Restricted Truck Lane Feasibility Study

A Case Study for Locations in Lubbock, Amarillo, and El Paso Texas

By

Hao Xu, Ph. D.
Hongchao Liu, Ph. D., P.E.,
Dali Wei
Wesley Kumfer
Chad Ostrander

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Chapter 1. Introduction

This study was conducted on behalf of the Texas Department of Transportation. TxDOT contracted the TransTechLab (TTL) to conduct a feasibility and capacity analysis of highway segments in the Lubbock, Amarillo, and El Paso Districts to evaluate the feasibility of restricted truck lanes. The ultimate goal of this project was to recommend to TxDOT whether the four locations identified for the study should be subject to truck lane restrictions as well as to indicate what the potential costs in operational performance restricting lanes to trucks in these locations may be.

The goals of various forms of truck lanes are to improve traffic operations, improve safety, and facilitate the flow of goods. Lane restrictions typically prohibit trucks from using the far left lane. At least three travel lanes are normally needed to implement lane restrictions, as shown in Figure 1. A survey of state practices by FHWA identified the most common reasons for using truck lane restrictions as:

1. Improving operations
2. Reducing accidents
3. Pavement structural considerations
4. Restriction in construction zones.

![Figure 1: Example Configuration of NC Lane-Use Restrictions for Trucks](http://www.doh.dot.state.us/preconstruct/traffic/safety/trucksafety/trucklane)

This task involved studying four highway segments in Lubbock, Amarillo, and El Paso, TX. The four segments are:

- South Loop 289 from Avenue S. to Marsha Sharp Freeway in Lubbock (Approximately 6 miles)
- I-27 from South Loop 289 to 0.8 miles north of Yucca Lane in Lubbock (Approximately 7 miles)
- I-40 from Coulter Avenue to Pullman Road in Amarillo (Approximately 13 miles)
- US 54 from I-10 to Hondo Pass in El Paso (Approximately 7 miles)

The locations are shown below in Figures 2 through 4. Figure 2 shows the study segments of I-27 and South Loop 289 in Lubbock. Figure 3 shows the segment of I-40 in Amarillo. Figure 4 shows the segment of US 54 in El Paso. All of these segments were investigated to ascertain the efficacy of a truck lane restriction on each.

Figure 2: Study Segments in Lubbock

Figure 3: Study Segment in Amarillo
Figure 4: Study Segment in El Paso
Chapter 2. Literature Review

This section highlights a brief history of truck lane restrictions both in other states and in Texas. It also examines other studies conducted into the safety and operational impacts of truck lane restrictions. These studies were conducted over the last two decades using field data, simulation, or both. Results from these studies pertaining to operation and safety are detailed in this section.

2.1. Background

Truck lane restriction strategies (TLRS) have been implemented in this country since the late 1990s. The purpose of these strategies is to “typically prohibit trucks from traveling in the median lane, potentially increasing passing opportunities and reducing negative interactions between slow-moving trucks and other vehicles” (Fontaine and Torrence, 2007). Various forms of TLRS have been employed. These strategies, as listed by Gan and Jo in 2003, include:

- Restricting trucks from the left travel lane(s)
- Restricting trucks from the right travel lane(s)
- Route restrictions
- Time of day restrictions
- Differential speed limits (DSL)

These different strategies all have varied advantages and disadvantages. Restricting trucks from the left travel lanes can increase travel speed for passenger cars on the left lane, but it may also block visibility of road signs on the right side. Restricting trucks from the right travel lanes may be used to prevent pavement deterioration in heavily-used right lanes, but this method may cause dangerous lane changing maneuvers near exit ramps and weigh stations. Route restrictions may remove congestion from urban roadways, but they may also increase operating costs for trucks. Time of day restrictions may limit congestion at certain hours, but trucks may be forced onto roadways that are not designed to handle truck loads. DSL may decrease rear-end crashes but increase lane-change crashes. Obviously, TLRS may benefit safety and operations when implemented carefully; however, lane restrictions could be detrimental to traffic operations if implemented improperly (Gan and Jo, 2003).

Many states have other restrictions used in conjunction with the aforementioned TLRS. For example, most states have regulations limiting truck lane restrictions to access-limited highways. However, five states allow lane restrictions on non-access limited urban arterials. These five states are: Alabama, Delaware, Florida, Georgia, and New Jersey (Mwakalonge, 2007). Other states may use combinations of the above TLRS. For example, Virginia has two different lane restrictions depending on the number of lanes present. When three lanes are present, trucks may be restricted from travel in the far left lane. When two lanes are present, trucks are not permitted to drive 15 miles per hour (mph) below the speed limit (Fontaine and Torrence, 2007). A third TLRS used in Florida involves a combination of High Occupancy
Vehicle (HOV) lanes and truck-restricted left lanes to increase travel speed in the left lane (Moses et al., 2007).

In Texas, TLRS was first written into law in 1997. The 75th State Legislature drafted laws for lane restrictions to resolve problems related to truck traffic in Dallas. These codes have since been refined and are contained in Texas Transportation Commission Codes § 545.0651 and § 545.0652. These codes are shown below (LawServer, 2013):

§ 545.0651 - Restriction On Use of Highway

(a) In this section:

(1) "Commission" means the Texas Transportation Commission.

(1-a) "Department" means the Texas Department of Transportation.

(2) "Highway" means a public highway that:

(A) is in the designated state highway system;

(B) is designated a controlled access facility; and

(C) has a minimum of three travel lanes, excluding access or frontage roads, in each direction of traffic that may be part of a single roadway or may be separate roadways that are constructed as an upper and lower deck.

