



TxDOT Administration Research: Tasks Completed FY 2012

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Cooperative Research Program

TEXAS A&M TRANSPORTATION INSTITUTE
COLLEGE STATION, TEXAS

in cooperation with the
Federal Highway Administration and the
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TXDOT ADMINISTRATION RESEARCH: TASKS COMPLETED FY 2012

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DISCLAIMER

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WORK ORDER 22: ASSESSING HIGH-LEVEL CORRIDOR IMPACTS OF TRUCKS USING HOV LANES

EXECUTIVE SUMMARY

The Texas Department of Transportation (TxDOT) requested that the Texas A&M Transportation Institute (TTI) conduct an analysis of the corridor traffic operations impacts of allowing trucks to use a concurrent-flow high-occupancy vehicle (HOV) lane. To conduct a time-sensitive and cursory assessment, TTI staff chose to study northbound US 75 between IH 635 and the President George Bush Turnpike (PGBT) for the evening peak hour. This corridor was chosen because TTI staff had access to an existing VISSIM simulation model, developed and calibrated in 2008 for a previous TxDOT assignment.

The US 75 freeway corridor has a single, concurrent-flow, pylon-separated HOV lane in each direction. The northbound HOV lane starts near IH 635 with entrances from IH 635 and a flyover ramp at Midpark Road. The HOV lane has an interim access point near Park Boulevard (north of the PGBT), which is the first location where HOV lane users can exit. The existing lane configuration through this section is four general purpose lanes (GPLs) and one concurrent HOV lane. The simulation model from Midpark Road to the PGBT was previously used to analyze the operational effects of adding a mid-point HOV lane access near Collins Boulevard. TTI developed the VISSIM simulation model for the existing access configuration and for the proposed mid-point HOV lane access for comparison.

TTI staff previously collected manual traffic counts on US 75 at Collins Street (between IH 635 and the PGBT) in November 2011. The data revealed about 140 to 160 trucks traveling northbound during the evening peak hour. For the current analysis, TTI staff evaluated a scenario adding approximately half of the trucks to the HOV lane, or 80 trucks in the peak hour.

The vehicle inputs in the existing VISSIM models were modified to include the trucks in the HOV lane, and the network data collection inputs were changed to capture these trucks during simulation. Both configurations were used to assess the impacts of trucks operating in an HOV lane.

The findings from this assessment are inconclusive. Truck use of the HOV lanes on the study corridor did not cause meaningful changes to speeds and throughput on both the HOV lane

and GPLs. A more detailed analysis would be needed on any given corridor to further assess the actual corridor-specific impacts.

OVERVIEW

TxDOT requested that TTI conduct an analysis of the corridor traffic operations impacts of allowing trucks to use a concurrent-flow HOV lane. To conduct a time-sensitive and cursory assessment, TTI staff chose to study northbound US 75 between IH 635 and the PGBT for the evening peak hour. The findings from this assessment are inconclusive. Truck use of the HOV lanes on the study corridor did not cause meaningful changes to speeds and throughput on both the HOV lane and GPLs. A more detailed analysis would be needed on any given corridor to further assess the actual corridor-specific impacts. Other considerations for possible consideration are also presented.

DESCRIPTION OF ANALYSIS CORRIDOR AND SIMULATION MODEL USED

To conduct a time-sensitive and cursory assessment, TTI staff chose to study northbound US 75 between IH 635 and the PGBT for the evening peak hour. They chose this corridor because they had access to an existing VISSIM simulation model, developed and calibrated in 2008 for a previous TxDOT assignment.

The US 75 freeway corridor has a single, concurrent-flow, pylon-separated HOV lane in each direction. The northbound HOV lane starts near IH 635 with entrances from IH 635 and a flyover ramp at Midpark Road. The HOV lane has an interim access point near Park Boulevard (north of the PGBT), which is the first location where HOV lane users can exit. The existing lane configuration through this section is four GPLs and one concurrent HOV lane. The simulation model from Midpark Road to the PGBT was previously used to analyze the operational effects of adding a mid-point HOV lane access near Collins Boulevard. TTI developed the VISSIM simulation model for the existing access configuration and for the proposed mid-point HOV lane access for comparison.

