Appendix A.

NCHRP Project 03-73 Separation of Vehicles – CMV-Only Lanes Task 7 – Interim Report

A. NCHRP Project 03-73 Separation of Vehicles – CMV-Only Lanes Task 7 – Interim Report

A.1 Introduction

This interim report document provides results of the first phase of research on National Cooperative Highway Research Program (NCHRP) Project 03-73 Separation of Vehicles – Commercial Motor Vehicle-Only Lanes project. It presents a review and discussion of a wide range of issues relevant to planning, designing, and evaluating a variety of concepts from CMV-Only Lanes that should be useful to planners and policy makers in the public and private sector. It also presents an evaluation of available data and its suitability to conduct additional analyses in Phase II of the research plan.

A.1.1 Project Overview

For a number of years, there has been growing interest in commercial motor vehicle (CMV)-only lanes and several notable proposals for CMV-only lane systems/projects have appeared in the planning and traffic engineering literature. To a large extent, this growth in interest has been related to the growth in truck traffic relative to automobile traffic and the contribution of truck traffic to congestion.

Heavy trucks have a greater impact on capacity than their sheer volume would suggest, especially when mixed with automobiles. Separation of autos and trucks may be a beneficial way of building more system capacity in certain circumstances. A number of studies also have suggested that CMV-only lanes that are tolled may present a viable means of financing system capacity improvements. The argument has been made that trucks have a higher value of time than autos, and may therefore be willing to pay a higher price for congestion relief.

A number of studies have shown that system reliability is especially critical in the movement of high-value, time-sensitive commodities, and that the reliability benefits of CMV-only lanes (due to the combination of less overall congestion and the incident-reduction potential of truck-auto separation) may provide added value for which truckers/shippers would be willing to pay. It also has been suggested that separation of autos and trucks may have significant safety benefits. Autos are far more maneuverable than heavy trucks, yet auto drivers often do not take this into account when making certain fast response driving maneuvers and this can lead to increased crashes. Further, when trucks and autos are involved in crashes, they are far more likely to be fatal crashes than when crashes involve only autos.

The objectives of the Separation of Vehicles – CMV-Only Lanes project are to compile data from actual applications and studies of emerging concepts and use these data to present a profile of the benefits and costs of CMV-only lanes. This information will serve as a reference guide for planners who may be considering CMV-only lane concepts in corridor studies or other

planning applications. The analyses in the project also will provide data that practitioners can use to support their own evaluations of CMV-only lane projects.

The research comprises 10 tasks for meeting the objectives of the project:

1. Conduct a literature review of existing CMV-only facilities as well as proposed concepts, which will provide information for subsequent tasks.

2. Describe planning process issues associated with the development of CMV-only lanes.

3. Describe major configurations and identify and analyze key design issues.

4. Discuss opportunities to apply Intelligent Transportation Systems (ITS)/Commercial Vehicle Operations (CVO) to CMV-only lanes and the benefits that can accrue from these deployments.

5. Examine opportunities to operate longer combination vehicles (LCV) and heavyweight trucks on CMV-only lanes.

6. Explore issues and opportunities associated with tolling and privatization of CMV-only lanes.

7. Prepare an interim report that summarizes the findings and data collected in the first six tasks (described in more detail in Chapter 1.3).

8. Compile available field and modeling data into a performance evaluation of different CMV-only lane concepts.

9. Evaluate CMV-only lanes in terms of relative costs and benefits.

10. Prepare a final report that summarizes the results of the analyses conducted in the project. This report will include a summary of existing CMV-only facilities, a description of different configurations and the factors that influence the feasibility of each configuration, a discussion of performance data, and a summary of the benefits and costs of different CMV-only lane systems.

A.1.2 Definition of Commercial Motor Vehicle

A "commercial motor vehicle" can be variously defined. In response to a request from the project Technical Panel, a working definition of a CMV was developed for this project.

The Federal Motor Carrier Safety Administration (FMCSA) under the Code of Federal Regulations – Title 49 (49 CFR) Part 390 (Rulemaking Procedures – Federal Motor Carrier Safety Regulations) defines commercial motor vehicles for U.S. Department of Transportation vehicle registration purposes as:

- Vehicles having a gross vehicle weight rating or gross combination weight rating (in the case of combination vehicles) of at least 10,001 pounds; or

- Vehicles designed or used to transport more than eight passengers (including the driver) for compensation; or

- Vehicles designed or used to transport more than 15 passengers (including the driver), but not for compensation; or

- Vehicles used in transporting material found by the Secretary of Transportation as being hazardous under 49 U.S.C. 5103, and transported in a quantity requiring placarding under 49 CFR, Subtitle B, Chapter 1, Subchapter C.

This standard Federal definition for CMVs includes not only trucks – based on a weight- and commodity- (hazardous) based categorization – but also passenger vehicles such as buses. Another, more restrictive Federal definition is based on commercial driver licensing (CDL) requirements (Part 383: Commercial Driver's License Standards; Requirements and Penalties). This definition includes trucks with a gross vehicle weight or gross combination weight rating of at least 26,001 pounds, trucks carrying hazardous materials requiring placarding (same as Part 390), and vehicles carrying 16 or more passengers, including the driver.

Finally, the Federal Highway Administration (FHWA) classifies nonpassenger vehicles by the number of axles and number of units, as opposed to the FMCSA's definition based on weight or commodity. Single- and multitrailer trucks (i.e., not single unit trucks), for example, fall within Classes 8 to 13 in FHWA's scheme.

The Technical Panel agreed with Cambridge Systematics' recommendation that the types of vehicles included in the CMV definition for this project will be directly dependent on the types of vehicles best served by various CMV-only lane configurations and not tied to any of the Federal definitions, as stated in a memorandum on the subject dated April 15, 2008.

Consequently, as trucks are implicitly the focus of this research, passenger vehicles falling under the CMV classifications under Federal regulations (discussed above) will not be included as CMVs. Since the work approach for this project involves analyzing different types of truck-only lane configurations, flexibility in the CMV definition has been adopted to accommodate different types of trucks, based on the type of application of truck-only lanes (note that the terms "CMV-only" and "truck-only" generally will be used interchangeably in this document).

A.1.3 Purpose of Interim Report

This interim report is the first of two deliverables for the Separation of Vehicles – CMV-Only Lanes project. This deliverable represents Task 7. The second project deliverable, the final report, will be delivered at the conclusion of Task 10.

This document summarizes the work performed in Tasks 1 through 6. It includes:

- Comprehensive description of current and past experience with CMV-only lanes, including proposed facilities;

- Evaluation of the feasibility of the available data to compile a performance evaluation and a benefit/cost analysis; and

- Commentary on aspects of the data and analysis that are notably weak and that may impact the performance evaluation and benefit/cost analysis.

Cambridge Systematics will meet with the Technical Panel after submitting the interim report to discuss the condition of the data. The project team will determine if any adjustments must be made to the workplan to reflect the availability of data with which to conduct the remaining proposed analyses in Tasks 8 and 9.

A.1.4 Organization of Document

This document contains nine chapters. These chapters are:

- **Chapter 1.0, Introduction –** Provides an overview of the project, a definition of a commercial motor vehicle for this project, and the purpose of this report;

- **Chapter 2.0, Task 1 – Literature Review –** Details the literature review conducted as a foundation for subsequent tasks;

- **Chapter 3.0, Task 2 – Planning Process Issues –** Describes planning process issues associated with the development of CMV-only lanes;

- **Chapter 4.0, Task 3 –** Configurations and Design Issues and Related Institutional Questions – Describes major configurations and identifies and analyzes key design issues;

- **Chapter 5.0, Task 4 –** Integration with Intelligent Transportation Systems – Discusses opportunities to apply ITS/CVO to CMV-only lanes and the benefits that can accrue from these deployments;

- **Chapter 6.0, Task 5 –** Longer Combination Vehicle Operations – Examines opportunities to operate LCVs and heavyweight trucks on CMV-only lanes;

- **Chapter 7.0, Task 6 –** Tolling and Privatization – Explores issues and opportunities associated with tolling and privatization of CMV-only lanes;

- **Chapter 8.0, Data Evaluation and Commentary –** Addresses the feasibility of the available data to support performance and benefit/cost evaluations; and

- **Chapter 9.0, Next Steps –** Identifies the activities that will be undertaken following the submission of the interim report.

Four appendices also are included in this document. These appendices are:

- **Attachment A –** Provides the results of the initial Task 1 Literature Review;

- **Attachment B –** Provides a list of sources used in Tasks 2 through 6;

- **Attachment C –** Provides data tables, figures, and graphs that support the analyses performed in Tasks 2 through 6; and
- **Attachment D –** Provides a glossary of acronyms used in this document.

A.2 Task 1 – Literature Review

A.2.1 Purpose

The objective of Task 1 was to conduct a comprehensive literature review related to CMV-only lanes to lay the foundation for future tasks, 2 through 6, of the project.

A.2.2 Methodology

As a starting point, the project team reviewed those references that were most familiar, i.e., research and feasibility studies on truck-only lanes previously conducted by Cambridge Systematics, Inc. (CS). Other well known sources were also targeted, such as the work of James G. Douglas as a Parsons Brinckerhoff (PB) Scholar, Robert Poole and his colleagues at the Reason Foundation, the Texas Transportation Institute (TTI), and the Transportation Research Board (TRB), among others. While these are some of the best documented sources, numerous lesser known works-in-progress were found via Transportation Research Information Services (TRIS) catalog searches and Internet "Google" and "Google Scholar" searches using common industry terminologies such as "truck-only lanes," "truck toll lanes," and "truckways."

The literature search identified over 200 sources of information related to a variety of truck-only lane applications and topics. As this information will guide all future tasks, care was taken in the proper identification of all the pertinent issues contained within each source. A literature review matrix was developed to provide a detailed list of all the sources identified and to help categorize the information collected from each source. This review matrix can be found in Attachment A.

Prior to delving into the details of each source, three questions were posed and answered related to the relevance of the reference:

- Is the source applicable to the NCHRP 03-73 project?
- Is the source recent?
- Is the source credible?

After this initial review, 128 sources remained as potentially applicable to the current study. Each remaining source was reviewed to determine for which future task(s) it could provide information. To aid in this determination, broad categories were assigned to columns in the literature review matrix as follows:

- Existing Truck Lane Project;
- Feasibility/Planning/Analytical/Modeling Study;

- Types of Facilities;
- Performance Measures;
- Data Inputs and Tools for Evaluation of Performance Measures, Physical Criteria/Design Considerations;
- Costs;
- User Fee/Tolling Considerations;
- Planning Process Issues;
- ITS Applications; and
- LCV Applications.

If information pertaining to any category was found within a source, a check mark was placed in the appropriate category column. This method not only optimizes the data collection effort required for future tasks, but also provides a high-level overview of "hot-button" topics in the truck-only lane literature.

A.2.3 Initial Findings

As the matrix in Attachment A shows, there are a substantial number of references to CMV-only lane topics. While the intent of this literature review was to identify two types of information relevant to this study – information from actual working examples of truck-only lanes and information from analytical studies and modeling exercises – the preponderance of information was found in planning, policy, and feasibility studies with limited real-world application of the truck-only lane concept.

Additional findings suggest that there is a shortage of information in the areas of ITS applications and Longer Combination Vehicles (LCVs). This could be attributed to the fact that the inclusion of ITS and LCVs in the CMV-only lane concept are "add-ons," and not necessarily at the core of the studies identified during the literature review. However, there are numerous sources that discuss the economics of CMV-only lanes. This could be attributed to the fact that the CMV-only lane concept and tolling go hand-in-hand, with one not being discussed without mention of the other. In many instance tolling is at the heart of CMV-only lane projects, as it is often intended to design these lanes to be self-funding.

These findings, and others, are further explored in Tasks 2 through 6 found in the following chapters.

A.3 Task 2 – Planning Process Issues

A.3.1 Introduction

The purpose of Task 2 is to describe some of the critical planning process issues associated with the development of commercial motor vehicle- (CMV) or truck-only lanes (TOL) at the regional, state, and multistate level. This includes network- and project-level planning process issues. The following questions will be addressed:

- During long-range planning processes, what approaches can be used to identify the best opportunities for truck lanes?
- What are the tradeoffs that will need to be considered in comparing truck lanes with other alternatives for additional capacity?
- What are the implications of truck-lane networks for cooperative multistate and multiregional planning processes?

Additionally, historically, truck-only lane projects have been evaluated and pursued by public agencies. Thus, as each new project contemplates the use of public funds for potential private company benefit, institutional issues arise. Chapter 7 reviews the role industry should have in planning truck lanes, to help bring clarity to an often cloudy topic. Additional institutional issues will reviewed as part of the Task 3 Technical Memorandum, Configurations and Design Issues and Related Institutional Questions.

Task 2 concludes with general guidance on planning process techniques and analytical approaches that can be incorporated by MPOs and state DOTs into their ongoing long-range, corridor, and project-specific planning efforts in order to adequately address truck-lane opportunities.

A.3.2 Why CMV-Only Lanes?

CMV-only lanes have been the topic of feasibility studies by regions, states, and multistate consortia for a variety of reasons, most importantly, because of the benefits they provide. And, depending on their configuration, the benefits of CMV-only facilities can accrue to a number of stakeholders. Table A.1 illustrates a sampling of benefits that CMV-only lanes can provide to both those using the CMV-only lanes, as well as those traveling in general purpose lanes. Table A.2 takes these benefits one step further and presents additional advantages of CMV-only lanes when used in combination with tolling.

Table A.1 CMV-Only Application Benefits

Category	Benefit	Group Benefiting	Description
Operational Efficiency	Higher Travel Speeds Less Delay Improved LOS	General Purpose Lane Users CMV-Only Lane Users	Vehicle separation allows all vehicles to travel at their designated speed without conflict. Slower commercial vehicles are not present in right (slow) travel lanes. Less weaving. Improved operational efficiency.
Safety	Enhanced Safety	General Purpose Lane Users CMV-Only Lane Users	Fewer, less severe crashes as a result of vehicle separation.
Economic	Enhanced Travel Options	CMV-Only Lane Users	Increased trip reliability and reduced transportation costs of fuel consumption due to severe congestion or delay caused by truck-car accidents.
	Improved Freight Productivity	CMV-Only Lane Users	The efficiency of freight movement in and around major metropolitan areas is an important factor in the competitiveness of comparable regions.
Environmental	Reduced Vehicle Emissions	General Purpose Lane Users CMV-Only Lane Users	Stop-and-go traffic conditions improve as congestion is decreased on general purpose lanes, air pollution emissions from slowed or stalled cars and trucks will be reduced.