(b) The commission by order may restrict, by class of vehicle, through traffic to two or more designated lanes of a highway. If the lanes to be restricted by the commission are located within a municipality, the commission shall consult with the municipality before adopting an order under this section. A municipality by ordinance may restrict, by class of vehicle, through traffic to two or more designated lanes of a highway in the municipality.

(c) An order or ordinance under Subsection (b) must allow a restricted vehicle to use any lane of the highway to pass another vehicle and to enter and exit the highway.

(d) Before adopting an ordinance, a municipality shall submit to the department a description of the proposed restriction. The municipality may not enforce the restrictions unless the department’s executive director or the executive director’s designee has approved the restrictions.

(e) Department approval under Subsection (d) must:

(1) be based on a traffic study performed by the department to evaluate the effect of the proposed restriction; and

(2) to the greatest extent practicable, ensure a systems approach to preclude the designation of inconsistent lane restrictions among adjacent municipalities.

(f) The department’s executive director or the executive director’s designee may suspend or rescind approval of any restrictions approved under Subsection (d) for one or more of the following reasons:

(1) a change in pavement conditions;

(2) a change in traffic conditions;

(3) a geometric change in roadway configuration;

(4) construction or maintenance activity; or

(5) emergency or incident management.
§ 545.0652 - County Restriction On Use of Highway

(a) In this section:

(1) “Department” means the Texas Department of Transportation.

(2) “Highway” means a public roadway that:

(A) is in the designated state highway system;

(B) is designated a controlled access facility; and

(C) has a minimum of three travel lanes, excluding access or frontage roads, in each direction of traffic.

(b) A county commissioners court by order may restrict, by class of vehicle, through traffic to two or more designated lanes of a highway located in the county and outside the jurisdiction of a municipality.

(c) An order under Subsection (b) must allow a restricted vehicle to use any lane of the highway to pass another vehicle and to enter and exit the highway.

(d) Before issuing an order under this section, the commissioners court shall submit to the department a description of the proposed restriction. The commissioners court may not enforce the restrictions unless:

(1) the department’s executive director or the executive director’s designee has approved the restrictions; and

(2) the appropriate traffic-control devices are in place.

(e) Department approval under Subsection (d) must to the greatest extent practicable ensure a systems approach to preclude the designation of inconsistent lane restrictions among adjacent counties or municipalities.

(f) The department's executive director or the executive director's designee may suspend or rescind approval under this section for one or more of the following reasons:

(1) a change in pavement conditions;

(2) a change in traffic conditions;

(3) a geometric change in roadway configuration;

(4) construction or maintenance activity; or

(5) emergency or incident management.

(g) The department shall erect and maintain official traffic control devices necessary to implement and enforce an order issued and approved under this section. The current form of these codes allows them to be consistently applied throughout different parts of the state. This consistency is maintained by requiring that TxDOT, municipalities, and counties all work together to implement and enforce lane restrictions (Borchadt et al., 2004). TLRS have been successfully implemented in other states as well as Texas. However, the effects of implementation in Texas are not widely known due to the fact that most lane restrictions act as retrofits to existing freeway sections within often rigid geometric
configurations, operational parameters, and established eligibility considerations (Venglar et al., 2004). Numerous studies detailing the various effects of these implementations are discussed below.

2.2. Field Studies

Various field studies have been conducted in numerous states to gather information regarding whether TLRS are effective in improving safety and operations on limited access freeways and non-access limited urban arterials. These studies typically involve before-and-after studies or operation analysis using real data in simulation software. Several studies, as well as their findings and recommendations are listed below.

In a 2004 report, Borchadt, Jasek, and Ballard published their findings regarding truck lane restrictions on the I-10 East Freeway in Houston, TX. The researchers conducted before-and-after studies to determine the efficacy of a left-lane restriction implemented on this highway segment in 2000. Trucks were restricted from using the left lanes between the hours of 6 a.m. and 8 p.m. on weekdays. The research team collected crash data for the research period to determine the efficacy of the TLRS and found that long term crash rates were reduced. The research team recommends left lane restrictions if various guidelines are met, if local traffic engineers believe safety benefits will result from the lane restrictions, if law enforcement is assured, and if there will be no detrimental impacts on trucks and movements of goods. The research team proposed the following guidelines for left lane restrictions:

- The section of freeway must meet the previously mentioned Texas Transportation Commission codes;
- The freeway must have a minimum of four percent total trucks in the traffic stream for 24 hours;
- At least ten percent of the total trucks must currently use the lane to be restricted;
- The freeway segment must be spaced at least a mile from any entrance or exit ramps;
- The freeway should be at least six miles in length;
- An overall implementation plan must be developed;
- Implementation must be monitored post-installation to ensure guidelines are maintained;
- Traffic enforcement should be routine;
- Signs notifying trucks of the restrictions should be routinely spaced at one mile intervals;
- A media outreach program should be used to educate truck drivers and the driving public.

This study indicated that under the right conditions and guidelines, left-lane restrictions can be used beneficially to improve safety conditions on freeways in Texas (Borchadt et al., 2004).

A study by Fontaine and Torrence published in 2007 detailed a field study from numerous sites in Virginia. Crash data was collected from 43 sites with lane restrictions and 16 without restrictions. Operations data were collected from seven sites with lane restrictions and 6 sites
without restrictions. This study found that roadways with two lanes that have restrictions on truck speeds in the left lane benefit from safety and operational improvements. However, no statistically significant speed or travel time improvements were found for three-lane sites with lane restrictions. For three-lane sites, there were decreases in crash rates for freeways with traffic volumes below 10,000 vehicles per day (vpd) per lane; there were increases in crash rates when the traffic volume was above that level. Although findings for two-lane sites were promising, these types of restrictions do not apply to Texas highways (Fontaine and Torrence, 2007).