TTI staff previously collected manual traffic counts on US 75 at Collins Street (between IH 635 and the PGBT) in November 2011. The data revealed about 140 to 160 trucks traveling northbound during the evening peak hour. For the current analysis, TTI staff evaluated a scenario adding approximately half of the trucks to the HOV lane, or 80 trucks in the peak hour.

The vehicle inputs in the existing VISSIM models were modified to include the trucks in the HOV lane, and the network data collection inputs were changed to capture these trucks during simulation. Both configurations were used to assess the impacts of trucks operating in an HOV lane.

The calibrated simulation model used the narrowly defined, almost homogeneous, passenger car and truck types that are defaults in the simulation model. In reality, each corridor has variation in truck and passenger car types with varying vehicle lengths. A more robust analysis should focus on the vehicle characteristics of the specific corridor being analyzed. The simulation model also assumed a level terrain, which is somewhat reasonable for US 75.

Per good simulation practice, each alternative was simulated multiple times to account for variability in the simulation results (for this analysis, five model runs were conducted per alternative). The results from these simulations were then averaged.

RESULTS

The tabular results are included in Tables 1 and 2. Table 1 presents the results from the existing HOV access configuration. Because the previous analysis conducted for TxDOT included a new intermediate access point, TTI also looked at how trucks might impact corridor operations when access was more closely spaced. Table 2 displays the results with an intermediate HOV access configuration.

The GPLs were evaluated over three sections. The HOV lane results are fairly consistent across all three sections. Table 1 shows the results for the existing US 75 HOV access configuration. Alternative 1 is the existing access condition. Alternative 2 is the existing access condition with the truck volume split evenly with 80 trucks on the HOV lane and 80 trucks on the GPL. Table 1 shows that moving trucks into the HOV lane results in marginal or no performance improvement on the GPL with marginal or no performance penalty on the HOV lane.

Table 1. Simulation Results for Northbound Existing Configuration Alternatives (PM Peak Hour).

Alt. #	Description	GPL						HOV	
		Midpark Rd.– Belt Line Rd.		Belt Line Rd.– Campbell Rd.		Campbell Rd.– PGBT		Belt Line Rd.– Campbell Rd.	
		Avg. Speed (MPH)	# Veh.*	Avg. Speed (MPH)	# Veh.*	Avg. Speed (MPH)	# Veh.*	Avg. Speed (MPH)	# Veh.*
1	Existing Access No Trucks in HOV	17.5	5,296	24.6	5,236	30.6	4,172	62.4	954
2	Existing Access 80 Trucks in HOV	17.7	5,336	24.7	5,268	31.02	4,180	61.3	1,034

* Number of vehicles counted during the peak-hour VISSIM simulation

Table 2. Simulation Results for Northbound Intermediate HOV Access Configuration Alternatives (PM Peak Hour).

Alt. #	Description	GPL						HOV	
		Midpark Rd.– Belt Line Rd.		Belt Line Rd.– Campbell Rd.		Campbell Rd.– PGBT		Belt Line Rd.– Campbell Rd.	
		Avg. Speed (MPH)	# Veh.*	Avg. Speed (MPH)	# Veh.*	Avg. Speed (MPH)	# Veh.*	Avg. Speed (MPH)	# Veh.*
3	Intermediate Access No Trucks in HOV	13.2	4,480	24.1	4,360	30.4	3,916	30.1	954
4	Intermediate Access 80 Trucks in HOV	15.67	4,916	22.4	4,712	30.58	4,124	27.6	1,034

* Number of vehicles counted during the peak-hour VISSIM simulation

Table 2 presents the results for the intermediate access configuration. Alternatives 3 and 4 include an HOV lane entrance and exit between Belt Line Road and Campbell Road. This mid-point access allows the GPL traffic to enter the HOV lane and allows HOV lane traffic to exit to the GPLs. Alternative 3 neither includes trucks in the HOV lanes nor allows trucks to enter the HOV lane from the mid-point HOV access. Alternative 4 is the intermediate access point configuration with the truck volume split evenly with 80 trucks in the HOV lane. This includes the trucks entering the HOV lane using the mid-point HOV access and trucks exiting the HOV lane using the mid-point HOV access.