Table A.2 Additional CMV-Only Application Benefits through Tolling

Category	Benefit	Group Benefiting	Description
Operational Efficiency	Congestion Management	General Purpose Lane Users CMV-Only Lane Users	By imposing fees when demand levels reach capacity on CMV facilities, the level of congestion on CMV facilities is controlled.
Economic	Revenue	General Purpose Lane Users CMV-Only Lane Users	Fees can provide an additional source of revenue to pay for transportation improvements, especially the operations and maintenance of the CMV lanes themselves.

Note: Benefits are general, not specifically tied to either mandatory optional tolling scenarios.

While the benefits are widely discussed, the planning methods used to obtain these data are varied. Part 3.5 will review measures that recent literature used to quantify these benefits.

A.3.3 Determining CMV-Only Lane Project Fit

As illustrated in part 3.2, numerous benefits have been attributed to both commercial and passenger vehicles through CMV-only lane implementation. However, essential understanding of regional issues is required in order to determine whether CMV-only lanes are the right fit for the regional or local conditions, and whether or not the concept fits with the goals that have been established through other planning efforts. This chapter begins the link between the CMV-only lane concept and the planning process. This guidance is applicable whether a project is conceived at the regional, state, or multistate level.

Each region is different, containing numerous transportation issues and needs. No two areas are alike, and thus, no two areas will have the same solution to these issues/needs. Understanding CMV-only lane intent at the highest level will help planners uncover whether or not the regional context/market does in fact support CMV-only lane implementation. According to a recent feasibility study in Georgia related to this concept, "to achieve the highest and best use of a truck-only lane system investment requires an understanding of the market for truck-only lanes and designing a system that captures the greatest market share and provides the greatest opportunity to garner travel time savings."[1] Understanding the regional context and the transportation environment and conditions is vital prior to pursuit of a CMV-only lane project.

Linking CMV-Only Lane Project to Ongoing Planning Processes

During long-range planning processes at the state and MPO level, approaches should be used to identify the best opportunities for truck-only lanes while comparing them with other alternatives for additional capacity. Currently, few formal guidelines are available for implementing CMV-only facilities, including the tradeoffs that may need to be made with respect to planning, design, and operation of CMV-only facilities for different geographies. While design and operation considerations of the system certainly falls under the feasibility study umbrella, they should be reviewed at a high level within the initial planning stage to understand what options may be evaluated, including: configuration alternatives; mandatory versus voluntary truck use; and tolling strategies.

Link Project to Strategic Direction/Long-Range Planning Goals

Pursuit of a CMV-only lane project should not supersede well established, Federally mandated planning processes. State and MPO Long-Range Transportation Plans (LRTP) provide a 20-plus-year "roadmap" of strategic and capital improvements. These roadmaps are developed to guide the effective investment of public funds in multimodal transportation facilities.

The process of developing an LRTP every four years is extensive; it involves methodical goal setting for a strategic direction and continual public involvement throughout development of

[1] *Truck-Only Lanes Needs Analysis and Engineering Assessment*, Georgia Department of Transportation, April 2008.

the the plan to ensure all stakeholders have an opportunity to comment. This plan is recongized and helps justify pursuit of major feasibilty studies within every city, region and state in the Nation. This study recommends that for these resons that any CMV-only lane project be pursued within either a State or MPO LRTP context.

- The Georgia DOT feasibility study provided a firm foundation for goal setting and ensured that the objectives set for the CMV-only lane project meshed with the long-range objectives previously set forth in the region. In Georgia, goals and objectives developed as part of the Statewide Transportation Plan and Federal planning factors detailed in SAFETEA-LU were used as a starting point for the project. The Steering Committee and Freight Task Force each reviewed these goals and objectives, and offered suggestions that were incorporated. The revised goals and objectives were presented to the public at a series of meetings that took place at various locations around the State. As example, Georgia's truck-only lane project goals were as follows:[2]

  - **Goal 1 –** Improve safety for cars and trucks on Georgia's highway network;

  - **Goal 2 –** Promote security of the highway network for all motorists;

  - **Goal 3 –** Protect and improve mobility;

  - **Goal 4 –** Provide a plan for truck-only lanes that is fiscally responsible, economically feasible, and equitable to all parts of the State;

  - **Goal 5 –** Support local, regional, state, and national economic development initiatives; and

  - **Goal 6 –** Avoid, minimize, and mitigate adverse impacts to the built, natural, social, and cultural environment.

- In the Southern California Association of Governments' (SCAG) I-15 Comprehensive Corridor Study, the project team reviewed six major problem areas and established study objectives associated with each, as follows:[3]

  - Traffic Congestion;

  - Goods Movement;

  - Transit;

  - Safety;

  - Design Improvements; and

[2] *Truck-Only Lanes Needs Analysis and Engineering Assessment*, Georgia Department of Transportation, April 2008.

[3] *I-15 Comprehensive Corridor Study*, SCAG, December 2005.

- Cost-Effectiveness.

By establishing these goals in the SCAG study, the project team wasn't locked into a CMV-only lane solution. Through analysis, the team evaluated five-plus different alternatives, including no-Build, TDM/TSM, HOV lanes, full corridor dedicated truck lanes, reversible managed lanes, and interchange bottleneck elimination. The purpose of the planning stage is to identify the best solution to the area need, not to purely pursue a CMV-only lane project.

- In the I-710 Major Corridor Study, the Policy Oversight Committee established guiding principles for the corridor:[4]

1. Minimize right-of-way acquisitions with the objective being to preserve existing houses, businesses, and open space;

2. Identify and minimize both immediate and cumulative exposure to air toxics and pollution with aggressive advocacy and implementation of diesel emissions reduction programs and use of alternative fuels as well as in project planning and design;

3. Improve safety by considering enhanced truck safety inspection facilities and reduced truck/car conflicts and improved roadway design;

4. Relieve congestion and reduce intrusion of traffic into communities and neighborhoods by employing a comprehensive regional systems approach that includes adding needed capacity as well as deploying Transportation Systems Management and Transportation Demand Management technologies and strategies (TSM/TDM) to make full use of freeway, roadway, rail, and transit systems; and

5. Improve public participation in the development and consideration of alternatives and provide technical assistance to facilitate effective public participation.

Similar to the SCAG study, this LA study kept options open during the exploratory stage of project development, and wasn't locked into a CMV-only solution. Developing criteria with an open mind is vital to ensuring that what gets built is in fact what the region needs.

Evaluation Criteria and Thresholds

Because of the high level of investment required for CMV-only lane projects, several studies have recommended "thresholds" be in place prior to pursuit of the project. These threshold categories are reasonable when considering that CMV-only lanes are most attractive when they provide meaningful blocks of travel time savings to commercial vehicle users, thus minimum values for numbers of trucks or percent trucks on roadway segments can serve as a guide for planning. However, the conditions in the field necessary to ensure a successful CMV-only lane project can be difficult to quantify. By providing thresholds planners are able to gauge, at a high level, whether the region's conditions warrant the concept. Research shows that a variety

[4] *I-710 Major Corridor Study Final Report*, Los Angeles County MTA, March 2005.

of thresholds have been developed as shown in Table A.3. Thresholds have been proposed for items such as:

- Average Daily Traffic (measured in vehicles per hour per lane);
- Average Daily Truck Traffic (measured in vehicles per hour per lane);
- Truck Percent of Total Mainline Traffic; and
- Proximity to Freight Generators.

Table A.3 CMV-Only Lane Planning Thresholds

Measure	Criteria	Source
Mainline Volume	Peak hour > 1,800 vphpl Off-peak hour > 1,200 vphpl	Janson
	Two-way ADT > 120,000	Douglas
	ADT > 100,000	Battelle
Heavy Truck ADT	>20,000 for 10 miles	Douglas
Heavy Vehicle Mix	> 30%	Janson
	25% Trucks	Battelle
Freight Generator Proximity	Truck Generator at one terminus	Douglas

Source: *The Potential for Exclusive Truck Facilities in Ohio*, Dorothy, 2007.

Peak and off-peak hour thresholds should be reviewed carefully and in combination with each other, as within many critical corridors trucking companies have made adjustments to their operations to avoid the most congested travel periods. The Federal Highway Administration has noted this national trend in "An Initial Assessment of Freight Bottlenecks on Highways" (October 2005) which reported that "…most motor carriers work aggressively to schedule and route their truck moves outside of peak periods and around known bottlenecks. Truck volumes typically peak during the midday, especially on urban Interstate highways, and are relatively high in the early morning and at night compared to automobile volumes."

Also, while the source notes that proximity to a freight generator at one terminus is ideal, this concept should be expanded to better describe the stature of the generator (e.g. deep water port, major intermodal rail facility, or national distribution center). If only a single generator is present, logic dictates that it would need to be truly "significant" in order to warrant an exclusive truck-lane to serve it.

Although not well documented, research has shown that a few additional factors could also be evaluated as part of the planning process. CMV-only lanes may serve as a supplement to rail service where rail networks are congested, and conversely, CMV-only lanes may not draw high traffic volumes in areas where parallel rail corridors are present. For this reasons it makes sense to take a harder look at the mix of long-haul truck trips that could potentially use a CMV-only facility. Evaluation thresholds also could reflect:

- Percent of through truck trips; and
- Percent of truck trips 500 miles from destination.

These values will help planners evaluate longer haul, CMV-only lane corridors, and potentially those corridors pursued by multistate coalitions.

Additionally, existing and future land use designations should be evaluated to determine whether or not the presence of a large amount (or multiple pockets) of industrial square footage warrants CMV-only lanes to connect truck freight generators. In the *Mid-City Freightway Study* the CMV-only corridor alignment was selected partially based on its proximity to, and ability to serve, industrial land use. The study reviewed several alternatives that provided varying levels of service for through truck trips, but each providing uninterrupted, and enhanced service for local businesses within the freightway.

A.3.4 Develop Performance Measures and Screening Criteria

Development of performance measures and screening criteria for CMV-only lane projects will aid agencies in ensuring objectives set early on in the planning process are met, and provide ease during initial design and while operational considerations are examined.

- Hsing-Chung Chu at the Georgia Institute of Technology, reviewed performance measures that could achieve set objectives for tolled CMV-only lanes. While not applicable to every CMV-only lane application, the concepts are still valid and include:
  - Maintaining a travel speed of level-of-service C or D during peak periods on truck-only toll (TOT) lanes;
  - Reducing the truck-related crash rate (fatality, injury, and property damage only) on each TOT corridor being lower than the regional, statewide, or national average;
  - Producing a travel time saving benefit greater than trucker's toll cost threshold;
  - Providing convenient access to major truck trip generators along a TOT corridor and efficient connectivity between TOT corridors;
  - Increasing toll revenues by creating at least a 50 percent utilization rate of TOT lanes; and
  - Generating a truck diversion rate greater than 0 percent by increasing truck vehicle-miles traveled (VMT) on TOT lanes and reducing truck VMT on general purpose lanes as well as parallel local routes.5
- In the Georgia DOT study, the project team developed screening criteria for alternatives. These recommended categories are derived from the goals and objectives developed from

[5] *Implementing Truck-Only Toll Lanes at the State, Regional, and Corridor Levels: Development of a Planning Methodology*, Hsing-Chung Chu, Georgia Institute of Technology, December 2007.

outreach to the study's steering committee, the freight community, and general public. These criteria included:6

- **Safety and Security –** Impacts to the number of crashes, injury crashes, and fatal crashes; providing access to freight amenities and security features;
- **Congestion and Mobility Effects –** Travel demand, roadway capacity, level-of-service, travel time, access, truck movement, and access to key freight generators;
- **Cost-**effectiveness **and Affordability –** Capital costs, operations and maintenance costs, achievement of benefits commensurate with resource commitment, sources and sufficiency of revenues;
- **Economic Development Initiatives –** Compatibility with local and regional plans and policies;
- **Environmental Effects –** Natural environment (air quality, noise, energy consumption, water quality and quantity, vegetation, wildlife, soils, open space, parklands, ecologically significant areas, drainage/flooding, aesthetics and visual quality); socioeconomic and cultural environment (historic, cultural, and archaeological resources; residential and business displacement/dislocation; socioeconomics and equity; neighborhood integrity and cohesion); and
- **Other Factors –** Constructability and construction effects.

• In the Georgia DOT case, workable measures for screening and evaluating the CMV-only were influenced by four key considerations:[7]

- **Effectiveness and Comprehensiveness in Measuring Goal Attainment –** The screening and evaluation measures were selected to reflect and measure the extent to which the alternative strategies contribute to the achievement of accepted transportation-related goals and objectives. Similarly, they were proposed to conform to Federal guidelines governing the evaluation of major transportation investments.
- **Ability to Reflect the Specific Nature of the Alternatives –** The recommended screening and evaluation measures are relevant to the need to evaluate alternative transportation strategies in isolation, as well as in combination. These measures are capable of reflecting interactions between transportation and other factors, such as local versus long-distance freight mobility, environment impacts, and market accessibility.
- **Realistic in Terms of Technical and Resource Requirements –** The computation of measures allow for efficient use of available data and provide comparable levels of detail,

[6] *Truck-Only Lanes Needs Analysis and Engineering Assessment*, Georgia Department of Transportation, April 2008

[7] *Truck-Only Lanes Needs Analysis and Engineering Assessment*, Georgia Department of Transportation, April 2008

both among different screening and evaluation categories and across alternative strategies.

- **Relevance for Policy Evaluation –** The total number of screening and evaluation measures is reasonable and allows for thorough coverage of key goals and issues. Where possible, quantitative as opposed to qualitative methods are employed to depict potential effects in an objective manner.

- The selection of the recommended measures reflects the emphasis placed on measures that would best reveal differences among the alternative investment strategies, reflect local and regional goals and objectives, address known issues, and minimize redundancy.

A.3.5 System Analysis

The literature reviewed for this task primarily centered on feasibility studies that were conducted for CMV-only facilities to be constructed either alongside or contained within existing freeway right-of-way. The following snapshot findings are augmented with a more detailed data analysis in Chapter 8.0, and detailed data tables and figures found in Attachment C.