In 2007, a study published by Moses, Price, and Suihi detailed findings on lane restrictions in Florida. The study site was an 83 mile corridor of I-95 in South Florida. This site contained both HOV lanes and left lane restrictions. The researchers gathered field data and validated their observations with VISSIM simulations. The study found that there were significant speed gains for HOV vehicles and passenger cars using the left lane when restrictions were in place. The team also observed that large truck volumes can cause long queue lengths at merging and diverging areas along the highway. The research team found that although the changes in operations were not appreciable, it is likely that truck lane restrictions caused increases in safety due to a decrease in lane changing movements to avoid trucks in the left lane (Moses et al., 2007).

In 2006, the North Central Texas Council of Governments (NCTCOG) published a report on lane restrictions on I-30 and I-20 in the North Central Texas region. The team conducted the implementation and study of lane restrictions in four phases:

1. Base conditions
2. Increased enforcement
3. Truck lane restrictions and increased enforcement
4. Truck lane restrictions

NCTCOG gathered data from numerous sources to determine the efficacy of the lane restriction implementation. These data sources include:

- Police and sheriff crash records
- On-site Intelligent Transportation System (ITS) monitoring devices
- Mobile video cameras
- Automated traffic count monitoring devices
- In-cab freight truck video collection
- Public surveys

NCTCOG aimed to answer the following questions with the data collected:

- “Do truck drivers comply with the “No Trucks Left Lane” Signage?
- Do truck lane restrictions have a positive effect on travel speeds?
- Do truck lane restrictions allow normal entering and exiting of freeways?
- Did the rate of crashes decrease?
- Is the general public accepting of truck lane restrictions?
• Are truck lane restrictions effective without added enforcement?
• Do truck lane restrictions have a positive air quality impact?”

The research team found that the answer to all of these questions was “Yes!” There were measurable improvements to both operations and safety. This study seems to indicate that a combination of media outreach, proper signage, and early enforcement can allow for beneficial implementation of left lane restrictions (Sim and Royster, 2006).

2.3. Simulation Studies
Numerous simulation studies have also been conducted in Texas and other states to determine the benefits of left lane restrictions. Many of these studies were conducted using some real data, although others were used to simulate possible scenarios when real data was missing. Simulation packages used include VISSIM, CORSIM, and the Mechanistic Empirical Pavement Design Guide (MEPDG) software.

A paper published in TRB in 2004 detailed a simulation study that used VISSIM to compare before-and-after scenarios under different variations in volume, grade, percentage of trucks, and presence of entrance and exit ramps. The different scenarios based upon variable parameters are shown in Table 1.

Table 1: Different Simulation Scenarios for 2004 Truck Restriction Study (Cate and Urbanik, II, 2004)

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Volume</th>
<th>% Trucks</th>
<th>Grade</th>
<th>Ramps?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>High</td>
<td>Average</td>
<td>0%</td>
<td>No</td>
</tr>
<tr>
<td>2</td>
<td>Low</td>
<td>Average</td>
<td>0%</td>
<td>No</td>
</tr>
<tr>
<td>3</td>
<td>Average</td>
<td>Average</td>
<td>0%</td>
<td>No</td>
</tr>
<tr>
<td>4</td>
<td>Average</td>
<td>Low</td>
<td>0%</td>
<td>No</td>
</tr>
<tr>
<td>5</td>
<td>Average</td>
<td>High</td>
<td>0%</td>
<td>No</td>
</tr>
<tr>
<td>6</td>
<td>Average</td>
<td>Average</td>
<td>2%</td>
<td>No</td>
</tr>
<tr>
<td>7</td>
<td>Average</td>
<td>Average</td>
<td>4%</td>
<td>No</td>
</tr>
<tr>
<td>8*</td>
<td>Average</td>
<td>Average</td>
<td>0%</td>
<td>Yes</td>
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<tr>
<td>13</td>
<td>High</td>
<td>High</td>
<td>0%</td>
<td>Yes</td>
</tr>
</tbody>
</table>

The study found that there may be significant gains in safety resulting from a decrease in lane-changing maneuvers. However, the study indicated no significant operational benefits under any of the variations. The exception to this finding is when steep grades are present. Under this scenario, truck restrictions on the left lane produced significant benefits to travel time and speed for passenger cars. The difficulty with this study is the limited parameter set and lack of data. Although the results are promising, they are by no means definitive (Cate and Urbanik, II, 2004).
Another simulation study used multiple scenarios in 2002 to analyze restricted lanes in Texas. VISSIM models were built using data for the Katy Freeway in Houston Texas. The research team analyzed such issues as critical weaving and traffic separation under multiple scenarios. This study focused mainly on model validation and found that simulations tools may indicate no detrimental effects from lane restrictions under certain weaving conditions (Venglar et al., 2002).

A thesis published in 2007 detailed a study in Florida where VISSIM was used to simulate truck lane restrictions on a five mile section of SR 70 in Fort Pierce, Florida. A network was built consisting of 22 roadway sections with 121 signalized intersections. The study tested the network to determine the safety and operational impacts to traffic on the freeway segment. The research team found that there were no negative impacts on traffic due to the left lane restrictions; in fact, the simulation found that travel speed may actually increase. However, the study showed negative impacts under right lane restrictions, such as problems with lane changing, reduced travel speed, increased queue lengths, and stopped delay. Therefore, the authors recommended that TLRS only employ left lane restrictions (Mwakalonge, 2007).