Table 2 shows marginal changes in speeds between Alternatives 3 and 4. The significantly lower HOV speeds in Table 2 compared to Table 1 are more reflective of the operational impacts of the intermediate HOV access point than the operation of trucks in the HOV lane. Trucks merging into and from the HOV lane would also logically result in a reduction of already lower HOV speeds.

SIMULATION CAVEATS

There are several caveats to consider when interpreting these results:

- Simulation models are very difficult to calibrate in heavily congested corridors such as US 75, and models are more error prone under these conditions.
- The average speeds in the tables are for the number of vehicles shown in the “# Veh.” column. A higher number of vehicles processed by the simulation suggests better traffic flow and lower congestion in the network. Vertical alignment and heavy vehicle performance on grades were not assessed in this simulation.

OTHER POSSIBLE CONSIDERATIONS

There are other possible considerations to allowing trucks to use concurrent-flow HOV lanes:

- What are the actual truck operating conditions in a single-lane HOV lane with limited cross section and minimal clearance to barrier walls? The simulation currently models trucks in the HOV lane in the same manner as in GPLs.
- What will the incident management impacts be of allowing trucks into HOV lanes (i.e., what happens when a truck breaks down in the lane)?
- How would trucks impact the geometric design of the HOV lane merge points back to the freeway main lanes?
- How will the addition of trucks complicate the signing of HOV and managed lanes?
- How do the HOV lane access points serve the truck origin-destination (OD) patterns (e.g., Houston HOV lanes [except for the new Katy Managed HOV Lane] were basically built to serve work-commuter traffic destined for downtown; routing may not make sense for trucks, which may have different destinations)?

- How will pricing impact truck demand on managed lanes for those HOV lanes with plans to expand to manage lanes?

The conclusions from this work suggest:

- The simulation produced inconclusive results on GPL and HOV lane speed performance when trucks are allowed to operate within the HOV lane.
- Corridor-specific analysis should be conducted to examine truck use of a specific HOV lane corridor.
- Consideration should be given to the use of a dynamic traffic assignment simulation to assess the truck OD patterns and operational impacts.

**WORK ORDER 24:
ESTIMATION OF ADDITIONAL INVESTMENT NEEDED TO SUPPORT
ENERGY INDUSTRY ACTIVITY IN TEXAS**

BACKGROUND

In recent years, Texas has experienced a boom in energy-related activities, particularly in wind power generation and extraction of oil and natural gas. While energy developments contribute to enhancing the state's ability to produce energy reliably, many short-term and long-term impacts on the state's transportation infrastructure are not properly documented.

To address this concern, the Texas Department of Transportation funded a two-year project with the Texas A&M Transportation Institute to measure the impact of increased levels of energy-related activities on the TxDOT right-of-way and infrastructure, as well as to develop recommendations to reduce and manage TxDOT's exposure and risk resulting from those activities. Project 0-6498 developed geodatabases of existing and anticipated energy developments, and conducted field visits to collect data to measure impacts resulting from energy developments. Researchers assessed pavement impacts and reduction in pavement life, roadside impacts, operational and safety impacts, and economic impacts.

Project 0-6498 developed an approximate methodology to assess the cost impact of energy developments. That methodology is based on the predicted reduction in pavement life, and the average trends in construction and maintenance expenditures reported in TxDOT's Design and Construction Information System (DCIS) and Pavement Management Information System (PMIS) databases.

As needed, a variety of alternative scenarios could be evaluated to develop a better understanding of the range of potential impacts. Ideally, this analysis would be conducted for each impacted corridor and the results aggregated to determine a statewide estimate of the total pavement impact associated with energy developments. However, the task of collecting data to support such an analysis was beyond the scope and time frame of Project 0-6498.

Nevertheless, it is possible to develop a high-level, statewide preliminary estimate of the total impact associated with energy developments. By using a geodatabase of oil and gas wells and by defining impact areas of different sizes around each well, a surface could be generated and overlaid on the state highway network to identify road segments that fall within each of the buffers.