Review of Multiple Alternatives

In all cases reviewed, CMV-only facilities were compared against multiple alternatives, including the "No-Build" alternative, with the non-CMV-only alternatives typically including comparable levels-of-capacity expansion with traditional mixed flow lanes.

- SCAG's I-15 Comprehensive Corridor Study compared a number of capacity and operational alternatives to truck-only lanes, including no-Build, TSM/TDM, HOV lanes, and managed lanes alternatives.

- The Chicago Department of Transportation's Mid-City Freightway Study examined future build and no-build truck-only lane alternatives in combination with a variety of tolling structures along a several proposed new alignments.

- For the I-81 Corridor in Virginia, truck-only lanes were compared against not only a variety of roadway concepts (e.g., add one lane to mainline, add two lanes to mainline, uniform roadway cross-section, etc.), but also to four rail concepts to evaluate the diversion of truck trips to rail, as compared to the operational efficiencies from truck-only lanes.

Use of Travel Demand Modeling

In order to conduct the system analysis of each of these projects some type of model must be used. The data are typically outputs from travel demand models (TDM) that have the ability to differentiate performance measures by vehicle class (at least differentiating autos and trucks) with some providing time-of-day analysis taking into account the different time-of-day characteristics of trucks and autos.

- In the Mid-City Freight Study, discussions with the MPO planning staff at determined that while the regions truck trip table may be suitable for regional planning, a more detailed

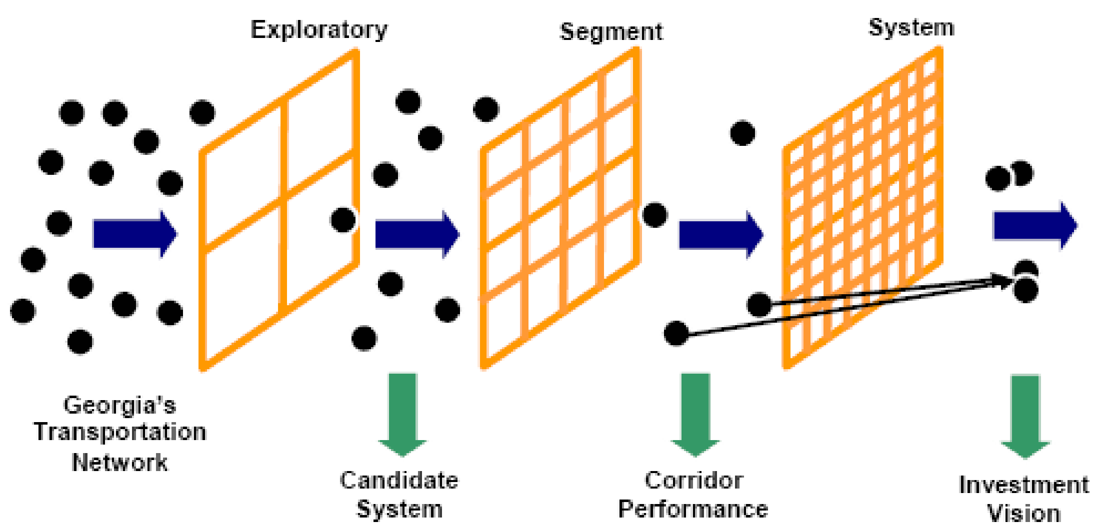
truck trip table would be required to test the various freightway alternatives in more detail. Thus for this study the nontruck portions of the TDM were used as they were, and an updated truck model trip table was developed with four major components: 1) commodity-carrying truck portion of the trip table estimated using commodity flow data from TRANSEARCH; 2) total truck trip table estimation using an ODME process; 3) treatment of different truck classification schemes; and 4) growth assumptions for developing the 2030 forecasts for the truck trip table.[8]

- In the GDOT Study the statewide TDM was used as a starting point for the analysis. Much work went into updating the model to include a new daily freight truck trip table based on TRANSEARCH data. Additionally freight truck types were refined and a Daily Non-Commodity Truck Table as created in addition to the Commodity Truck Table to reflect local deliveries. Using performance measures, segments of the transportation network that were considered candidate locations for truck-only lanes were modeled.[9]

Alternative Screening

This research found that CMV-only lane projects went through three stages of evaluation to narrow in on the most beneficial and feasible alternative. As studies progressed and more detailed results generated, performance measures or screening criteria were used to determine project fit. As noted in the GDOT study, these evaluation stages can be considered: 1) exploratory; 2) segment; and 3) system, as shown in Figure A.1.

Figure A.1 Example of Criteria Measured



[8] *Mid-City Freightway Study – Evaluation of Alternative Alignments and Tolls, Chicago Department of Transportation*, November 2006.

[9] *Truck-Only Lanes Needs Analysis and Engineering Assessment*, Georgia Department of Transportation, April 2008.

Source: *Truck-Only Lanes Needs Analysis and Engineering Assessment*, Georgia Department of Transportation, April 2008.

For each of these stages a variety of data are used to move alternatives to the next screening round or eliminate them from further consideration. Table A.4, below, illustrates the types of data that have been used for CMV-only feasibility planning studies to evaluate alternatives. Beginning with the "exploratory" stage, screening data is very broad and mostly qualitative, however as alternative alignments and configurations are refined, so too is the screening data.

Central to determining whether a project moves forward is the check between project benefits and project costs through a Benefit-Cost (B-C) Analysis. While this is something that must be considered, the true benefits and costs of CMV-only projects are hard to quantify, due to their limited operation, and oftentimes a qualitative B-C analysis results. This is especially true in the case of determining the benefit-costs of longer-combination vehicle use in CMV-only corridors.

Table A.4 Examples of Screening Criteria by Evaluation Stage

Evaluation Stage	Description	Examples of Data Used for Screening
Exploratory	The exploratory stage is a **broad scan of the statewide network** to identify specific segments that illustrate the most promise for CMV-Only Lanes investments based on: 1) existing and future operating conditions; and 2) Truck-Only Lanes utility.	**Primarily Qualitative Data** • Do the truck-only lanes serve key markets and routes? (yes/no) • Would truck-only lanes provide relief to major freight bottlenecks? (yes/no) • Would truck-only lanes investments complement planned and programmed improvements detailed in the state TIP, construction WP, and statewide LRTP? (yes/no) • > 30,000 trucks per day in 2035 (Quantitative)
Segment	Building on the work performed in the exploratory analysis, the candidate segments are subjected to more detailed evaluation criteria, specific access locations, and investment benefits and costs. **Each corridor is tested independently** relying upon individual utility to advance to the system-level analysis.	**Primarily Quantitative Data** • Crash Rates/Annual Savings • Corridor Demand (ADT and Truck ADT) • Average Travel Speed • Level-of-Service (V/C Ratio) • VMT and VHT • Daily Hours of Delay • Connect Freight Origins and Destinations (Qualitative) • Cost Effectiveness • Effect on Natural Environment (Qualitative) • Social and Cultural Effects (Qualitative) • Constructability

Table A.4 Examples of Screening Criteria by Evaluation Stage (continued)

Evaluation Stage	Description	Examples of Data Used for Screening
System	The **system analysis** selects higher performing segments and groups them into systems for additional analysis. Thus, groupings of project investments constitute a system that, in combination, illustrates higher performance collectively than the sum of the individual parts.	**Quantitative Data** • Average Daily Truck-Lane Usage • Average Daily General Purpose Lane Usage • Percent of Trucks Utilizing CMV-Only Facility • Vehicle Miles Traveled per Day (with and without Corridor Buffers) • Vehicle Hours Traveled per Day (with and without Corridor Buffers) • Average Daily Speeds (General Purpose and CMV-Only Lanes) • Employment and Change in Employment by Industry • Gross State Product • Real Personal Income • Market Accessibility • Capital and O&M Costs • Benefit Cost Analysis (25 years after completion of project)

Source: *Truck-Only Lanes Needs Analysis and Engineering Assessment*, Georgia Department of Transportation, April 2008.

Taking this data one step further and meshing it with study goals and objectives, Table A.5 provides a view of what data could be used for each of a variety of screening criteria. System analysis should take into consideration screening criteria within the general groupings of operational efficiency, safety, economic impacts, environmental impacts, and constructability. Additional examples of data that could be measured are found in Attachment C.

Table A.5 Linking Screening Criteria to Data

Screening Criteria	Examples of Data
Congestion and Mobility/Operational Efficiency	• Corridor Demand (ADT and Truck ADT) • Average Daily Truck-Lane Usage • Average Daily General Purpose Lane Usage • Average Daily Speeds (General Purpose and CMV-Only Lanes) • Daily Hours of Delay • Level-of-Service (V/C Ratio) • Percent of Trucks Utilizing CMV-Only Facility • Vehicle Miles Traveled per Day (with and without Corridor Buffers) • Vehicle Hours Traveled per Day (with and without Corridor Buffers) • Connect Freight Origins and Destinations
Safety	• Number of Crashes (Fatal, Injury, PDO) – cars and trucks • Crash Rates – cars and trucks • Crash Reductions • Annual Savings due to Crash Reductions • Security Features
Economic Impacts	• Cost Effectiveness • Capital Costs • O&M Costs • Thirty-year Benefit Cost Analysis • Employment and Change in Employment by Industry • Gross State Product • Real Personal Income • Market Accessibility
Environmental Impacts	• Air Quality • Noise Quality • Water Quality • Energy Consumption • Social and Cultural Effects • Change in Land Use
Constructability	• Right-of-Way • Typical Sections • Bridge Replacement • Utility Coordination

Source: *Truck-Only Lanes Needs Analysis and Engineering Assessment*, Georgia Department of Transportation, April 2008.

A.3.6 Institutional Considerations

Establish Project Committee Structure

Due to the high level of investment required to implement CMV-only lane projects, it is important for all parties that will be involved in the project at some point, whether it be planning, design, or operation are at the table in the very beginning. A project committee structure is advised for all CMV-only projects, enabling consensus decision-making.

In order for all voices to be heard through CMV-only lane project planning it is recommended that several levels of committees be implemented to interface with groups that cover issues, including policy, planning, technical, finance, and public involvement. Depending on the stage a CMV-only lane project is in, some of these groups may be combined or minimized. For example, during the exploratory stage of a project, policy and planning groups may be combined. Or, during the detailed design of a project, separate working groups may be developed to cover each of several technical issues, including design, operation, and constructability. As no two areas are alike, no two CMV-only lane projects will be alike and committee structure will vary. However the committees are structured, it is vital that there is a well-thought out process for how their input will be solicited and included in decisions being made.

- In the I-710 Major Corridor Study in Southern California, an Oversight Policy Committee (OPC) was developed comprised of elected officials from 14 participating cities and the County of Los Angeles; executive managers or senior staff from three principal partners (MTA, Caltrans, and SCAG); and a Commissioner from each of the Ports of Long Beach and Los Angeles. This OPC was advised by a set of committees made up of concerned citizens, stakeholder groups, and technical and engineering staff from participating municipalities and public agencies: a) the Tier 2 Community Advisory Committee; b) the Tier 1 Community Advisory Committees; and c) the Technical Advisory Committee.[10]

- In the Atlanta Truck Only Toll (TOT) Feasibility Study a study steering committee was developed consisting of representatives of transportation agencies as well as the trucking industry, and included: Atlanta Regional Commission (ARC); Federal Highway Administration (FHWA); Georgia Department of Transportation (GDOT); State Road and Tollway Authority (SRTA); Georgia Motor Trucking Association; American Transportation Research Institute; and Industry representatives like United Parcel Service, Lithonia Lighting, Drug Transport, Inc. According to the report, the steering committee met four times to review study progress, discuss policy implications, and provide input. The primary purpose of the steering committee was to incorporate freight industry input and provide for coordination with planning partners in the region.[11]

Need for Public Acceptance

While favorable public opinion is desired on all projects DOTs pursue, favorable public opinion is particularly vital on CMV-only lane projects because of the legislative changes that likely

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[10] *I-710 Major Corridor Study Final Report*, Los Angeles County MTA, March 2005.

[11] *Truck-Only Toll Facilities: Potential for Implementation in the Atlanta Region/Atlanta TOT Facilities Study*, State Road and Tollway Authority, July 2005.

need to be implemented. In some cases legislative changes need to be made by local or state jurisdictions to enable truck restrictions. In most cases legislative changes are required for project advancement in order to enable financing options that may be required to fund a project. It is critical that all local and state elected officials who will be required to support enabling legislation are educated on the prospects at the very beginning of project inception.

As public opinion is critically important, a multitiered public education and awareness program should be incorporated all phases of CMV-only lane project development and design. This process must include, at a minimum, state and local leaders, community interest groups, and the general public.

- In the I-70 Truck-Only Lane Corridor of the Future Phase II project application, a marketing strategy and public education campaign were proposed within the application, in advance of any feasibility studies being underway.[12]

- The I-710 project included community advisory committees (CAC) as part of organizational structure for sharing input throughout the study process. These CACs were formed for each of the cities that bordered the I-710 freeway, and were tasked with focused on key issues that affected their communities, including health, environment and quality of life issues, safety and mobility issues, as well as economic development and land use issues.[13]

- VDOT's public involvement for the I-81 Corridor Improvement Study began with coordination of local, state, and Federal agencies and the public was conducted during the formal scoping process and continued throughout the study. The scoping process began with a series of seven public scoping meetings and one agency scoping meeting, resulting in over 1,100 comments. Additional forums were held during the study and included three formal partnering meetings with Federal resource agencies, interviews with city/county planners and administrators, coordination with the Virginia Department of Rail and Public Transportation as well as Norfolk Southern, and other miscellaneous meetings. All project information was available for the general public to access via press releases, newsletters, and a project web site.[14]

Multistate Collaboration on Projects

As railroad and trucking companies have long known, states are beginning to acknowledge that the freight system traveling through their communities is not bound by jurisdictional lines. As such, more and more projects that focus on goods movement issues are crossing jurisdictional boundaries, and operating agencies are beginning to partner on solutions together.

The I-70 Truck-Only Lane Corridor of the Future project is a recent example of four states partnering together, while other earlier projects like the I-710 Major Corridor Study and I-81 Corridor Improvement Study have laid a foundation for cross-jurisdictional collaboration, the I-70 project will conduct the first true multistate CMV-only lane feasibility study.

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[12] *I-70 Corridor of the Future Phase II Application*, INDOT, 2007.

[13] *I-710 Major Corridor Study Final Report*, Los Angeles County MTA, March 2005.

