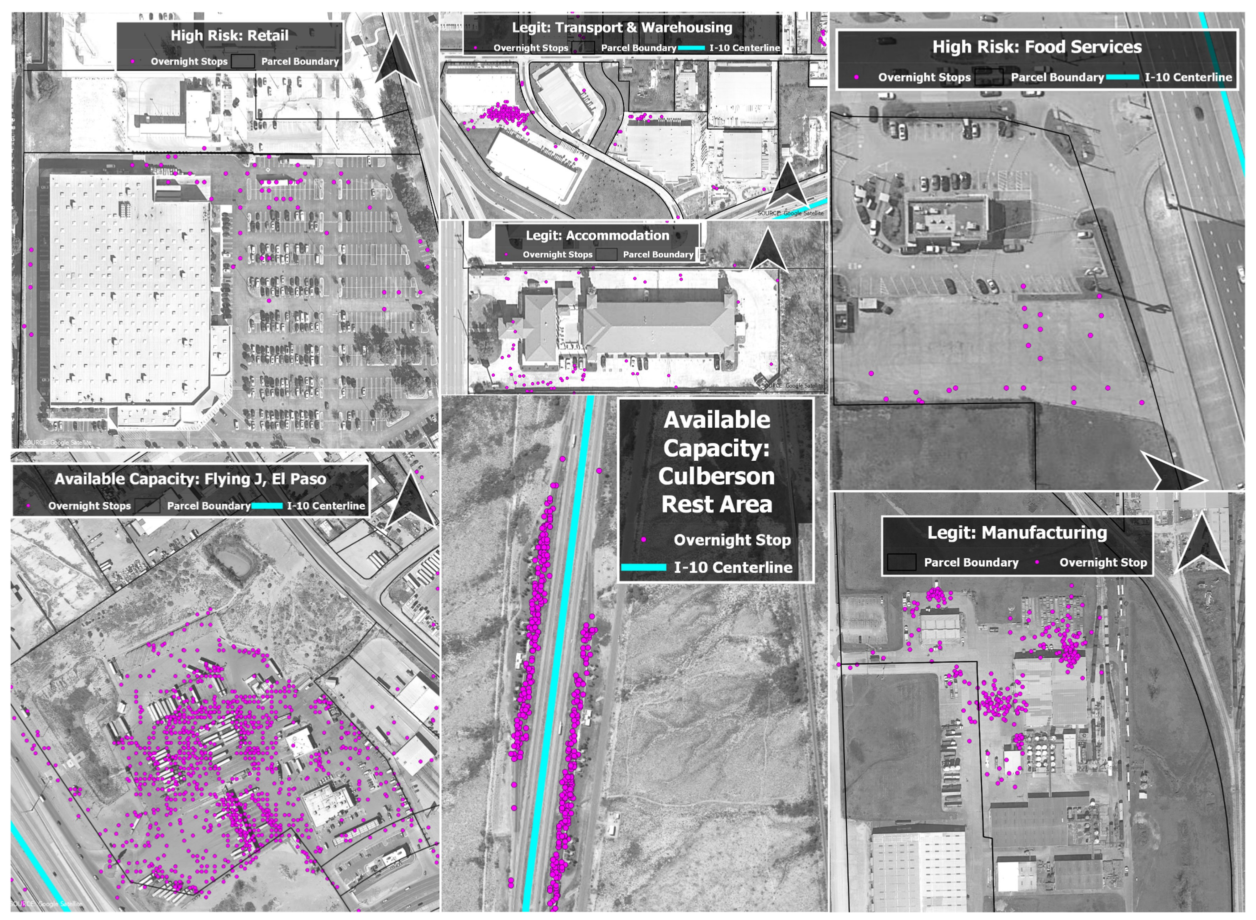
1. Cleanse data by removing trucks with < 20 GPS pings and < 30 minutes of GPS data.
2. Derive average speed between pings using the great-circle distance and time stamps.
3. Determine stops using a pre-defined threshold and discarding pings representing a truck in motion.
4. Cluster stops with the same Truck ID and within 2,000 feet of one another.
5. Identify "Parking Stops" utilizing a minimum stop duration threshold of 15-minutes to account for stops due to heavy traffic and clustering stops within a 2,000 foot threshold to account for intra-facility movements.