Another study in Florida compared VISSIM and CORSIM models in assessing TLRS. However, the research team found that the CORSIM model lacked robustness and did not give substantive results. By assessing study data with VISSIM, the team produced several findings. The first was that truck restrictions generally increase travel speed under low density, low truck volume, and low ramp volume. However, when density, truck volume, and ramp volume are high, there is a minimal decrease in average speed. The exception to the minimal decrease in speed was when numerous lanes were restricted; in this circumstance, travel speed was severely hampered. The team indicated therefore that moderate number of lanes should be restricted. The second finding was that a large number of restricted lanes resulted in high throughout under small truck volumes. The third finding was that speed differentials are significant between restricted and unrestricted segments. The fourth finding was that lane restrictions drastically reduce the number of lane changes, possibly leading to a reduced number of collisions. The fifth finding was that one truck restricted lane is suitable for most highways (Gan and Jo, 2003).

A study published in 2004 involved a simulation analysis of an I-75 corridor in north Florida. On this facility, trucks are restricted from using the left lane. Field data was used with a CORSIM model to mixed results. The model and field analysis indicated that although lane restrictions caused no gain in travel time, they also did not reduce delays. However, the safety findings of the study were similar to those of other studies. The simulation indicated that opening all lanes to trucks would cause an increase in lane changing maneuvers. This in turn would likely cause an increase in crashes, resulting in a negative impact on safety. Therefore, the research team indicated that truck restricted lanes are likely beneficial for safety purposes if not for operations (Mussa and Price, 2004).

An interesting thesis published in 2010 contained a study of truck lane restrictions from a unique perspective. The researcher analyzed left lane restrictions on a highway segment near Lake Charles, Louisiana to determine if lane restrictions produced any negative impacts on
pavement in the right lane. The researcher used traffic loading, climatic, and structural data in the MEPDG software to determine if restricting trucks to the right lane would cause significant failures to that lane of the facility. Although the results indicated that left lane restrictions may cause pavement in the right lane to fail earlier than expected, the time to failure was not significantly different than the norm. This could indicate that safety, as far as the facility structure is concerned, is not significantly impacted by TLRS (Radhakrishnan, 2010).

A recent study in used both field crash data and a CORSIM simulation model to analyze the impacts of restricted truck lanes on an I-35 corridor near Waco, Texas. Although the study found no negative impacts from truck lane restrictions, no meaningful benefits were found. Crash decreases were nominal, and no significant change in travel speed was produced by the model. The author indicated a set of implementation issues that may affect the efficacy of truck lane restrictions. These issues include signing, compliance, motorist opinion, and intermediate construction and transition locations. Perhaps more promising results could be produced if these issues are addressed properly during implementation (Venglar, 2012).

Both the field and simulation studies produced mixed results. Benefits from truck lane restrictions varied from negative in certain situations to extremely positive in others. However, a few overarching trends can be seen in these studies:

- Lane restrictions should be implemented in the left lane, as right lane restrictions are likely to increase the number of crashes;
- Average speed benefits may be low, although some gain is possible;
- Implementation seems to be key in seeing significant results

These findings will impact TTL’s recommendations for lane restrictions in the locations of this study.
Chapter 3. Site Information

3.1. Typical Study Sites
As mentioned in the introduction, four freeway segments were selected for a study of the feasibility of truck lane restrictions. However, due to the time constraints of the study, not every mile of every segment could be analyzed. Therefore, typical sections of each segment were identified as possible locations for data collection and assessment by microscopic simulation. These sites were selected based on their geometric characteristics, entrance and exit ramp patterns, speed limits, grades, and surrounding residential/commercial developments. The selected sites are indicated below.

3.1.1. I-27 (Lubbock) Study Limits
Three possible study sections were identified for the I-27 study segment in Lubbock.

- Section A of I-27 is between South Loop 289 and 50th Street. This section has four mainlanes each way with three entrances and three exits to the facility; these ramps form a complicated interchange system.
- Section B of I-27 is between Marsha Sharp Freeway and North Loop 289. There are five mainlanes each way with four entrance ramps and four exit ramps. The interchange ramps are also complicated at this site.
- Section C of I-27 is between 50th Street and 34th Street. It features three mainlanes in each direction with two entrance ramps and two exit ramps.

These Sections are shown in Figures 5 through 7.

Figure 5: I-27 Section A
Figure 6: I-27 Section B

Figure 7: I-27 Section C
3.1.2. South Loop 289 (Lubbock) Study Limits

Five possible study sections were identified for the South Loop 289 segment in Lubbock.

- Section A of South Loop 289 is between Slide Road and Marsha Sharp Freeway. This section has five mainlanes each way with a complicated ramp pattern of five entrance ramps and four exit ramps.
- Section B of South Loop 289 is between I-27 and University Avenue. It has four mainlanes each way with three entrance ramps and three exit ramps.
- Section C of South Loop 289 is between Quaker Avenue and Slide Road. It has three mainlanes each way with two entrance ramps and two exit ramps.
- Section D of South Loop 289 is between Indiana Avenue and University Avenue. It has three mainlanes each way with two entrance ramps and two exit ramps.
- Section E of South Loop 289 is between Indiana Avenue and Quaker Avenue. It has three mainlanes each way with two entrance ramps and two exit ramps.

These sections are shown in Figures 8 through 12. Although these sections were identified, TxDOT has notified the research team that it does not wish to restrict lane use on these lanes due to unbalanced traffic distributions on the lanes at present.

Figure 8: South Loop 289 Section A
Figure 9: South Loop 289 Section B

Figure 10: South Loop 289 Section C

Figure 11: South Loop 289 Section D
Figure 12: South Loop 289 Section E
3.1.3. I-40 (Amarillo) Study Limits
There are three identified sections of I-49 in Amarillo.

- Section A of I-40 is between Coulter Street and Bell Street. It features three mainlanes each way with two entrance ramps and two exit ramps.
- Section B of I-40 is between Washington Street and Ross Osage Drive. It features four mainlanes each way with a complicated pattern of six entrance ramps and four exit ramps.
- Section C of I-40 is between Grand Street and Eastern Street. It features four mainlanes in each direction with six entrance ramps and six exit ramps.