[14] *I-81 Corridor Improvement Study*, Tier 1 Draft Environmental Impact Statement, VDOT, 2005.

There are several considerations the I-70 multistate cooperative will need to pioneer, including:

- Establishing memoranda of agreement/understanding;
- Developing cost sharing arrangements; and
- Presenting a unified message.

As the I-70 project develops, the states' approaches to these issues will be revealed. Currently, the states are developing Memorandums of Understanding with each other and the FHWA. This process has taken extensive time, and has yielded a rule of thumb for multistate project collaboration; ensure there is enough time and budget in the project to allow for unforeseen challenges, as much of the projects will cover new planning ground.

Industry Role in Planning CMV-Only Lanes

Commercial motor vehicle- or truck- only lanes, as their names imply, should require some active involvement during the planning process by those commercial motor vehicle users. And clearly the success and use of these facilities is predicated upon whether or not the industry supports the concept. However, to date, many CMV-only lane planning studies have limited involvement by the industry. According to Forkenbrock, adding CMV-only lanes to existing highways would be expensive enough that public agencies pursuing the projects are unlikely to find sufficient resources to fund them using traditional sources.[15] Thus, oftentimes CMV-only facilities are discussed in unison with the tolling concept, and many times tolling is presented as being applied to the motor vehicle carriers; those using the new facility. Because of this obvious implication, the commercial motor vehicle interests should have a seat at the table during the project planning stage.

Studies have been conducted on the willingness of truckers to pay tolls, and key to each CMV-only lane project moving forward is that it must have industry support. The American Transportation Research Institute has begun to be a partner in the early stages of several studies, including the I-70 Truck-Only Lane Corridor of the Future project application. They have developed a position of being supportive of "a fair and open analysis of funding options that is not predicated on a limited number of preselected options such as tolling."[16] In order for a project to move forward with success it is vital that the trucking industry provide a clear picture of industry operations; how a truck-only lane would be used, how a truck-only tolled facility would be used, and what the implications are to the surrounding street network if the toll were mandatory versus voluntary.

While each new CMV-only lane has unique considerations for the corridor or region within it is being pursued, general principles have been agreed upon by the trucking industry as, again, documented within the I-70 Truck-Only Lane Corridor of the Future project application. At the time it was developed, the FAST (Freeing Alternatives for Speedy Transportation) program, offered as an amendment to the SAFETEA-LU legislation, met all of the American Trucking Associations' transportation policies, including:

[15] *Issues in the Financing of Truck-Only Lanes*, Forkenbrock, David J.; March, Jim, Public Roads, September 2005.

[16] I-70 Corridor of the Future Phase II Application, INDOT, 2007.

- "To allow new, tolled express traffic lanes on the Interstate system. The Federal restrictions on existing capacity/lanes would continue since a) these provide trucks and cars with the alternative options, and b) there is some rational argument that at least the infrastructure capital of existing lanes already has been paid for with fuel taxes;
- Use of FAST lanes would be voluntary – FAST lanes would represent new capacity;
- Toll collection must be electronic and offer freeway-speed processing;
- Toll revenue collected must be expended on the new capacity; and
- Tolls would be eliminated once the new FAST lane infrastructure capital was paid for."[17]

While these points should be used as initial guidelines when considering development of CMV-only lanes, these are not substitution for actual industry involvement. At the very early stages of CMV-only lane project development, the trucking industry, either through ATRI, the ATA or local trucking authority, should be included in the discussions.

A.3.7 Summary of Findings

In summary, in order to achieve CMV-only lane project success during the planning process, following are recommended guidelines:

- CMV-only lane studies should be appropriately linked to existing regional goals, objectives, and the over-all long-range planning processes;
- CMV-only lanes should be one of several alternatives evaluated during feasibility study;
- System analysis should take into consideration screening criteria within the general groupings of operational efficiency, safety, economic impacts, environmental impacts, and constructability;
- A formal structure of committees and decision-making authority must be established for the project, to include decision-makers, technicians, and planners;
- A comprehensive public involvement mechanism must be part of the process, and public should have easy access to information generated by the project; and
- Trucking industry input must be included in project decisions.

[17] I-70 Corridor of the Future Phase II Application, INDOT, 2007.

A.4 Task 3 – Configurations and Design Issues and Related Institutional Questions

A.4.1 Introduction

The Task 2 chapter of this report (Section A.3) provided a discussion of key planning issues associated with developing CMV-only lanes at the regional, state, and multistate level. The objective of this chapter is to provide a synopsis of the configuration and design issues pertaining to CMV-only lanes. This discussion is based on a review of literature on planning and feasibility studies conducted for truck facilities across the United States, guidebooks on highway facility design, as well as review of information, as available, on the configurations of existing facilities with at least some element of truck-auto separation, such as the New Jersey Turnpike. An understanding of these issues is critical to future efforts for the planning, development and implementation of CMV-only lanes. This chapter also delves into some of the key institutional issues impacting CMV-only lane facility planning and development. These include, but are not limited to, issues related to the role of the private sector (shippers, carriers, etc.) in planning CMV-only lane projects, trucking industry equity issues in the use of tolled truck facilities, and restrictions of specific truck classes from the use of CMV-only lanes. The information presented in this chapter is organized as follows: Chapter 4.2 presents a brief overview of the major types of truck facilities; Chapter 4.3 provides a discussion on the key configuration and design issues associated with various types of CMV-only lane treatments (subparts in this chapter present discussions of method of separation, right-of-way issues, access limitations/lane restrictions, pavement and geometric design issues, and costs); and Chapter 4.4 discusses some key institutional issues related to the planning and development of CMV-only lanes.

A.4.2 Types of Truck Facilities

Task 2 provided a description of the various types of truck facilities serving different needs for truck-auto separation and exclusive treatments of truck traffic. This chapter revisits the definitions for some of the key types of truck facilities to provide the platform for subsequent discussions of design and configuration issues associated with these facility types.

Mainline Truck Treatments

- **Exclusive Truck Lanes –** Exclusive truck lanes (ETLs) are lanes dedicated to truck traffic for the purpose of separating trucks from passenger vehicles along a designated segment of the highway network. Truck traffic flows on ETLs are separated from flows on general purpose highway lanes either through the construction of barriers (in the case of at-grade sections) or through the development of elevated or underground truck-only lane facilities. Depending on the availability of right-of-way (ROW), ETLs can be potentially implemented in the median of existing highways or adjacent to them. ETLs typically have dedicated access/egress ramps solely for truck traffic to enter/exit the facilities.

- **Nonexclusive Truck Lanes –** Nonexclusive truck lanes are mainline lanes dedicated to truck traffic, and are adjacent to general purpose travel lanes. These lanes are called nonexclusive because they do not have a barrier separation with the general purpose lanes (unlike exclusive truck lanes), and are often separated by rumble strips or indicated with

signage. Though these lanes are restricted to truck traffic, autos have to weave through these lanes to access the general purpose lanes. The primary advantage of nonexclusive truck lanes is that they obviate the need to construct additional access/egress as well as interchange ramps for trucks, since trucks can use the existing interchanges. A primary issue with these lane configurations is the problem associated with weaving conflicts between trucks and autos.

- **Dual-Dual Roadways (Auto-Only and Preferential Truck Lanes) –** The dual-dual roadway concept has been implemented along the New Jersey Turnpike, which consists of inner auto-only lanes, and outer lanes that carry mixed-flow (autos and trucks) traffic which are preferential truck lanes (preferred for truck traffic). Though the concept is not exactly the same as a truck-only lane, it comes close to achieving the objective of separating trucks from autos on the highway to realize safety and operational benefits.

Truck Interchange Bypasses

Truck interchange bypasses are facilities for trucks to bypass highway interchanges for the purpose of removing trucks from interchange merge areas where their presence could be potentially detrimental to interchange operations as well as exacerbating interchange safety issues. As discussed in Douglas,[18] interchange bypasses are typically suitable under three situations, which include 1) merging freeways, 2) freeway-to-freeway ramps, and 3) freeway-to-arterial ramps.

Truck Climbing Lanes

Truck climbing lanes are exclusive lanes dedicated to truck traffic at certain sections of the highway network for the purpose of separating slow-moving trucks from the highway mainlines to prevent their impacts on optimal traffic speeds. These lanes are typically implemented on sustained highway upgrade sections where slower speeds of trucks on mainlines can impede the normal speeds of faster moving passenger vehicles. Truck climbing lanes not only improve highway operations by ensuring optimal traffic speeds on upgrades, but also have safety benefits by eliminating lane changes by fast-moving vehicles that must pass slow-moving trucks.

Truck Ramps

Truck ramps are ramps dedicated to serving trucks entering and exiting highway mainlines for the purpose of improving the efficiency of truck access and egress in areas with high concentration of truck traffic. Depending on the type of facility and the purpose served, truck ramps can take various forms, which include 1) ramps that provide truck access/egress for mainline highway lanes, 2) ramps that provide truck access/egress for truck-only lanes, 3) ramps that provide bypass for trucks on general purpose on-ramps with ramp meters, and 4) exclusive truck lanes on general purpose ramps.

This chapter specifically focuses on the configuration and design issues associated with mainline CMV-only lane treatments, including exclusive and nonexclusive CMV-only lanes,

[18] James G. Douglas, *Handbook for Planning Truck Facilities on Urban Highways*, August 2004.

and dual-dual roadways (based on information available for the New Jersey Turnpike). Very limited information could be retrieved on nonexclusive CMV-only lanes, since most of the CMV-only lane planning and feasibility studies in the United States have primarily focused on exclusive lanes. A brief discussion on the configuration and design features of the dual-dual roadway sections of the New Jersey Turnpike provides insights into some of the key issues that might find potential future applications for CMV-only lane projects.

4.3 Truck Facility Configuration and Design Issues

Method of Separation

Since the primary objective of implementing CMV-only lanes is the separation of trucks from autos to realize highway safety and operational benefits, the method of separation is a key component of the configuration of CMV-only lanes. The method of separation considered for CMV-only lanes directly depends on the type of facility. Exclusive CMV-only lanes (ECLs) which are at-grade with the existing highway network are typically separated from the general purpose lanes by the use of Jersey Barriers, as used on the New Jersey Turnpike. These lanes can also be separated from general purpose lanes through the construction of elevated or underground facilities. These separation methods offer complete elimination of truck-auto conflicts on the highway network. Jersey Barriers have been implemented along the dual-dual roadway sections on the New Jersey Turnpike, achieving a similar objective of separating the inner auto-only lanes with the outer preferential truck lanes. Other kinds of CMV-only lane treatments such as nonexclusive lanes cannot employ physical structural barriers for the separation of trucks and autos, due to the need for autos entering/exiting the highways to weave through the CMV-only lanes. Consequently, these facilities typically use rumble strips between the general purpose and the CMV-only lanes in order for drivers to differentiate between the two lane types. Clearly, unlike Jersey Barriers or grade separations, this type of separation does not completely eliminate truck-auto conflicts.

The following subparts delve deeper into the configurations associated with the methods of separation identified above. These subparts also include information on other cross-sectional features associated with CMV-only lane facilities, such as lane and shoulder widths.

Jersey Barriers for ECLs

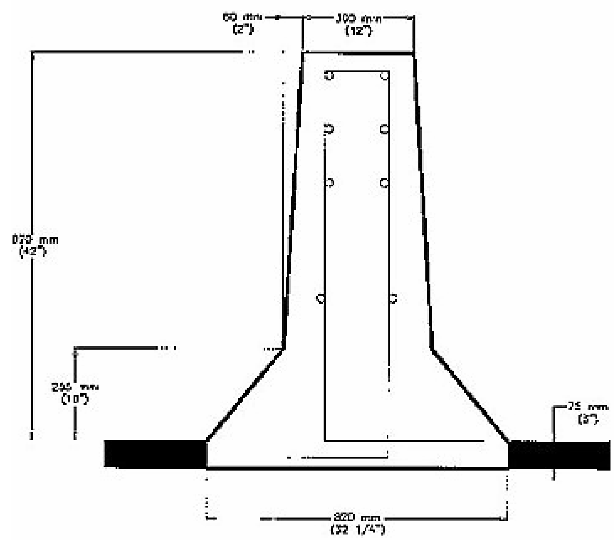
As discussed above, Jersey Barriers are provided in the case of ECLs and dual-dual roadways (such as sections of the New Jersey Turnpike) to ensure complete separation of truck and auto traffic flows. In the case of exclusive lanes constructed at-grade with the general purpose lanes, Jersey Barriers can serve the purpose of not only separating trucks from autos, but also of separating truck traffic moving in opposite directions. For example, in the case of ECLs implemented on median right-of-way (ROW) along existing highways, Jersey Barriers are implemented to separate opposing lanes of truck traffic, as well as to separate trucks from adjacent general purpose lanes. Jersey Barriers are also a necessary feature in the case of elevated and underground truck lanes, again for the purpose of separating opposing truck movements. However, they do not find applications in underground truck lanes that have opposing lanes of truck traffic in separate tunnels.

The general configuration of Jersey Barriers in terms of the cross-sectional design features is governed by the need to develop a configuration that minimizes the possibility of collisions between opposing traffic movements, as well as minimizing the impacts on vehicles hitting the

barrier. Cross-sectional dimensions of the barriers in terms of the height and width of sections are also governed by the types of facility. For example, in the case of CMV-only lanes, the cross-sectional dimensions of the barriers should effectively ensure that the barriers serve their purpose in the events of truck traffic impacts.

A detailed discussion of the configuration features of Jersey Barriers is provided in McDevitt.[19] The configurations of these barriers offer significant safety benefits by minimizing vehicle impacts and overturns. Figure A.2 shows the standard configuration of the Jersey Barrier implemented by the New Jersey Turnpike Authority.

Figure A.2 New Jersey Turnpike Authority's Heavy-Vehicle Median Barrier



Source: Charles F. McDevitt, *Basics of Concrete Barriers*, Public Roads, March 2000.

The New Jersey Turnpike Authority has crash-tested the 42-inch-high Jersey Barrier with the cross-section features presented above, and found that the barrier can safely contain and redirect tractor-trailers to an upright position. The 42-inch height for Jersey Barriers is considered to be the minimum requirement, particularly to function effectively under truck impacts. The 12-inch thickness at the top is also considered as a minimum requirement. However, some states have implemented barriers that are only 6 to 8 inches thick at the top, but it is expected that these configurations do not function effectively under truck impacts due to the possibility of break-off of V-shaped piece of concrete at the top construction joints.