Truck Stop Cluster and Merged Clusters After Criteria Applied

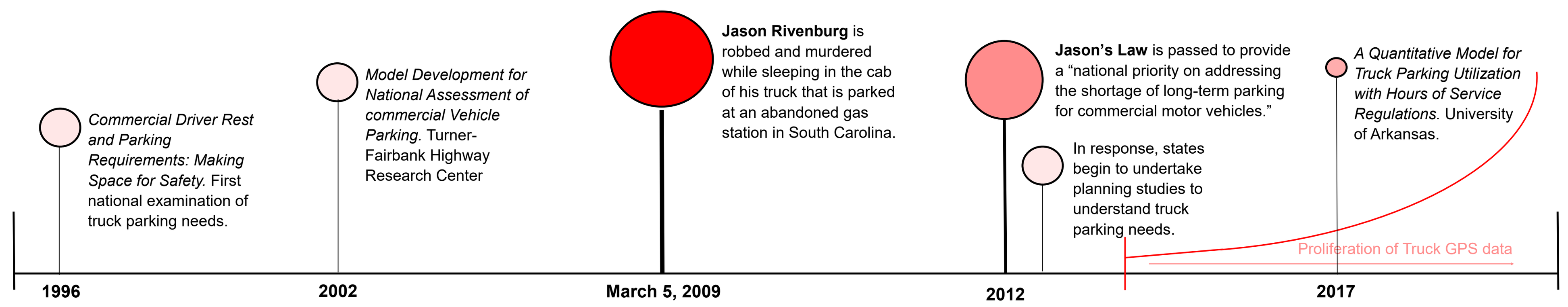


- Truck Parking Demand Classification -

To account for trucks stopping at "unauthorized sites", overnight truck parking stops were classified into six categories using information from InfoUSA, TNRIS, and satellite imagery, including: **Available Capacity** (private truck stops and public rest areas); **Available Capacity, High Risk** (open or unpaved parcels); **High Risk** (retail locations); **Legitimate** (parcels with parking provided); **Right-of-Way** (overnight stops in the ROW); and **Other** (NEC, generally in parcels with less than 10 stops).



- I N T R O D U C T I O N -



Optimization Modeling is a math-based approach that uses linear programming and "big data" to find the optimal solution to complex problems.

An optimization model is composed of three components:

1. **Objective Function-** the value to be optimized. In this case, to minimize the distance truck drivers must drive to find an *authorized* parking space.
2. **Model Paraments/Decision Variables-** the items that impact the solution. In this case, the location and capacity of existing truck parking facilities and the demand for truck parking spaces.
3. **Constraints-** items that restrict the values of the decision variables. In this case, the primary constraints include the speed of travel along the I-10 Corridor and Federal Hours of Service (HOS) regulations limiting the time a driver can operate.

Over the past 30 years, the application of network optimization modeling has become a common private sector planning tool for both strategic and operational planning to minimize costs, maximize efficiencies, and prioritize investments.

Specific uses include:

- Design of trucking firms' terminal and routing networks.
- Network planning, routing, and scheduling within railroad networks.
- Supply chain network design (e.g., where to locate production site or distribution centers and warehouses).
- Identify and prioritize needed freight infrastructure investments.