Figures 13 through 15 show these sections.

![Figure 13: I-40 Section A](image1)

![Figure 14: I-40 Section B](image2)
Figure 15: I-40 Section C
3.1.4. US 54 (El Paso) Study Limits
Four typical sections were identified along US 54 in El Paso.

- Section A of US 54 is between Hondo Pass Avenue and Hercules Avenue. It features three mainlanes in each direction with two entrance ramps and two exit ramps.
- Section B of US 54 is between I-10 and Altura Avenue. It features three mainlanes in each direction with two entrance ramps and two exit ramps.
- Section C of US 54 is between Pershing Drive and Cassidy Road. It features four mainlanes each way with three entrance ramps and two exit ramps.
- Section D of US 54 is between Ellerthorpe Avenue and Hayes Avenue. It features four mainlanes in each direction with three entrance ramps and four exit ramps.

These sections are shown in Figures 16 through 19.

![Figure 16: US 54 Section A](image)
Figure 17: US 54 Section B

Figure 18: US 54 Section C
3.2. Selected Study Sites

Due to the difficulty of accumulating, simulating, and analyzing the data from 15 different sites in four different cities, one section for each segment was chosen for analysis. These sections are:

- I-27 (Lubbock) Section A (hereafter referred to as Site 1)
- South Loop 289 (Lubbock) Section E (hereafter referred to as Site 2)
- I-40 (Amarillo) Section B (hereafter referred to as Site 3)
- US 54 (El Paso) Section D (hereafter referred to as Site 4)

These four sites, along with the final data collection locations, are shown in Figures 20 through 23. These sites were identified due to their ease of data collection and typical geometric alignments.
Figure 21: Site 2 (South Loop 289) with Mainlane Data Collection Points

Figure 22: Site 3 (I-40) with Mainlane Data Collection Points
Figure 23: Site 4 (US 54) with Mainlane Data Collection Points
Chapter 4. Traffic Data Collection and Analysis

The research team made use of both existing data and field collected data. Trips were made to gather traffic counts at Sites 3 and 4 in Amarillo and El Paso, respectively. Additionally, a subcontractor was used to collect other data required to use the simulation software. C J Hensch and Associates were contracted by TxDOT to gather specific traffic volume, speed, and composition data. The composition data was collected to determine the percentage of trucks and percentage of passenger vehicles. The data were collected at a 15-minute resolution on the mainlanes in each direction and at the entrance and exit ramps. Data for peak hour traffic and peak truck percentage at each site were used to calibrate the VISSIM model. Truck categorization was performed using the specified length of trucks from the AASHTO “Green Book.”

4.1. Overview of Traffic Data

Before presenting the simulation study, the traffic data is analyzed in this chapter to gain an overview of the traffic condition, especially the percentage of truck volume and their lane distribution. The analysis found that the daily truck volume is over 4% for all study sites. The summary of the truck traffic data is presented in Table 2.

<table>
<thead>
<tr>
<th>Locations</th>
<th>I-27 (Lubbock)</th>
<th>South Loop (Lubbock)</th>
<th>I-40 (Amarillo)</th>
<th>US 54 (El Paso)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direction</td>
<td>North bound</td>
<td>South bound</td>
<td>West bound</td>
<td>East bound</td>
</tr>
<tr>
<td>Daily Truck Volume</td>
<td>727</td>
<td>668</td>
<td>2924</td>
<td>1343</td>
</tr>
<tr>
<td>Daily Truck Percentage</td>
<td>13.70%</td>
<td>7.50%</td>
<td>7.10%</td>
<td>1.60%</td>
</tr>
<tr>
<td>Truck Percentage using leftmost lane</td>
<td>10.40%</td>
<td>10.00%</td>
<td>7.50%</td>
<td>15.00%</td>
</tr>
</tbody>
</table>

4.2. Site 1: 1-27 in Lubbock

The data collection locations at the Site 1 of I-27 in Lubbock are marked in Figure 20. The truck and car volumes at northbound and southbound are plotted in Figures 24 and 25. The daily truck volumes are 13.7% and 7.5% for northbound and southbound traffic, respectively. The peak hour of the northbound traffic appears in the morning. In contrast, for the southbound mainlanes, the traffic is most congested during the afternoon peak hours.
For both northbound and southbound volumes, truck traffic that is currently using the left lane is approximately 10%. From Figures 26 and 27, we can see that most trucks tend to use the middle for the southbound traffic. But for the northbound traffic, most trucks are using the right lane.
4.3. Site 2: South Loop 289 in Lubbock

The data collection locations at the study Site 2 of South Loop 289 in Lubbock are marked in Figure 21. The truck and car volumes for westbound and eastbound traffic are plotted in Figures 28 and 29. The daily truck volumes are 7.1% and 1.6% for eastbound and westbound traffic, respectively.

For eastbound truck traffic, only 16% of trucks are currently using the leftmost lane. Most trucks tend to use the middle lane, as shown in Figure 30. For the westbound, trucks using the leftmost lane only take up 7.5%. Most trucks are using the right lane, as shown in Figure 31.
It can be projected that the middle lane in the eastbound will bear even more truck traffic if the truck lane restrictions are implemented.