Rumble Strips for Non-ECLs

Rumble strips are a common feature on highways as a safety measure to alert drivers from potentially dangerous situations, by causing tactile vibrations and audible rumbling, transmitted through the wheels to the vehicle body. For example, they are applied at the edge of lanes and shoulders to alert drivers when they drift from the mainline highway lanes onto

[19] Charles F. McDevitt, *Basics of Concrete Barriers*, Public Roads, March 2000.

shoulders. In the case of non-ECLs, rumble strips can be applied as a way of separating general purpose and CMV-only lanes. Unlike ECLs, nonexclusive lanes are implemented adjacent to general purpose lanes. There are many factors that can favor the application of non-ECLs in lieu of exclusive facilities for trucks, such as right-of-way availability, costs, interchange and ramp requirements, and amount of truck traffic demand.

Rumble strips between general purpose and truck lanes in nonexclusive truck facilities alert auto and truck drivers in the event of drifting of vehicles from general purpose to truck lanes or vice versa, thereby impeding potential conflicts between cars and trucks. Rumble strips also serve the purpose of acting as markers to assist drivers in differentiating between general purpose and CMV-only lanes on the highway. Since the functional characteristics of rumble strips for non-ECLs would be same as those applied for shoulders in mixed-flow facilities, the configuration of rumble strips for truck-auto lane separation applications are expected to follow the same standards developed by the FHWA for mixed-flow facilities. Also, based on the literature review in Task 1, no new studies have been found to have analyzed rumble strip configurations specific to non-ECLs.

CMV-Only Lane Cross-Sectional Configurations

This chapter presents the cross-sectional configurations that have been analyzed (and proposed in some cases) for CMV-only lanes in various truck facility planning and feasibility studies conducted in the United States. Notable among these studies include the I-710 major corridor study in Southern California, a study on the potential for exclusive facilities for trucks in Florida, a Texas Transportation Institute (TTI) study on strategies for separating trucks and passenger vehicles, a Reason Foundation study on the analysis of corridors for toll truckways in the United States, a preliminary feasibility study for the Miami Toll Truckway, and a study on truck-only lanes in Atlanta as a strategy to relieve congestion and increase mobility.

The configurations presented in this chapter focus on at-grade, elevated, and underground exclusive truck lanes. The chapter also discusses the key configuration issues associated with the dual-dual roadway section of the New Jersey Turnpike, to understand the cross-sectional features of auto-only and preferential truck lanes. Based on the literature review conducted in Task 1, very limited, if any, information appears to be available on cross-sectional features of non-ECLs.

The typical cross-sectional features of highway facilities with ECLs include the following:

- **ECLs –** These lanes exclusively serve truck traffic. Depending on ROW availability and magnitude of truck traffic, these may include passing lanes to allow for truck passing maneuvers. Passing lanes also provide access to safety vehicles and prevent blockage of mainline lanes in the event of truck crashes. Passing lanes may not be required if shoulder widths are adequate to make them viable for use as breakdown lanes in the event of crashes. A subsequent subpart on cross-sectional design issues discusses some of the key design parameters for ECLs such as number of lanes, and minimum lane and shoulder widths. The configurations for ECLs will also be different depending on where they are implemented on the highway (for example, CMV-only lanes can either be implemented on existing highway median ROW if sufficient median width is available, or adjacent to the highway mainlines).

- **General Purpose Lanes –** These lanes are typically used by autos, since they are not allowed on the ECLs. Depending on lane restrictions, these lanes could either be allowed to serve truck traffic, or be exclusively for autos.

- **Jersey Barriers (for Truck-Truck and/or Truck-Auto Lane Separation) –** Functional characteristics and configurations of these structures have been discussed in the previous section.

- **Outer and Inner Shoulders –** These act as buffer zones along the highway to handle emergency breakdowns of vehicles.

Texas Transportation Institute (TTI) CMV-Only Lane Configurations

A study conducted by Middleton et al.[20] from TTI on strategies for separating trucks from passenger vehicles presents various types of CMV-only lane facility configurations under different ROW scenarios. These configurations focus specifically on at-grade and elevated ECLs. Figure A.3 shows the various possible types of CMV-only lane configurations, and provides insights into standard CMV-only and general purpose lane widths, outer and inner shoulder widths, the locations of Jersey Barriers, and the possible placement of CMV-only lanes relative to general purpose lanes. Some standard observations on CMV-only lane facility configurations from Figure A.3 are presented below:

- Standard width of CMV-only and general purpose lanes = 12 feet (the recommended width of the general purpose lanes on highways with ECLs is 12 feet and not lower, even though these lanes are exclusively used by autos);

- Standard width of Jersey Barriers = 2 feet (standard widths of barriers for general purpose lanes could be a little lower than 2 feet if they provide separation only for autos);

- Standard width of inner and outer shoulders = 10 feet;

- Minimum width of outer shoulders = 10 feet;

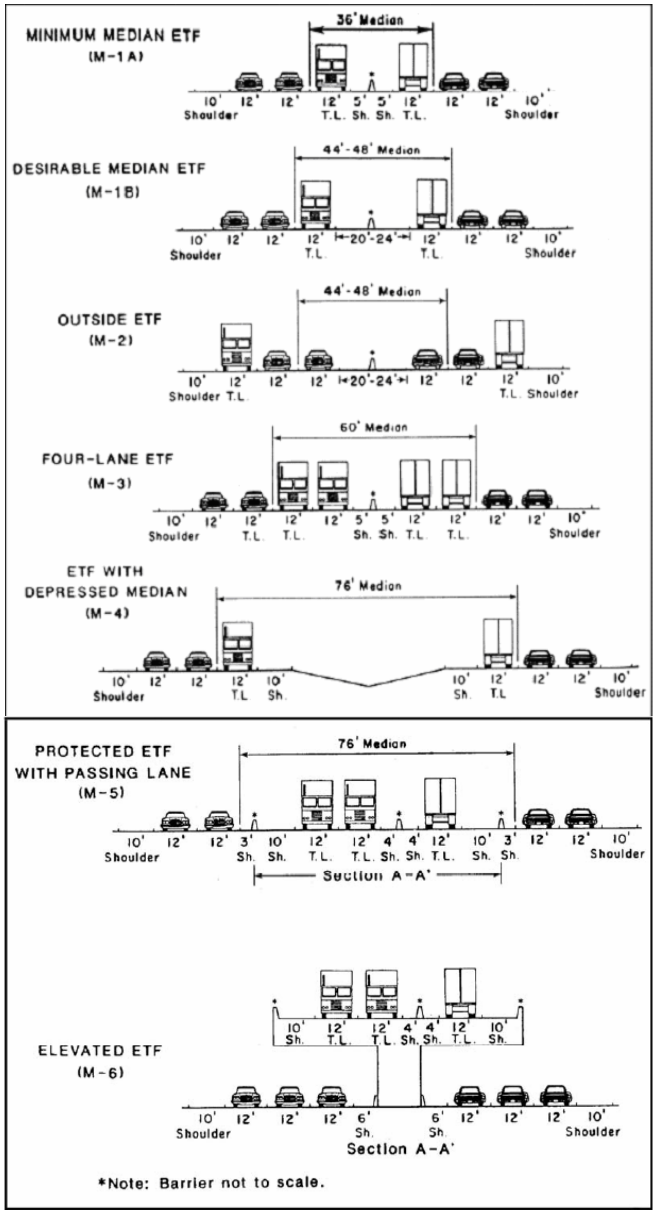
- Minimum width of inner shoulders on CMV-only lanes = 4 feet (minimum width of inner shoulders on general purpose lanes = 3 feet);

- Minimum median width for at-grade two- and four-lane ECLs on existing highway median ROW = 36 and 60 feet, respectively; and

- Desirable median width for at-grade two-lane ECLs on existing highway median ROW = 46 to 50 feet.

[20]Dan Middleton, Steve Venglar, Cesar Quiroga, Dominique Lord, and Debbie Jasek, *Strategies for Separating Trucks from Passenger Vehicles: Final Report,* September 2006.

Figure A.3 TTI ECL Configurations



Source: Dan Middleton, Steve Venglar, Cesar Quiroga, Dominique Lord, and Debbie Jasek, *Strategies for Separating Trucks from Passenger Vehicles: Final Report,* Research Report 0-4663-2, September 2006.

Table A.6 discusses the advantages and disadvantages associated with the various CMV-only lane configurations presented in Figure A.3.

Table A.6 Advantages and Disadvantages of Various ETL Configurations

Typical Truck Lane Configurations

ETF type	Median width	Total # truck lanes	ETF location	Inside shoulder width	Advantages	Disadvantages
Minimum median	36 ft.	2	inside	5 ft.	Applicable in narrow medians Specific pavement structure for trucks Longer life for existing lanes Most economical	Limited control of exit/entrance maneuvers No provision for truck-only passing lanes Long weaving distances near interchanges Lack of shoulder room for disabled trucks
Desirable median	44-48 ft.	2	inside	10-12 ft.	Same as above	Limited control of exit/entrance maneuvers No provision for truck-only passing lanes Long weaving distances near interchanges
Outside lane	44-48 ft.	2	outside	10-12 ft.	Applicable in narrow medians Specific pavement structure for trucks Longer life for existing lanes Minimized weaving, Slower vehicles on right Smaller median barrier (for cars) required	Existing pavement may be insufficient for total truck loads Lack of capacity near interchanges Provides small incremental improvement
Four-lane	60 ft.	4	inside	5 ft.	Pavement designed exclusively for trucks Passing lane	Limited control of exit/entrance maneuvers Long weaving distances near interchanges Lack of shoulder room for disabled trucks
Depressed median	76 ft.	2	inside	10 ft.	Lower cost: no barrier required because of wide median Exclusive pavement for trucks	Limited control of exit/entrance maneuvers Long weaving distances near interchanges Lack of shoulder room for disabled trucks
Protected w/ variable passing lane	76 ft.	3	inside	4 ft.	Total control of exit/entrance maneuvers Exclusive pavement design for trucks Compatible with separate truck interchanges and elevated facility	Greater required median width Less clearance for wide loads
Elevated w/ variable passing lane	n/a	3	center	4 ft.	Minimal median width required Passing maneuvers provided Control of access by large vehicles Potential for transit use Compatible with protected lane option	High cost Difficulty in future expansion Icing potential in winter Less clearance for wide loads Potential noise problems

Source: *Operational and Geometric Evaluation of Exclusive Truck Lanes*, Research Report 331-3F, pp. 18-23, TTI, May 1986.

The information provided in Table A.6 is useful in gaining insight into some of the key issues to which attention should be paid while designing ECL configurations, which are summarized below:

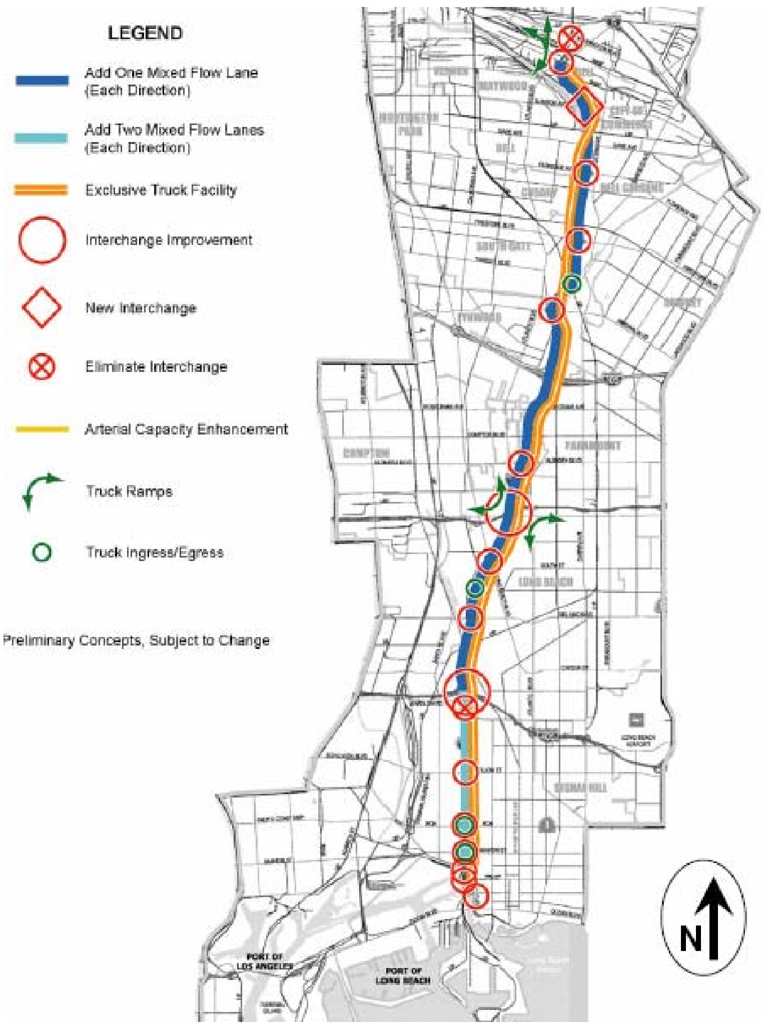
- Configuration issues to address the need for truck passing;
- Shoulder widths to accommodate disabled trucks;
- The impacts of configuration elements on total cost of the facility (for example, elevated ETL configurations have higher costs compared to at-grade ETLs);
- Accounting for the need for future expansion in existing configuration designs; and
- Accounting for the efficiency and ease of exit/entrance maneuvers for trucks in the ECL configurations.

I-710 Major Corridor Study (MCS) Proposed CMV-Only Lane Configurations

The I-710 Major Corridor Study (MCS) was initiated in January 2001 to analyze traffic mobility, congestion, and safety issues along the I-710 corridor in Southern California, and develop solutions to address these problems. The study was completed in March 2005. A key outcome from the study was the development of a Locally Preferred Strategy (LPS) to address

congestion, mobility, and safety problems along the corridor, which included the implementation of exclusive truck lanes. Owing to the heavy truck traffic demand along the corridor, attributed both to high volumes of port container traffic through the San Pedro Bay ports as well as significant domestic and transload cargo flows, four-lane ECL facilities (2 lanes in each direction) were recommended along the corridor in the LPS, running from Ocean Boulevard in Long Beach to the intermodal yards in Vernon/Commerce close to downtown Los Angeles. Figure A.4 presents the longitudinal routing plan for the proposed ECL facilities in the LPS.