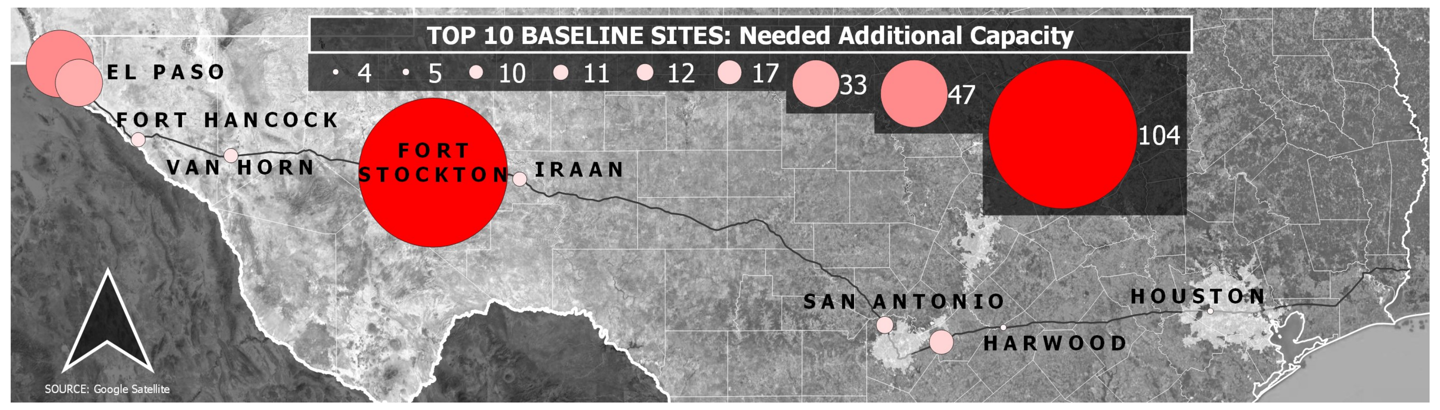
Benefits from optimization include a reduction in operational costs related to labor and fuel consumption, and improved asset utilization. Optimization modeling used to assist location decision making often employ one of two optimization approaches: path- or node-based.

- R E S U L T S -

Modeling Outputs assigned demand to each truck parking location, each I-10 Corridor segment, and segment groups while a post-optimization process assessed the needed capacity in relation to the current capacity to identify locations of insufficient or excessive capacity. Other outputs included, 1) Optimized locations for new facilities with latitude/longitude data; 2) Potential demand (the estimated number of trucks for a given time period) at each existing or new location; and 3) Average distance traveled from a demand location to a parking facility. Two scenarios were modeled.

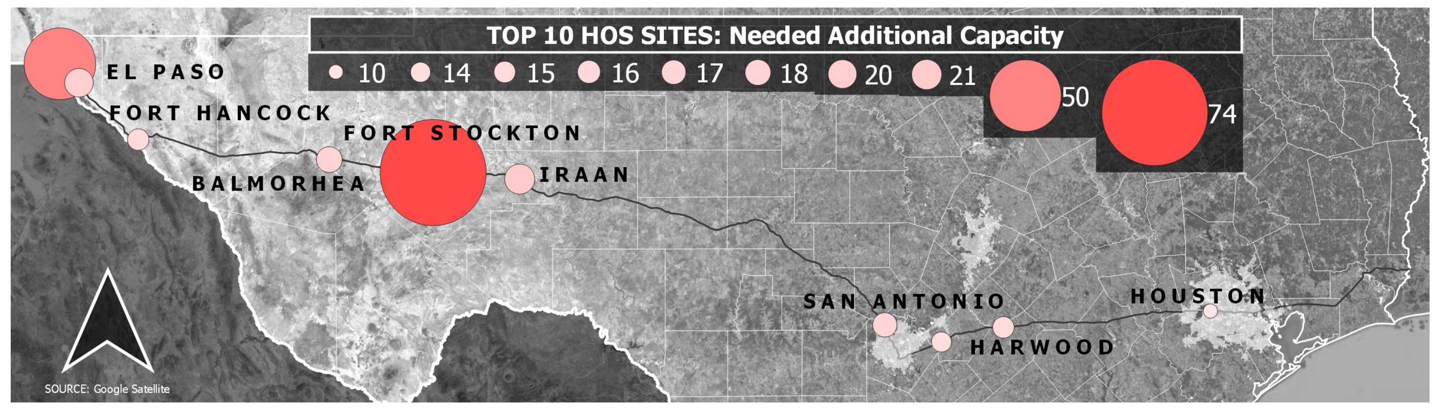
Baseline Demand Optimization

In this scenario, the overnight parking baseline demand was used to run truck parking optimization to identify locations needing additional capacity.