Figure 30: Car and Truck Lane Distributions for Eastbound Traffic at Site 2

Figure 31: Car and Truck Lane Distributions for Westbound Traffic at Site 2

4.4. Site 3: I-40 in Amarillo
The data collection locations at study Site 3 in Amarillo are marked in Figure 22. The truck and car volumes in the westbound and eastbound directions are plotted in Figures 32 and 33, respectively. The daily truck volume is 12.7% and 15.7% for eastbound and westbound traffic, respectively. The morning and afternoon peaks show a similar pattern for both directions. The truck volume during the morning peak is less when compared to the afternoon peak.
Figure 32: Car and Truck Volumes for Eastbound Traffic at Site 3

Figure 33: Car and Truck Volumes for Westbound Traffic at Site 3

For both eastbound and westbound directions, most trucks are using the middle lanes. 14.7% of eastbound truck traffic is using the left lane. Meanwhile, only 6.5% of truck traffic is using the leftmost lane for the westbound traffic. These distributions are shown in Figures 34 and 45.

Figure 34: Car and Truck Lane Distributions for Eastbound Traffic at Site 3
4.5. Site 4: US 54 in El Paso

The locations of the data collections at study Site 4 in El Paso are marked in Figure 23. The truck and car volumes within a day for both southbound and northbound directions are plotted in Figures 36 and 37. It can be seen that the busiest hour for the northbound traffic is during the afternoon peak. For the southbound traffic, the busiest hour appears during the morning peak. The truck volume is generally stable and does not show a notable fluctuation during the day. The daily truck percentages of all vehicles for both directions are around 5% for both directions.
The percentages of the truck traffic currently using the leftmost lane are plotted in Figures 38 and 39. For the southbound truck traffic, 15.2% is using the leftmost lane at the collection location, and 11.2% of the northbound truck traffic is using the leftmost lane. The lane distributions are obviously uneven for both directions. Truck traffic using the leftmost lane is much less when compared with other lanes.

Figure 38: Car and Truck Lane Distributions for Southbound Traffic at Site 4

Figure 39: Car and Truck Lane Distributions for Northbound Traffic at Site 4
Chapter 5. Microscopic Simulation Results and Findings

As mentioned in the Introduction, the research team performed VISSIM microscopic simulations to assess the feasibility of truck restricted lanes at these sites. VISSIM was used to assess these sites in terms of operations. For operational efficiency, the team performed level of service (LOS) analysis, traffic volume analysis, traffic density analysis, and lane distribution analysis to determine if adding restrictions to left lanes decreased the LOS on any of the travel lanes.

The basic geometry of the simulation networks were coded on aerial photographs of the study area from Google Earth. Links and nodes are the two design parameters which are used to develop a network in VISSIM. Links are used to define the main lanes, frontage roads, and ramps while the nodes are used to connect all the necessary links in the network. Details such as speed limits and routings are coded in their respective ways for each program to match the real world conditions or modified if needed for the different configurations.

5.1. Overview of Analysis
The results and conclusions from the simulation analysis are summarized in this section.

5.1.1. Site 1: I-27 in Lubbock
Current LOS values along I-27 in Lubbock are either B or C across different lanes. The traffic lane-distribution is not significantly uneven. Truck traffic at this site is at the lowest level among the four study sites. Simulation results indicate that the truck lane restriction will not have a negative impact on the operational performance. LOS values and lane-distributions of most sections will remain the same. The study also reveals that the impedance of trucks to the general traffic is minimal at this site due to lower truck volume and relatively even lane distribution, therefore the benefit of restricted lane would be very marginal on this site.

5.1.2. Site 2: South Loop 289 in Lubbock
The traffic lane distribution is seriously uneven for South Loop 289 at Lubbock due to close-spaced ramps and short-distance trips. LOS values of some sections on the middle and right lanes are already D or even E. Although the simulation results did not indicate a significant change on operational performance, adding more trucks to the middle or right lanes may cause an already serious congestion problem to become worse during the peak hours, as doing so could further hinder the lane change maneuvers and lead to more uneven lane distributions.

5.1.3. Site 3: I-40 in Amarillo
The traffic lane distribution is uneven for the study segments at Amarillo. Implementing the truck lane restriction, approximately 40 trucks per hour will be shifted to the middle lanes. Though it has a relatively higher truck percentage, the truck lane restriction will not have a significant impact on the operational performance either. The current traffic conditions are not congested. LOS values of most sections will remain the same if implementing the truck lane restriction.
5.1.4. Site 4: US 54 in El Paso
Current LOS for each lane along this freeway segment is either B or C. If implementing the truck lane restriction, the car volume will increase less than 10% in the leftmost lane. The truck traffic currently using the leftmost lane will shift to the middle lane. However, this difference will not significantly change the density and speed of each lane or the traffic distribution among different lanes. The LOS values will not be degraded. Implementing the truck lane restriction will not impose an adverse impact on the operational performance of this freeway segment.

5.2. Site 1: I-27 in Lubbock
The simulation scope of the I-27 is between South Loop 289 and 59th Street. The morning and afternoon peaks are simulated for northbound and southbound traffic, respectively. Figure 40 shows the length of simulation at Site 1.

For the northbound traffic, nearly 100 passenger cars per hour will be shifted from the middle lane to the left lane, while the number of cars in the right lane will remain the same. The 44 trucks that are currently using the left will move to the middle lane. The truck traffic in the right lane will also increase by four trucks per hour. The southbound traffic is lighter than the northbound traffic. The passenger car traffic will increase in the left lane and decrease accordingly in the middle lane. Only eight trucks per hour will be moved to the middle lane. Figures 41 and 42 show the simulated change in lane distributions of cars before and after lane restrictions. Figures 43 and 44 show the simulated change in lane distributions of cars before and after lane restrictions.
Figure 41: Northbound Lane Distribution of Cars Before and After Lane Restrictions at Site 1

Figure 42: Southbound Lane Distribution of Cars Before and After Lane Restrictions at Site 1

Figure 43: Northbound Lane Distribution of Trucks Before and After Lane Restrictions at Site 1
Figure 44: Southbound Lane Distribution of Trucks Before and After Lane Restrictions at Site 1

The change of car and truck traffic volumes will not cause any meaningful impacts on the operational performance in terms of traffic density. LOS values for the evaluated sections are either B or C, some of which are on the edge of B and C. The traffic condition of this segment is not congested and implementing the truck lane restriction will not impose a negative impact. Figures 45 and 46 show the passenger car densities per lane before and after the simulated truck lane restrictions.