Figure A.4 Longitudinal Configuration of Proposed ETLs in the I-710 Major Corridor Study

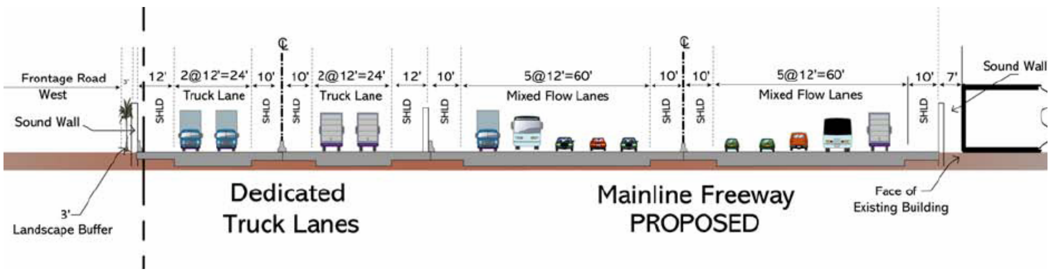


Source: *I-710 Major Corridor Study Final Report*, March 2005.

Most of the sections of the proposed truck facilities in the LPS are at-grade while some sections are elevated (near the SR 91 interchange, north of I-105 near Imperial Highway, and north of Slauson Avenue) and below-grade (a section at the south end of the corridor) owing to ROW

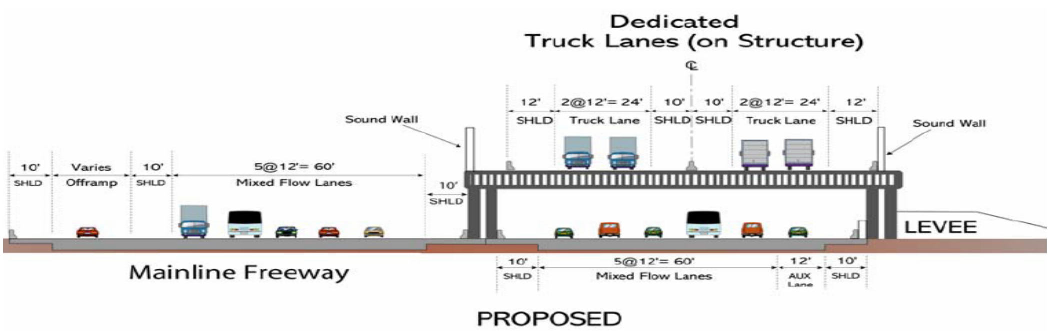
constraints. Figures A.5, A.6, and A.7 present the proposed cross-sectional configurations of the at-grade and elevated sections of in the LPS.

Figure A.5 I-710 Corridor Cross-Sectional Configurations
At-Grade ETLs



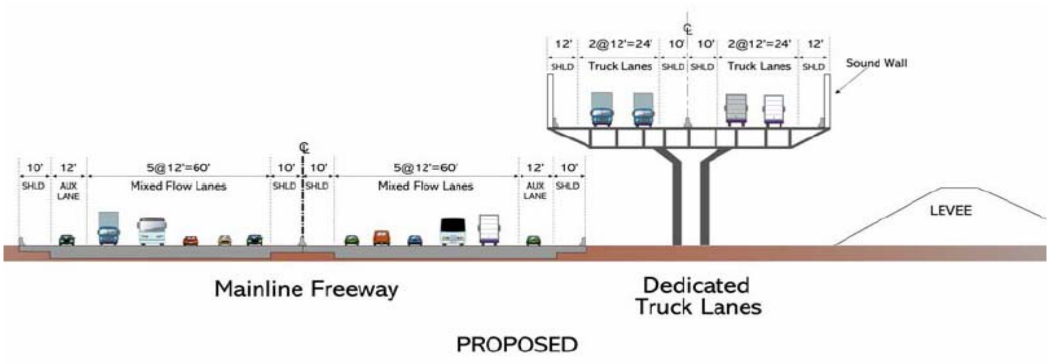
Source: *I-710 Major Corridor Study, Final Report*, March 2005.

Figure A.6 I-710 Corridor Cross-Sectional Configurations
Elevated ECLs (Configuration 1)



Source: *I-710 Major Corridor Study, Final Report*, March 2005.

Figure A.7 I-710 Corridor Cross-Sectional Configurations
Elevated ECLs (Configuration 2)



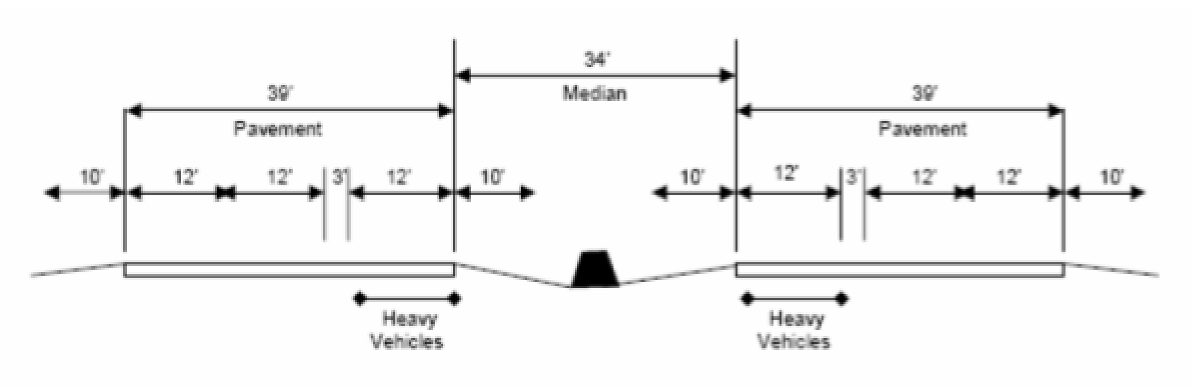
Source: *I-710 Major Corridor Study, Final Report*, March 2005.

The primary differences between the ECL configurations proposed in the I-710 MCS and the TTI configurations presented in Figure A.3 are the outer shoulder widths and the requirement for at least two lanes in each direction in the California design standards. The I-710 study proposed outer shoulder widths of 12 feet for ECLs, which are 2 feet wider compared to those in the TTI configurations. The at-grade ECL configuration in the I-710 MCS also ensured complete separation between CMV-only and general purpose lanes by the use of Jersey Barriers, as well as implementation of Sound Walls to mitigate traffic noise impacts. The presence of major existing structures adjacent to the corridor had an impact on the configuration of the elevated ECL sections, as well as the proposed interchange spacing.

Florida I-75 Corridor Proposed CMV-Only Lane Configurations

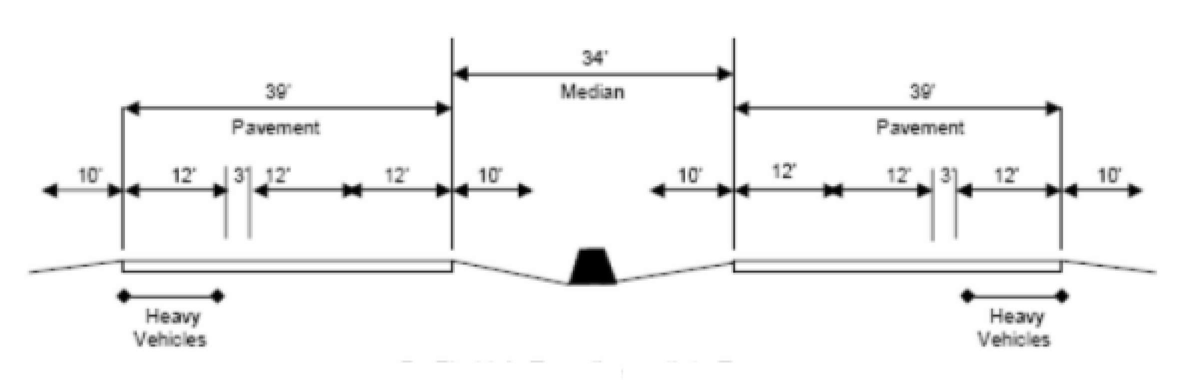
As early as 1979, the Florida and Georgia Departments of Transportation (FDOT and GDOT) engaged in joint planning efforts to develop a two-lane heavy truck facility along the I-75 corridor between Tampa and Atlanta. This effort resulted in the development of proposed configurations for CMV-only lanes along two separate sections of the corridor. Figures A.8 and A.9 present these proposed configurations for the Florida section of the corridor.

Figure A.8 Proposed I-75 ECL Configuration
Wildwood North to Georgia Border



Source: Stephen Reich, Janet Davis, Martin Catala, Anthony Ferraro, and Sisinnio Concas, *The Potential for Reserved Truck Lanes and Truckways in Florida*, Center for Urban Transportation Research, Research Report 21-17-422-LO, May 2002.

Figure A.9 Proposed I-75 ECL Configuration
Wildwood South to Tampa



Source: Stephen Reich, Janet Davis, Martin Catala, Anthony Ferraro, and Sisinnio Concas, *The Potential for Reserved Truck Lanes and Truckways in Florida*, Center for Urban Transportation Research, Research Report 21-17-422-LO, May 2002.

Reason Foundation Analysis of Toll Truckway Configurations

The Reason Foundation has conducted some important planning and policy studies related to ECL facilities, particularly focusing on tolled truckways with Longer Commercial Vehicle (LCV) operations. One of the studies conducted by Poole et al.[21] evaluates potential corridors

[21] Robert W. Poole, Jr. and Peter Samuel, *Corridors for Toll Truckways: Suggested Locations for Pilot Projects*, Reason Foundation, Policy Study 316, February 2004.

across the United States to assess the feasibility of implementation of tolled truckways along these corridors. The standard configuration of tolled truckways in the study assumes that the tolled truckway is built on the median ROW of existing Interstate highways, with the following cross-sectional characteristics:

- One CMV-only lane in each direction; Truck passing lanes at intervals of every few miles, and on hills to allow for truck passing maneuvers;
- Four-foot Jersey barrier in the center;
- Ten-foot outer breakdown shoulders in each direction; and
- Jersey barriers on each side separating the CMV-only lanes with the general purpose lanes.

The Reason Foundation study on tolled truckways recognizes the benefits of four-lane tolled truckways (two lanes in each direction) compared to two-lane truckways, particularly associated with increased capacity as well as truck passing capabilities. However, the preliminary analysis conducted in this study for the identification of pilot-project truckways assumes two-lane facilities as they have lower median ROW requirements (around 48 feet) compared to the median ROW requirements for four-lane truckways (between 72 and 92 feet). Other assumptions in the study on tolled truckways pertinent to this discussion include the following:

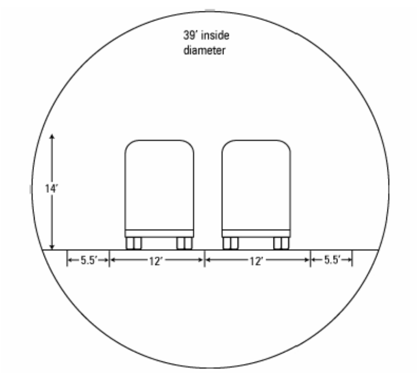
- The tolled truckways would have dedicated truck entrance and exit ramps to avoid mixing of heavy truck traffic with autos and light duty trucks in the general purpose lanes, which can lead to safety and operational problems; and
- For tolled truckways supporting LCV operations, the truckways would have adjacent Staging Yards, which would enable staging operations for LCVs adjacent to the truckways to avoid LCV movements on arterials and local streets.

Underground CMV-Only Lane Configurations

Among the literature on CMV-only lanes reviewed in Task 1, the only study that provided information on underground CMV-only lanes was a planning study conducted by the Reason Foundation[22] for CMV-only lanes in Atlanta as a potential strategy to alleviate congestion and improve traffic mobility in the Atlanta metropolitan area. The study proposed the development of a comprehensive tolled truckway in the region consisting of around 369 lane-miles of surface and elevated CMV-only lanes and around 57 lane-miles of underground CMV-only lanes (tunnels). The proposed truckway tunnels would consist of twin tubes, each 39 feet in diameter and providing for two full-size, one-way lanes and sufficient breakdown shoulder space for disabled trucks to pull over without disrupting tunnel truck traffic. Figure A.10 depicts the cross-sectional features of underground CMV-only lanes proposed in Atlanta.

[22] Robert W. Poole, Jr., *Reducing Congestion in Atlanta: A Bold New Approach to Increasing Mobility,* Reason Foundation and Georgia Public Policy Foundation, Policy Study 351, November 2006.

Figure A.10 Underground CMV-Only Lane Configuration
Atlanta Region (Proposed)



Source: Robert W. Poole, Jr., *Reducing Congestion in Atlanta: A Bold New Approach to Increasing Mobility,* The Reason Foundation and Georgia Public Policy Foundation, Policy Study 351, November 2006.