Constraint-Based Optimization

In this scenario, the HOS adjusted overnight parking demand data was used to run the truck parking optimization. The results were analyzed and compared with the baseline demand scenario to identify the common locations needing additional capacity in both scenarios.



- D I S C U S S I O N & C O N C L U S I O N S -

Findings from the I-10 Corridor truck parking optimization modeling effort mirrored those from a concurrent and independent statewide truck parking study conducted using the more traditional approach of truck GPS analysis and truck driver outreach. Based on the similar results, it was concluded that truck parking optimization modeling offers a dynamic, data-driven tool that can be updated as supply chain or network conditions change or as new GPS data as it becomes available. By utilizing overnight parking stop classifications, the model is better able to estimate the demand for private truck stops and public rest areas.

In addition to changes in HOS regulation, the model can be used to model other what-if scenarios related to:

- Truck parking needs when specific corridors, bridges, or stretches of roads are closed due to construction or emergencies/disasters.
- Future growth estimates in truck parking demand due to new industrial development, warehousing developments or changes in trade corridors/supply chains.
- Different types of truck parking demand such as areas with high levels of demand for truck parking while staging for pick-up or drop-off windows.

Having adequate truck parking for the purpose of providing drivers with safe and convenient locations to get the rest of they need is integral to DOT's culture of safety.

quètica Consulting & Engineering

Weiwen Xie
Chief Technology Officer
weiwen.xie@quetica.com

Mark Berndt
Lead Consultant
mark.berndt@quetica.com

Ben Zietlow
Optimization Solutions Practice Leader
benjamin.zietlow@quetica.com

Prakash Jamar Kattel
Supply Chain Modeler
prakash.jamarkattel@quetica.com

- M E T H O D O L O G Y -

Objective Function: Minimize the distance a truck must travel to find an *authorized* parking space.

Model Parameters/Decision Variables: Data sample counts below, see data section for data sources.

Constraints: HOS regulations and congestion along the I-10 Corridor by reducing the time drivers can operate a truck and the speed of which they can do so.

- HOS Regulations– up to 11 hours of drive time within a 14-hour on-duty limit per day, followed by 10 consecutive hours off-duty.
- Congestion– the free-flow speed, average speed, buffer index, and planning index were used to estimate the distance and amount of lead time needed to travel for truck drivers to find a parking space, when needed. The estimated time to park the truck was calculated using free-flow travel time multiplied by the planning time index.

Estimating Truck Parking Demand-

The processed truck GPS data sample included more than 1.4 billion pings, 709,426 stops, and 95,623 overnight stops. The demand for truck parking in the baseline scenario was based on 66,780 overnight stops classified as one of the following:

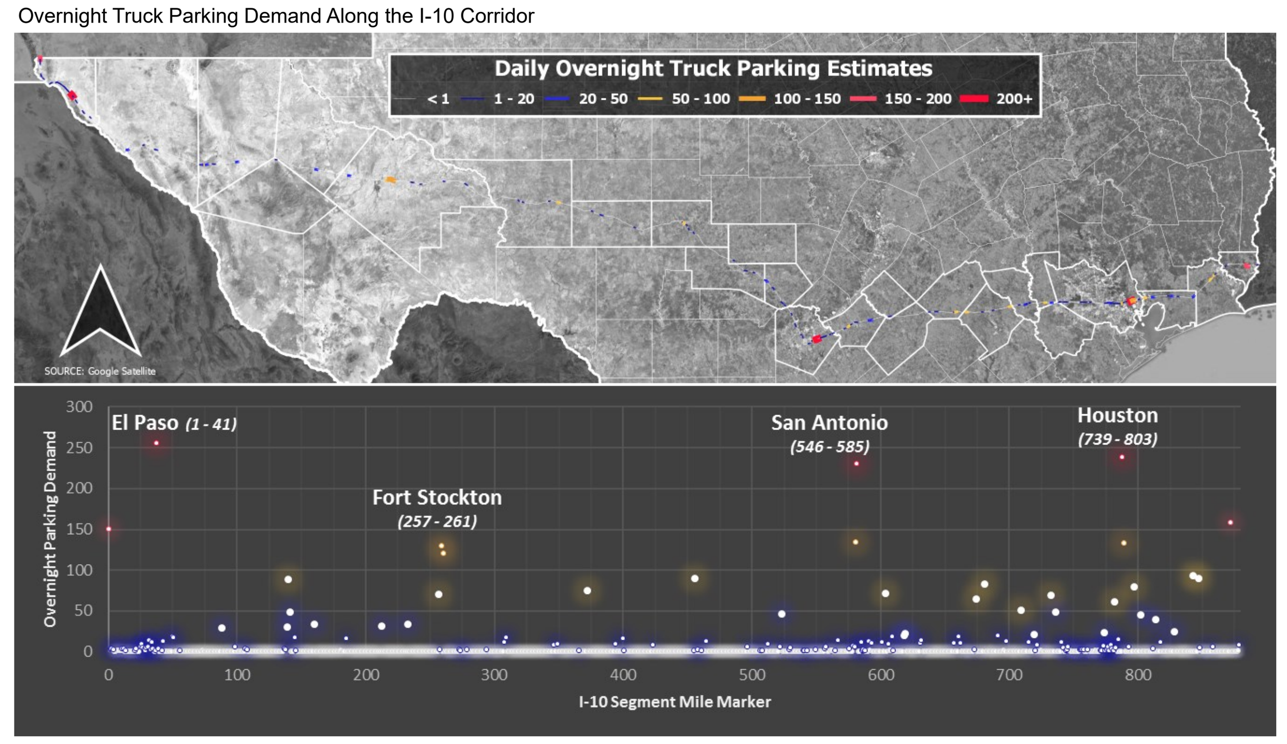
- Available Capacity
- Available Capacity — High Risk
- High Risk
- ROW

Truck GPS Data Sample Record Counts

Data Item	Feb-18	May-18	Jul-18	Oct-18	Total
# Days in GPS Sample	15	15	16	16	62
GPS Ping Record Count	350,306,942	366,996,035	372,422,487	336,508,292	1,426,233,756
GPS Data Stop Count	184,558	175,552	170,483	178,833	709,426
GPS Data Overnight Stop Count	24,840	23,278	23,634	23,871	95,623
Overnight Stop Count in Demand Categories	17,658	16,345	15,972	16,805	66,780

The **Baseline Demand** for overnight truck parking at the segment level is shown below. The average daily overnight truck parking demand is approximately 3,794. The one-mile segments with the highest demand were located on the eastern edges of major metropolitan regions: El Paso, San Antonio, and Houston. For 723 of the 879 segments, the demand for overnight truck parking was less than one.

Overnight Truck Parking Demand Along the I-10 Corridor



The **Constraint-Based Demand** assumed that if truck parking facilities were available, truck drivers would park at the "ideal" location to maximize their HOS while staying compliant with regulations. These locations may be different from the baseline parking locations relegated to the existing parking facilities.

The constraint-based demand was estimated by applying the HOS rules to individual truck trips and then aggregating the individual truck trips to location clusters.

A simulation was completed to adjust the overnight truck parking location for trips within the following:

- Long-Haul Truck Stops within HOS Required Time Limits– stops where optimization was possible because driver had option to driver further and stop without violating HOS
- Soft HOS Violation– stops where driver would violate the 11-hour driving limit or 14-hour on-duty limit by two hours or less.

The identified truck stops were adjusted using the following formula, and then aggregated to the I-10 Corridor segment level after applying expansion factors.

*Ideal Stop Time = Free Flow Truck Travel Time * Planning Time Index*