CURRENT CONDITION OF ROAD NETWORKS IN THREE TXDOT DISTRICTS

Figure 1 shows the remaining pavement life from a sample of roads impacted by energy development in the Abilene, Fort Worth, and Lubbock Districts. Using test data from a falling weight deflectometer and a ground-penetrating radar, researchers employed two separate pavement life models (MODULUS and OTRA) to estimate remaining life. The bottom line is the extra trucks and weights associated with energy development have dramatically shortened pavement life. The original research developed three long-range scenarios as mitigation approaches to maintain pavements over a 20-year life. The time and funding for this research necessitated some assumptions (see the next section) and the exclusion of some additional factors.

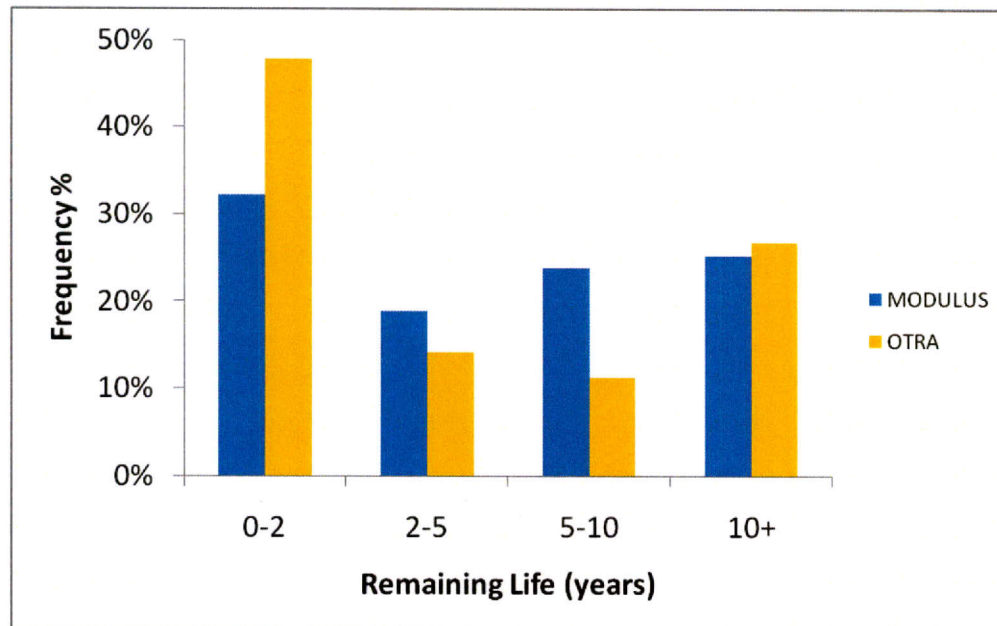


Figure 1. Summary of Remaining Life Analysis.

ASSUMPTIONS BEHIND RESEARCH METHODOLOGY

Assumptions behind the methodology include the following:

- A 20-year horizon.
- An annual discount rate to take into account the time value of money: 4 percent.
- A farm-to-market (FM) road (rural collector road).
- Maintenance expenditure (no-impact scenario): \$1,000 per lane-mile.
- Maintenance expenditure (impact scenario): \$3,000 per lane-mile.

- Seal coat cost: \$10,000 per lane-mile.
- Overlay: \$115,000 per lane-mile.
- Restoration: \$137,000 per lane-mile.
- Rehabilitation: \$255,000 per lane-mile.

The methodology also assumes the analyst has information about the type of energy development—more specifically, the anticipated truckloads and impact on remaining pavement life based on the cumulative number of 18-kip equivalent single axle loads (ESALs) the pavement was originally designed for, and the increased rate of ESAL applications associated with the energy development. This knowledge would enable the analyst to forecast when certain treatments need to be scheduled to maintain the functionality of the road, e.g., when to schedule a seal coat or an overlay, or when more substantial measures such as restoration or rehabilitation are required.

The methodology involves the following steps:

- Calculate 20-year anticipated expenditures without the energy development (base scenario).
- Calculate 20-year anticipated expenditures with the energy development in place (alternate scenario).
- Calculate the cost difference between the alternate and base scenarios. The additional cost associated with the alternate scenario is the cost due to the impact of the energy development on the transportation pavement infrastructure.