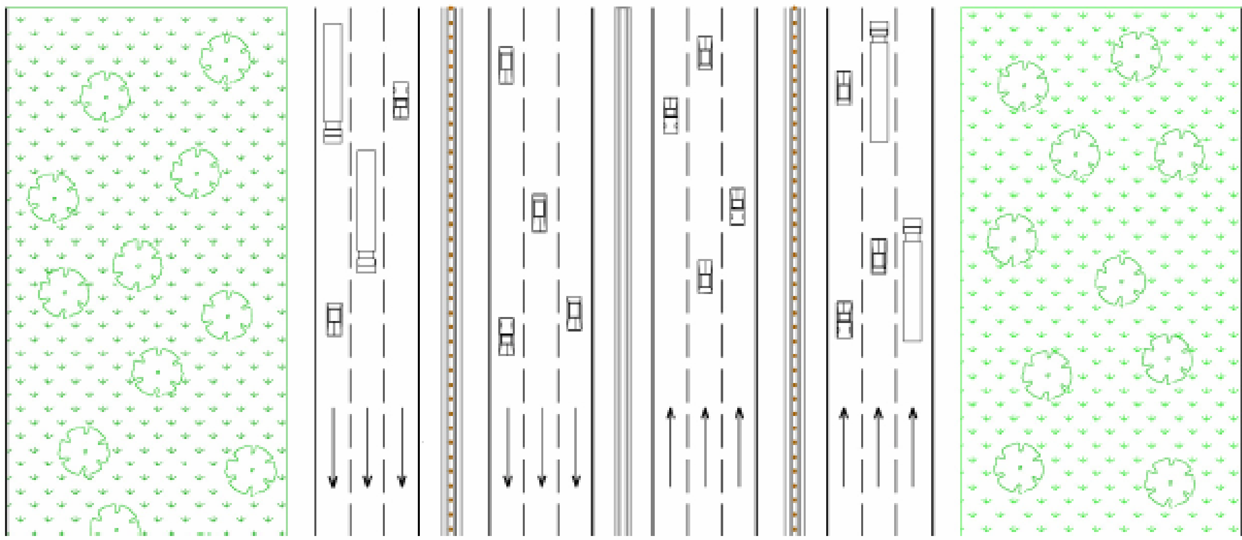
Dual-Dual Roadway Configurations (New Jersey Turnpike)

Based on the literature review conducted in Task 1, the New Jersey Turnpike was identified as the only real world application of a preferential treatment concept for trucks and autos. This concept consists of inner auto-only lanes and outer preferential truck lanes. The auto-only lanes are reserved exclusively for autos (trucks are prohibited from using these lanes); while the preferential truck lanes are open to auto traffic as well. Thus, the preferential truck lanes are, in fact, mixed-flow lanes, in which trucks account for a significantly large share of the total traffic (since majority of the auto traffic moves on the auto-only lanes). The section of the roadway that applies this concept is referred to as the dual-dual roadway. The auto-only and preferential truck lanes are physically separated from each other, and each is provided with its own access ramps to/from interchanges. Figure A.11 shows the cross-section detail (in plan view) of a typical section of the dual-dual roadway.

The cross-sectional features of the dual-dual roadway section of the New Jersey Turnpike are summarized below:

- Twelve-foot lane widths throughout for the outer and inner lanes.
- Twelve-foot outer shoulder widths for newer sections of the turnpike (10-foot widths for older sections).
- Forty-two-inch-tall Jersey Barriers for separation of auto-only and preferential truck lanes. These barriers are not only taller than the standard 32-inch barriers but also designed to be stronger to withstand CMV impacts. The barriers are 12 inches thick at the top instead of the standard 6 inches, more heavily reinforced, and anchored securely at the bottom.

Figure A.11 Typical Cross-Section of Dual-Dual Roadway



Source: Dan Middleton, *TTI Truck Accommodation Design Guidance: Policy-Maker Workshop*, TTI Research Report 4364-3, October 2003.

Truck Ramps

Douglas[23] provides a good discussion on truck ramp configuration issues, according to which, the location and separation of access/egress ramps for CMV-only lane facilities are typically governed by the following factors:

- The type and length of truck trips to be served by the CMV-only lanes.

- The location of major truck trip generators to be served by the CMV-only lanes.

- The spacing for truck ramps would be determined by the need to maintain efficient operations on the CMV-only lanes. For example, too short a spacing can potentially impede efficient truck operations at optimal speeds due to increased merging activity. The study recommends that the spacing between ramp interchanges should be at least two miles, if possible, to minimize friction caused by merging, and as a rule of thumb, access ramps for CMV-only lanes should be no more frequent than the general purpose ramps on the mainline.

- Truck access/egress ramps for exclusive CMV-only lane facilities should be spatially separated from general purpose ramps. The location of these ramps will be determined by land use patterns generating truck traffic and not by existing major auto ingress/egress locations.

[23] James G. Douglas, *Handbook for Planning Truck Facilities on Urban Highways*, August 2004.

Right-of-Way (ROW) Requirements

This section presents a discussion of ROW requirements for ECL facilities based on the cross-section characteristics described in the previous section. ROW requirements for CMV-only lanes depend on many factors, which include the following:

- Type of facility – At-grade, elevated, or underground CMV-only lanes.
- Location of CMV-only lanes relative to general purpose lanes – Whether the CMV-only lanes are located in the median ROW of existing highways, or adjacent to the general purpose lanes of existing highways.
- Number of CMV-only lanes.
- Width of CMV-only lanes.
- Width of inner and outer shoulders.
- Width of Jersey Barriers (and side barriers/guard rails if any).

At-grade CMV-only lane facilities have the maximum ROW requirement, and are typically implemented where there is ample ROW availability, either along the median of or adjacent to existing highways. In cases with ROW constraints, either elevated or underground CMV-only lane configurations are adopted. Elevated CMV-only lane facilities are increasingly proposing innovative elevated structural design concepts such as box girders with slender columns, to minimize their ROW requirements. Underground CMV-only lanes are not subject to ROW issues, but their implementation is typically dependent on the total cost of construction, since per lane-mile construction costs of underground facilities are the highest, compared to elevated and at-grade facilities. Elevated and underground CMV-only lanes are typically considered in metropolitan areas subject to significant land use constraints. If the ROW constraints along a highway mainline segment vary at different locations, it is possible that at-grade CMV-only lanes are implemented along certain mainline segments, while elevated or underground lanes are implemented at other locations. An example of this was observed in the I-710 MCS, where both at-grade and elevated CMV-only lanes were proposed along different mainline segments of the corridor. Table A.7 on the following page presents a summary of the ROW requirements for various CMV-only lane configurations based on the information available from the Task 1 literature review and the cross-sectional details discussed in the previous section.

CMV-Only Lane Design Issues

This section presents issues related to the key design elements associated with CMV-only lanes. The two main areas of focus in this section pertinent to CMV-only lane design issues include the following:

- Pavement design; and
- Geometric design

Table A.7 Right-of-Way (ROW) Requirements for Various CMV-Only Lane Configurations

Type of Facility	Location of Facility	Number of Lanes (Bidirectional)	Shoulder Configuration	ROW Requirement	Comments
At-grade CMV-Only Lanes	Median of existing highway mainlines	2	No inner shoulders; 12-foot outer shoulders	54 feet	Other assumptions: 12-foot lane widths; 2-foot Jersey Barrier width (total of 3 barriers for truck-truck and truck-auto separation)
At-grade CMV-Only Lanes	Median of existing highway mainlines	2	5-foot inner shoulders; 12-foot outer shoulders	64 feet	Other assumptions: 12-foot lane widths; 2-foot Jersey Barrier width (total of 3 barriers for truck-truck and truck-auto separation)
At-grade CMV-Only Lanes	Outside existing highway mainlines	2	No inner shoulders; 12-foot outer shoulders	52 feet	Other assumptions: 12-foot lane widths; 2-foot Jersey Barrier width (one barrier for truck-truck separation, and 1-foot side-barriers on either side of the facility)
At-grade CMV-Only Lanes	Outside existing highway mainlines	2	5-foot inner shoulders; 12-foot outer shoulders	62 feet	Other assumptions: 12-foot lane widths; 2-foot Jersey Barrier width (one barrier for truck-truck separation, and 1-foot side-barriers on either side of the facility)
At-grade CMV-Only Lanes	Median of existing highway mainlines	4	5-foot inner shoulders; 12-foot outer shoulders	88 feet	Other assumptions: 12-foot lane widths; 2-foot Jersey Barrier width (total of 3 barriers for truck-truck and truck-auto separation)
At-grade CMV-Only Lanes	Median of existing highway mainlines	4	10-foot inner shoulders; 12-foot outer shoulders	98 feet	Other assumptions: 12-foot lane widths; 2-foot Jersey Barrier width (total of 3 barriers for truck-truck and truck-auto separation)
At-grade CMV-Only Lanes	Outside existing highway mainlines	4	5-foot inner shoulders; 12-foot outer shoulders	88 feet	Other assumptions: 12-foot lane widths; 2-foot Jersey Barrier width (one barrier for truck-truck separation, and 1-foot side-barriers on either side of the facility)
At-grade CMV-Only Lanes	Outside existing highway mainlines	4	10-foot inner shoulders; 12-foot outer shoulders	98 feet	Other assumptions: 12-foot lane widths; 2-foot Jersey Barrier width (one barrier for truck-truck separation, and 1-foot side-barriers on either side of the facility)

Table A.7 Right-of-Way (ROW) Requirements for Various CMV-Only Lane Configurations (continued)

Type of Facility	Location of Facility	Number of Lanes (Bidirectional)	Shoulder Configuration	ROW Requirement	Comments
Elevated CMV-Only Lanes	Median of existing highway mainlines			Width of pier + (2 * inner shoulder width)	ROW does not typically depend on number of lanes (other than cases where number of lanes are too high to warrant more than one supporting pier for the elevated structure)
Elevated CMV-Only Lanes	Outside existing highway mainlines			Width of pier	ROW does not typically depend on number of lanes (other than cases where number of lanes are too high to warrant more than one supporting pier for the elevated structure)
Underground CMV-Only Lanes				None	No ROW requirement since facility is constructed underground

Pavement Design – Pavement design is an important issue in the planning and implementation of CMV-only lanes. CMV-only facilities will typically experience a higher degree of pavement wear-and-tear compared to mixed-flow facilities, due to the constant heavy truck loads, presumably at higher operational speeds. Pavement design is also an important issue to analyze in the case of CMV-only lanes supporting LCV operations; these units are significantly heavier compared to regular tractor/semitrailers, though with appropriate numbers of axles and weight distribution, heavy loads may be mitigated through the use of LCVs. The primary factors affecting pavement design considerations for CMV-only lane facilities include traffic loads, speeds, and the type of soil, and the specific elements to consider in pavement design include pavement thickness, and the type of material (for example, use of more durable materials). A study conducted by Button et al.[24] from TTI was identified from the Task 1 literature review as the single major source providing a discussion on pavement design issues addressing truck traffic loads. The following sections discuss information provided from this study pertaining to pavement design issues for heavy truck loads.

Large Stone Asphalt Mixtures (LSAMs) – Large Stone Asphalt Mixtures (LSAMs) are increasingly finding applications in the design of heavy-duty flexible pavements. Based on historic data, most so-called LSAMs have been conventional mixtures with a few big rocks, and these designs have not allowed for the attainment of mutual contact of the largest stones. However, research conducted by Mahboub et al.[25] points out that properly designed LSAMs can be potentially attractive candidates for construction in heavy-truck traffic routes owing to their high resistance to deformation. They specifically discussed some of the key problems often associated with LSAMs such as segregation, poor compaction, low-density, and particle crushing, and concluded that appropriate countermeasures employed during construction can provide effective relief from these problems. Research conducted on Kentucky's coal-haul roads by Anderson et al.[26] demonstrated that LSAMs offered better resistance to rutting than conventional mixtures.

New Material Specifications – It is anticipated that changes in existing material specifications will be necessary for the design of pavements intended to serve heavy truck traffic. In particular, researchers are of the opinion that one of the key factors in achieving cost-effective pavement designs for heavy truck lanes is the use of premium base materials. There are ongoing projects being conducted by the Texas Transportation Institute (TTI) for TxDOT in this regard, which involve field testing of experimental base materials that are expected to provide useful information for the evaluation of existing material specifications, particularly for heavy truck traffic conditions. A key requirement in this regard is the provision of durable materials, and several TxDOT districts have already conducted experimental projects in this area. For example, test sections have been constructed by the Corpus Christi district to identify the structural benefits of triaxial Class 1 base materials. In addition, the Fort Worth and Waco

[24] Joe W. Button, Emmanuel G. Fernando, and Dan R. Middleton, *Synthesis of Pavement Issues Related to High-Speed Corridors*, TTI, Research Report 0-4756-1, September 2004.

[25] Mahboub, K., and E.G. Williams, *Construction of Large-Stone Asphalt Mixes (LSAMs) in Kentucky*, Transportation Research Record 1282, Transportation Research Board, Washington, D.C., 1990, pp. 41-44.

[26] Anderson, R.M., D. Walker, J.A. Scherocman, and L.E. Epley, *Kentucky's Experience with Large Size Aggregate in Bituminous Hot Mix*, Journal of the Association of Asphalt Paving Technologists, Vol. 60, Seattle, Washington, 1991.

districts have conducted experimental tests to evaluate the rut resistance of large stone asphalt stabilized base layers. A key issue that needs to be addressed in conjunction with the development of new material specifications for CMV-only lanes is the application of new construction methods. It is expected that the implementation of new material specifications will likely require changes in existing pavement construction practices such as placing and compacting of new pavement materials.

Smart Materials and Systems – There has been an increasing focus on the potential applications of smart materials for heavy truck corridors, as their implementation is expected to have significant benefits associated with reduced costs of pavement maintenance, and improvements in traffic safety. A key area identified for future research is the laboratory investigation on the behavior of embedded Micro Electro Mechanical Systems (MEMS) in asphalt materials under dynamic loading. Understanding of the repeatability and long-term behavior of MEMS embedded in various types of pavements in different working and environmental conditions through field and laboratory investigations would be critical in assessing the applicability of these smart systems for CMV-only lanes.

Post-Tensioned Continuously Reinforced Concrete Pavements – Post-tensioned continuously reinforced concrete pavement designs were proposed for consideration for the CMV-only lanes for the Trans Texas Corridor (TTC). Some of the cited advantages of this design compared to asphalt material-based pavements include the following:

- Post-tensioned continuously reinforced concrete pavements would be thinner and less expensive compared to asphalt-based pavements;

- This designs will not experience problems associated with longitudinal joint separation; and

- This design will experience minimal, if any, loss of load transfer at transverse cracks.

Accelerated Pavement Testing

Accelerated pavement testing procedures can find useful applications in pavement designs for CMV-only lanes, which include, but may not be limited to, the following:

- They can be used to verify and calibrate existing models for the evaluation of the expected performance of pavements subjected to heavy truck traffic; and

- These methods can be used to evaluate the applicability of new materials for building pavements as well as verify potential pavement designs intended to serve heavy truck traffic.

Geometric and Cross-Sectional Design Issues

Although highway mainline design standards typically account for the physical and operating characteristics of trucks in the design processes for geometrics (horizontal and vertical alignments) and cross-sectional features (lane widths, shoulder widths, etc.), it is expected that these design standards would not be, in many instances, directly transferable to CMV-only lanes, because of factors such as differences in truck operating characteristics on CMV-only lanes compared to general purpose lanes (for example, CMV-only lanes would typically allow for higher truck operating speeds than general purpose lanes). Also, CMV-only lanes

supporting long-haul LCV operations would require the application of a separate set of design guidelines which specifically address the physical and operating characteristics of LCVs, which are quite different from those of regular combination trucks such as tractor/semitrailers.