Figure 45: Northbound Passenger Car Density Before and After Lane Restrictions at Site 1
5.3. Site 2: South Loop 289 in Lubbock
As mentioned, the simulation scope of Site 2 of South Loop 289 is between Indiana Avenue and Quaker Avenue, which is one of the busiest segments along this corridor. Based on a prior capacity analysis of South Loop 289 (IAC Phase 1 and 2), the traffic lane-distribution is significantly uneven because most trips are over short distances and because drivers tend to use the right and middle lanes to avoid potential lane change maneuvers (Xu et al., 2012). This is a key difference from the other three study sites, where the traffic is not congested and the traffic lane-distribution is relatively even. Figure 47 shows the simulation scope of Site 2.

Figure 47: Simulation Scope of Site 2: South Loop 289 in Lubbock
Figures 48 and 49 show the change in hourly passenger car volumes, and Figures 50 and 51 show the change in hourly and truck volumes in each lane before and after implementing the simulated truck lane restriction. As can be seen, differences for both truck and car traffic are very marginal. A small amount of trucks per hour, four for the eastbound direction and 16 for the westbound direction, are expected to shift to the middle lane.
Figure 48: Eastbound Lane Distribution of Cars Before and After Lane Restrictions at Site 2

Figure 49: Westbound Lane Distribution of Cars Before and After Lane Restrictions at Site 2

Figure 50: Eastbound Lane Distribution of Trucks Before and After Lane Restrictions at Site 2
Figure 51: Westbound Lane Distribution of Trucks Before and After Lane Restrictions at Site 2

The densities of each lane in South Loop 289 are plotted in Figures 52 and 53. As can be seen, the differences are very marginal. None of the LOS values in the section will be degraded. However, compared with the other three study sites, the traffic volume is much higher at South Loop 289. In particular, the traffic lane-distribution is significantly uneven, which has already been pointed out in the IAC South Loop Phase 1 and Phase 2 projects (Xu et al., 2012). For the eastbound traffic, the traffic on the right lane is nearly four times as high as the traffic in the left lane. Given the uneven distribution of the traffic across different lanes, efforts should be made to facilitate lane change maneuvers and encourage passenger cars to use the left lane. However, the truck lane restriction is expected to hinder the passenger cars’ lane changing behaviors as more trucks would use the middle lane.

Figure 52: Eastbound Passenger Car Density Before and After Lane Restrictions at Site 2
5.4. Site 3: I-40 in Amarillo

The capacity analysis was performed on two sections of the I-40 segment in the simulation. One is between the entrance ramp and exit ramp at Exit 70. The other section is between Exit 70 and the on ramp from I-27. These two sections form Site 3 as identified previously. The scope of this simulation is shown in Figure 54.

![Simulation Scope of Site 3: I-40 in Amarillo](image)

**Figure 54: Simulation Scope of Site 3: I-40 in Amarillo**

Figures 55 to 58 demonstrated the comparisons of simulation results before and after the truck lane restriction. The differences of passenger car volumes per hour before and after the truck lane restriction are very small, which is less than 2%. The lane distribution of the traffic is more uneven compared with the study site at El Paso. More traffic tends to use the rightmost lane, while the leftmost lane has the least traffic volume.
Figure 55: Eastbound Lane Distribution of Cars Before and After Lane Restrictions at Site 3 (Section 1)

Figure 56: Eastbound Lane Distribution of Cars Before and After Lane Restrictions at Site 3 (Section 2)

Figure 57: Westbound Lane Distribution of Cars Before and After Lane Restrictions at Site 3 (Section 1)
Figure 58: Westbound Lane Distribution of Cars Before and After Lane Restrictions at Site 3 (Section 2)

With the simulated truck lane restriction, truck traffic on the leftmost lane will be shifted to the middle lanes. The truck hourly volume on the middle lanes will increase by an average of 40 trucks per hour. The restriction on the leftmost lane in general does not have a significant impact on the traffic in the right lanes. Figures 59 through 62 show the lane distribution of trucks before and after the simulated lane restrictions.

Figure 59: Eastbound Lane Distribution of Trucks Before and After Lane Restrictions at Site 3 (Section 1)

Figure 60: Eastbound Lane Distribution of Trucks Before and After Lane Restrictions at Site 3 (Section 2)
Figure 61: Westbound Lane Distribution of Trucks Before and After Lane Restrictions at Site 3 (Section 1)

Figure 62: Westbound Lane Distribution of Trucks Before and After Lane Restrictions at Site 3 (Section 2)

Although the percentage of truck at I-40 in Amarillo is relatively higher compared to the study site in El Paso, implementing truck lane restrictions will not cause a significant difference in terms of freeway capacity. The densities and the LOS values are demonstrated in Figures 63 through 66. As can be seen, the LOS values of the right lanes are either B or C. All the middle lanes have the same LOS value of B. Comparatively, the traffic in the leftmost lane is much lighter, and the LOS values are either B or A.
Figure 63: Eastbound Passenger Car Density Before and After Lane Restrictions at Site 3 (Section 1)

Figure 64: Eastbound Passenger Car Density Before and After Lane Restrictions at Site 3 (Section 2)

Figure 65: Westbound Passenger Car Density Before and After Lane Restrictions at Site 3 (Section 1)
5.5. Site 4: US 54 in El Paso

The freeway segment in the simulation for US 54 in El Paso is marked in Figure 67. The segment was divided into two sections by the exit ramp of 24A and 25 for southbound and northbound, respectively. Densities, LOS values, and lane distributions for both sections will be examined in the simulation.