RELEVANT ADDITIONAL FACTORS

The range of factors potentially affecting impacts on roads is wide, so the original research was constrained to those variables that could be readily measured and analyzed within the research budget and time frame. TTI recognizes that other variables have a material effect on pavement life and has performed additional sketch-level analysis to assess the approximate impacts of departures from the following assumptions used in the original research:

- Assumed that all system roads received a preventive restoration treatment in Year 0.
- Assumed all trucks were 80,000 lb, while many may have a 2060 permit allowing 84,000 lb.

- Assumed no overweight vehicles because no objective data were available, other than observations.
- Did not include hauling of petroleum products by truck (especially significant in Eagle Ford).
- Assumed average material prices from 2004 through 2010.
- Examined damage primarily to FM roads, not local roads (city/county).

IMPACTS OF ADDITIONAL FACTORS

The following paragraphs describe in limited detail how departures from the above assumptions would affect the estimates of overall impact.

Assumption that all system roads received a preventive restoration treatment in Year 0. In creating alternative scenarios for mitigating impacts of energy development, the original research had to make some base assumptions. One of those assumptions was that each affected road received restorative maintenance in Year 0 of the analysis. Because there are insufficient funds to perform this preventive maintenance, the actual impacts are significantly greater than in the hypothetical scenarios in the original research. Using the original methodology and the revised assumption of limited or no preventive maintenance, the potential annual cost of pavement damage on secondary FM roads due to oil and gas energy developments was estimated to be \$885 million.

Effects of overweight and heavier permitted overloads. A large majority of commercial trucks operating in the energy development effort are Class 9 vehicles consisting of a steering axle with two tires and two tandem axles having eight tires each. Current legal axle loads on Class 9 commercial trucks are limited to a maximum total weight of 80,000 lb. In Texas, operators may purchase overload permits that allow a 5 percent overload for a maximum of 84,000 lb. Using the ESAL factor described above, this 5 percent increase in total load would result in a 20 percent increase in damage. If the actual load approaches 90,000 lb, then the damage per truck would increase almost 60 percent over the 80,000-lb unpermitted maximum weight.

Impact of trucking petroleum products from wells. Much of the energy development in Texas is occurring in regions that have a good network of pipelines to transport the petroleum products to refineries or other destinations. But some areas do not yet have the pipeline network,

so products must be transported by truck. This is especially true in parts of South Texas. Because of the significant regional differences, and the lack of time and resources to document them, the original research did not include petroleum hauling as an impact on pavements. The research team recognizes that those impacts do exist, at a significant level in some places. Therefore, researchers conclude that these impacts should be accumulated with the other factors in estimating the actual statewide needs for pavement maintenance and rehabilitation.

Update of material prices. The research methodology in Project 0-6498 used material prices for seal coats, overlays, restoration, and rehabilitation that are based on averages of costs obtained from the DCIS database during the years 2004 to 2010. The post-research analysis compared the average of the Highway Cost Index (HCI) from the 2004–2010 time frame to the first six months of 2012 to determine whether typical costs for road repair and maintenance have changed significantly. The average HCI for the original analysis period was 182, whereas the 2012 HCI is 211. Therefore, the team has concluded that the change in the HCI would contribute to a significant increase in the cost to provide serviceable roads.

Impacts on local roads. The original research was limited to state-maintained roads, primarily FM roads. The research team is aware that county roads and, in some cases, city roads service many energy developments. Part of the post-research assessment was an effort to develop an approximate estimate of local-road density and likely impacts of energy development. Because the amount and weight of truck traffic are typically low in the absence of energy development, those roads are often constructed to a lesser pavement design standard than FM roads or state highways. Therefore, the impact of repeated heavy loads is even greater than on the FM or state highway system. But to be conservative, the research team assumes the impact on local roads is equivalent to that on the documented FM system.

Further, an overview of the local road systems in the areas studied shows that network to be roughly the same lane-miles as the FM system. Therefore, the research team concludes that the cost to provide quality road repair and maintenance to the local roads is at least an additional \$1 billion, aside from the original \$1 billion estimated for the FM and state highway systems.

SUMMARY

An original study TTI conducted in 2011 examined the effects of energy development on the state-maintained road systems in some of the most intensive development areas in Texas. Building on that research, a TTI research team conducted a high-level assessment of additional factors and concluded that the statewide annual cost of providing quality maintenance and repair to affected state and local roads would be a minimum of \$2 billion.

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