If truck lane restrictions are implemented, a certain amount of passenger cars will shift from the middle lanes to the leftmost lane. In contrast, the truck traffic will accordingly increase in the middle lanes. Figures 68 through 75 show the changes of passenger car volumes and truck...
volume. As one can find, the average change of car volume in each lane is less than 5%; this will not cause a notable change in average traffic conditions. Truck traffic that is currently using the leftmost lane will shift to the middle lanes.

The lane distributions of traffic for both directions are not significantly uneven without the truck lane restriction. As indicated by the simulation result, this pattern will not change if the truck lane restrictions are implemented.

**Figure 68: Northbound Lane Distribution of Cars Before and After Lane Restrictions at Site 4 (Section 1)**

**Figure 69: Northbound Lane Distribution of Cars Before and After Lane Restrictions at Site 4 (Section 2)**
Figure 70: Southbound Lane Distribution of Cars Before and After Lane Restrictions at Site 4 (Section 1)

Figure 71: Southbound Lane Distribution of Cars Before and After Lane Restrictions at Site 4 (Section 2)

Figure 72: Northbound Lane Distribution of Trucks Before and After Lane Restrictions at Site 4 (Section 1)
The research team concludes that because the traffic flow, as well as its lane distribution, is not significantly changed, traffic density in each section will also be similar before and after the truck lane restriction, as demonstrated by Figures 76 through 79. The LOS values determined from the density are also marked in these Figures. As one can see, LOS values of all sections are C and B, indicating the traffic is not congested either before or after the truck lane restriction. Implementing the truck lane restriction will not deteriorate the operational performance of this freeway segment.
Figure 76: Northbound Passenger Car Density Before and After Lane Restrictions at Site 4 (Section 1)

Figure 77: Northbound Passenger Car Density Before and After Lane Restrictions at Site 4 (Section 2)

Figure 78: Southbound Passenger Car Density Before and After Lane Restrictions at Site 4 (Section 1)
Figure 79: Southbound Passenger Car Density Before and After Lane Restrictions at Site 4 (Section 2)
Chapter 6. Conclusions and Recommendations

6.1. General Conclusions
The feasibility of truck lane restriction was evaluated at four freeway segments at El Paso, Amarillo and Lubbock with the particular focus on operational performance. Detailed traffic data was collected at certain locations along these freeway segments. Microscopic simulation was performed to evaluate the potential impact before and after truck lane restriction.

According to the data analysis and simulation evaluation, following conclusions can be drawn:

- There are no left side ramps within the study segments.
- According to the simulation analysis, truck lane restrictions will not have a significant impact in terms of lane-based traffic density and traffic volume for sites 1, 3, and 4. Generally, trucks that are currently using the leftmost lane will shift to the middle lane. A small proportion of passenger cars will use the leftmost lane instead of the middle or right lanes.
- Traffic flow on South Loop 289 (Site 2) is the highest among the four study sites. LOS values of some sections are D or even E. Lane distributions are significantly uneven due to the short-distance trips and close-spaced ramps. Congestion is a significant problem along this segment of the highway.

6.2. Recommendations
Based on this study, the research team has the following recommendations for each of these sites in terms of traffic density, LOS values and traffic lane distribution.

6.2.1. Site 1: I-27 in Lubbock
Truck traffic at this site is the lightest among the four study sites. Current LOS values along I-27 in Lubbock are either B or C across different lanes. The traffic lane-distribution is not significantly uneven. Simulation results indicate that the truck lane restriction will not have a negative impact on the operational performance. LOS values and lane-distributions of most sections will remain the same. The lane restriction is feasible, but would not be beneficial as it is unlikely to increase the safety and would not improve the lane distribution or operational capacity of this segment of highway. Therefore, truck lane restrictions are not recommended at this site at this time.

6.2.2. Site 2: South Loop 289 in Lubbock
The traffic lane distribution is seriously uneven for South Loop 289 in Lubbock due to the close-spaced ramps and short-distance trips. LOS values for some sections on the middle and right lanes are already D or even E. Although the simulation results did not indicate a significant change on operational performance, adding more trucks to the middle or right lanes may cause more serious congestion because doing so may further hinder lane change maneuvers and lead to more uneven lane distributions. Truck lane restrictions are not recommended at this segment.
6.2.3. Site 3: I-40 in Amarillo
By implementing the truck lane restriction, approximately 40 trucks per hour will be shifted to the middle lanes. Though it has a relatively higher truck percentage, the truck lane restriction will not have a significant impact on the operational performance either. The current traffic conditions are not congested. LOS values of most sections will remain the same if implementing the truck lane restriction. The lane restriction can be recommended along this segment.

6.2.4. Site 4: US 54 in El Paso
Current LOS values for each lane along this freeway segment are below C. If implementing the truck lane restriction, the car volume will increase less than 10% in the leftmost lane. This difference will not significantly change the density and speed of each lane, as well as the traffic distribution among different lanes. The LOS values will not be degraded. Implementing the truck lane restriction will not impose any adverse impacts on the operational performance of this freeway segment. The lane restriction can be recommended along this segment considering the potential safety benefits.

6.3. Other Considerations
From an operational standpoint, the team recommends truck lane restrictions at all sites except Site 1 & 2. It is believed that relegating trucks to the outermost lanes will not substantially decrease safety conditions. However, if truck lanes are implemented, the research team suggests that TxDOT study such factors as signing, compliance, motorist opinion and construction (Venglar, 2012). Doing so will provide a much safer transition into good truck lane restriction implementation.
References