Table A.8 summarizes the major geometric and cross-sectional design parameters that would be important to consider in the design of CMV-only lanes. Middleton[27] identifies Stopping Sight Distance (SSD) as a key design issue for CMV-only lanes, particularly on grades. SSDs might affect CMV-only lane facility designs in the case of long downgrades, where truck speeds tend to exceed car speeds. According to the study, there should be particular caution in the use of horizontal curves at the end of long downgrades on CMV-only lanes owing to the issue of high SSDs for trucks on long downgrades.

Table A.8 Key Design Factors for CMV-Only Lanes

Design Category	Specific Focus Area
Sight Distance	Stopping Sight Distance
	Decision Sight Distance
	Passing Sight Distance
	RR-Highway Grade Crossing Sight Distance
	Intersection Sight Distance
Horizontal Alignment	Curve Radius
	Superelevation
	Intersection and Channelization
	Pavement Widening
Vertical Alignment	Critical Length of Grade
	Downgrades
Cross-Section Elements	Lane Width
	Shoulder Width and Composition
	Sideslopes and Drainage Features
	Pavement Cross-Slope Breaks
	Vertical Clearance
	Traffic Barrier
	Passive Signs
	Curbs
	Acceleration Lanes

Source: Dan Middleton, *TTI Truck Accommodation Design Guidance: Policy-Maker Workshop*, TTI Research Report 4364-3, October 2003.

[27] Dan Middleton, *TTI Truck Accommodation Design Guidance: Policy-Maker Workshop*, TTI Research Report 4364-3, October 2003.

The study also provides a discussion on intersection and channelization geometrics as key design elements (pertaining to horizontal curvature) for truck facilities, and the need to consider the impacts of trends/changes in vehicle configurations on design standards associated with these design elements. According to the study, the selection of the appropriate design vehicle is critical in properly designing intersection and channelization geometrics. For example, in the case of truck facilities, the typical design consideration for a large truck is a WB-65 (a tractor/semitrailer combination vehicle with a 53-foot semitrailer). However, the study emphasizes the fact that future truck roadways may allow operations of larger vehicles such as LCVs, and consequently, it is critical for designers to consider LCV characteristics in the intersection and channelization geometrics design process for facilities supporting LCV operations.

A CMV-only lanes needs analysis study conducted by HNTB[28] provides a discussion on the geometric and cross-sectional design issues specific to CMV-only lanes. Geometric design parameters discussed in this study include alignment (stopping sight distance, horizontal curvature, and superelevation), gradients, and clearance (vertical and lateral), while cross-sectional parameters include lane widths and cross-slopes. Table A.9 summarizes these design criteria.

Table A.9 Key Design Criteria for CMV-Only Lanes

Design Speed	Desirable	Reduced
	70 mph	50 mph
Alignment		
Stopping Distance	730 ft	425 ft
Horizontal Curvature	1820-2500 ft	760-835 ft
Superelevation	0.06 ft/ft	0.08 ft/ft
Gradients		
Maximum	5 percent	6 percent
Minimum	0.5 percent	0.5 percent
Clearance		
Vertical	16.5 ft	14.5 ft
Lateral	4 ft	4 ft
Lane Width		
Travel Lanes	12 ft	12 ft
Cross Slopes		
Maximum	0.020 ft/ft	0.020 ft/ft
Minimum	0.015 ft/ft	0.015 ft/ft

Source: *Truck-Only Lanes Needs Analysis and Engineering Assessment*, HNTB Technical Memorandum.

[28] *Truck-Only Lanes Needs Analysis and Engineering Assessment*, HNTB Technical Memorandum.

Douglas[29] provides a discussion on the design criteria for CMV-only lane cross-sectional configurations such as lane and shoulder widths. Table A.10 provides a summary of these design standards, which may vary (for shoulder widths) based on the number of lanes.

Table A.10 Design Criteria for Lane and Shoulder Widths for CMV-Only Lanes

	Number of Lanes		
	1 lane	2 lanes	3+ lanes
Lane Width	12-13 feet	12-13 feet	12-13 feet
Left Shoulder	0 feet	10 feet	12 feet
Right Shoulder	12 feet	12 feet	12 feet

Source: James G. Douglas, Handb*ook for Planning Truck Facilities on Urban Highways*, August 2004.

Following is an analysis of the design criteria presented in Table A.10:

- It recommends a desirable standard lane width for CMV-only lanes of 13 feet, and an absolute minimum width of 12 feet. The 12-foot minimum lane width is based on the specifications in the ITE reference manual *Geometric Design and Operational Considerations for Trucks*, which recommends 12-foot lane widths to accommodate off-tracking and provide sufficient margin for safety. However, the report observes that some studies have indicated truck drivers' dissatisfaction with 12-foot lane widths, and that lane widths should be at least 13 feet on highways with exclusive truck operations. It is also plausible that required minimum lane widths on some truck facilities can be as high as 14 feet based on design speeds and superelevation. However, in the absence of this information, the report recommends a 13-foot design standard for CMV-only lane widths for planning purposes.

- As indicated in Table A.10, left shoulders will typically not be needed for one-lane facilities, as right shoulders can effectively be used in cases of truck breakdowns. For a two-lane truck facility, however, it is recommended that a left shoulder with a minimum width of 10 feet is provided to serve trucks on the left lane that cannot cross over to the right shoulder in case of a breakdown. For a three-lane truck facility, it is recommended that both left and right shoulders be provided with minimum widths of 12 feet.

Costs

The costs associated with the development and operations of CMV-only lanes can be broken down into capital costs and operations and maintenance (O&M) costs. Capital cost components typically include ROW acquisition costs and construction costs. ROW acquisition costs are the highest for at-grade facilities, while the share of ROW acquisition costs of total capital costs are marginal in the case of elevated structures. ROW acquisition costs for the

[29]James G. Douglas, *Handbook for Planning Truck Facilities on Urban Highways*, August 2004.

development of CMV-only lane facilities depend on the land ownership patterns around existing highway corridors (for example, ROW acquisition costs might not be an issue under public land ownership, but will need to be incorporated into the total capital costs if land has to be acquired from private entities).

CMV-only lane facility construction costs can be further divided into construction costs associated with the following elements:

- CMV-only lanes;
- Inner and outer shoulders;
- Jersey Barriers;
- Guard rails/sound walls (if any); and
- Truck access/egress and interchange ramps.

Additionally, construction costs also include costs associated with mainline highway equipment such as signage, overhead signage structures, lighting equipment, ITS equipment, etc. Elevated and underground CMV-only lane facilities have higher capital costs compared to at-grade facilities, due to the additional costs associated with the construction of elevated structures and tunnels, respectively.

Highway O&M costs typically include costs associated with pavement maintenance (including maintenance of mainline lanes, shoulders, and Jersey Barriers), highway equipment maintenance costs, and highway operations costs such as those related to ITS operations, incident management systems, operational systems for tolls in the case of tolled truckways, etc. It is expected that diversion of trucks from mixed-flow to CMV-only lanes would result in a net reduction in total pavement maintenance costs, as the increased pavement costs associated with the CMV-only lanes would be off-set by the reduction in maintenance costs on the general purpose lanes due to reduction in pavement damage resulting from diversion of trucks to the CMV-only lanes.

Middleton et al.[30] provides a detailed discussion on the construction costs associated with exclusive CMV-only lane facilities as a function of the number of lanes, and how these costs compare against the construction costs of mixed-flow facilities. The study provides two separate set of estimates of construction cost comparisons between CMV-only lane and mixed-flow facilities, one in which the total number of lanes in the CMV-only lane and mixed-flow facilities are the same, and other with different number of lanes in the two facilities. Analysts in the study used planning cost estimates available from TxDOT for the costing analysis for CMV-only and mixed-flow lanes. The study, however, notes that these cost estimates should be considered preliminary as they are only intended to provide general comparison of costs between CMV-only and mixed-flow lanes, and should not be considered as accurate estimates of the construction costs associated with these facilities. Tables A.11 and A.12 summarize these estimates, in which the construction costs are provided in terms of costs per mile.

[30] Dan Middleton, Steve Venglar, Cesar Quiroga, Dominique Lord, and Debbie Jasek, *Strategies for Separating Trucks from Passenger Vehicles: Final Report,* September 2006.

Table A.11 Initial Construction Cost Per Mile Comparisons Between CMV-Only Lane and Mixed-Flow Facilities With Equal Number of Lanes (Both Directions)

No. Lanes by Direction	Mixed	Cost Scenario	Separated Separated	Cost Difference
4	$10,699,845	2+2	$16,964,429	$6,264,584
5	$16,018,968	2+3 [a]	$19,767,232	$3,748,264
6	$16,518,089	2+4	$21,699,845	$5,181,756
7	$19,069,090	2+5	$27,018,968	$7,949,878
8	Unavailable	2+6	$27,518,089	N/A
9	Unavailable	2+7	$30,069,090	N/A

[a] 2+3 is two truck lanes and 3 mixed lanes by direction.

Source: Dan Middleton, Steve Venglar, Cesar Quiroga, Dominique Lord, and Debbie Jasek, *Strategies for Separating Trucks from Passenger Vehicles: Final Report,* September 2006.c

Table A.12 Initial Construction Cost Per Mile Comparisons Between CMV-Only Lane and Mixed-Flow Facilities With Different Number of Lanes (Both Directions)

Lanes by Direction	Cost Mixed	Separated Scenario	Cost Separated	Difference	Separated Scenario	Cost Separated
4	$10,699,845	2+3 [a]	$19,767,232	$9,067,387	2+4	$21,699,845
5	$16,018,968	2+4	$21,699,845	$5,680,877	2+5	$27,018,968
6	$16,518,089	2+5	$27,018,968	$10,500,879	2+6	$27,518,089
7	$19,069,090	2+6	$27,518,089	$8,448,999	2+7	$30,069,090

[a] 2+3 is two truck lanes and 3 mixed lanes by direction.

Source: Dan Middleton, Steve Venglar, Cesar Quiroga, Dominique Lord, and Debbie Jasek, *Strategies for Separating Trucks from Passenger Vehicles: Final Report,* September 2006.

Estimates in Tables A.11 and A.12 can serve as useful inputs for CMV-only lane facility planning, particularly in the case of new facility development, where there is a choice between building a mixed-flow facility versus a separated facility (facility having separate CMV-only lanes). The column titled "Difference" in Tables A.11 and A.12 provides the incremental costs of building separated facilities compared to mixed-flow facilities. "Cost Mixed" and "Cost Separated" columns provide the total construction cost per mile for mixed-flow and separated facilities, respectively. The "Separated Scenario" column indicates the number of general purpose and CMV-only lanes in the separated facilities. Planners can use these numbers to compare the relative benefits and costs of CMV-only lane and mixed-flow facilities as part of an alternatives analysis process. It is inferred from these estimates that the construction cost for a two-lane truck facility (two bidirectional exclusive CMV-only lanes) is approximately $11 million per mile ($5.5 million per lane mile).

As seen in Tables A.11 and A.12, the costs of building separated facilities are always higher than mixed-flow facilities, and these incremental costs can be quite significant. The primary

factors contributing to higher costs for separated facilities is the higher quality and thickness of pavement, potentially wider and higher quality shoulders for the separated facilities and Jersey Barriers with larger cross-sectional features and increased reinforcements compared to mixed-flow facilities. If more lanes are provided in the separated facilities compared to mixed-flow facilities, as seen in Table A.12, the cost discrepancies (incremental costs) are observed to be even greater. However, some of the benefits associated with separated facilities such as safety and reliability improvements can outweigh the increased costs and justify their implementation compared to mixed-flow facilities.

Research conducted by Reich et al.[31] in Florida also provides some useful information on comparative costs of exclusive truck facilities under various scenarios. Table A.13 summarizes the cost findings reported in this study, which were obtained from a study conducted on the feasibility of exclusive CMV-only lanes for the Houston-Beaumont corridor.

Table A.13 Comparisons of Capital Costs of ECL Facilities

EFT Option	Cost (per mile)	Description
Build in existing median	$4 million	At least 36 feet required for construction Trucks share shoulder & passing lanes with normal roadway No grade separation ramps or exclusive connections to other roadways
Convert frontage road to EFT	$4.5 million	One travel lane and one shoulder/passing lane Grade separation for ramps and crossings
	$9 million	Two travel lanes (bi-directional) and two shoulder/passing lanes Grade separation for ramps and crossings Additional width required
Completely separate roadway	$7-8 million	Four-lane facility Separate right-of-way in new location New structures required

Source: *The Feasibility of Exclusive Truck Lanes for the Houston-Beaumont Corridor*, Research Report 393-3F, pp. 72-76, TTI, March 1987.

Reich et al.[32] estimated that the most cost-effective option for an ECL facility is a two-lane facility built on existing median ROW with minimum width of 36 feet, which is nonbarrier separated from the general purpose lanes, the capital cost for which would be around $4 million per mile. The Reason Foundation study on corridors for toll truckways[33] provides

[31] Stephen Reich, Janet Davis, Martin Catala, Anthony Ferraro, and Sisinnio Concas, *The Potential for Reserved Truck Lanes and Truckways in Florida*, Center for Urban Transportation Research, Research Report 21-17-422-LO, May 2002.

[32] Stephen Reich, Janet Davis, Martin Catala, Anthony Ferraro, and Sisinnio Concas, *The Potential for Reserved Truck Lanes and Truckways in Florida*, Center for Urban Transportation Research, Research Report 21-17-422-LO, May 2002.

[33] Robert W. Poole, Jr. and Peter Samuel, *Corridors for Toll Truckways: Suggested Locations for Pilot Projects,* Reason Foundation, Policy Study 316, February 2004.

even lower capital cost estimates of around $2.5 million per mile for two-lane toll truckways. The study assumes annual O&M costs associated with toll truckways to be around $115,000 per mile, and was the only source available on O&M costs associated with exclusive truck facilities.

Another Reason Foundation study on toll truckways[34] assumes baseline capital costs for toll truckways of $1 million per lane-mile, which is stated to be applicable for rural routes with wide medians and modest requirements for bridge work and climbing lanes). The study assumes capital costs of $2 million to $3 million per lane-mile for truckways in typical intercity conditions. The study also provides construction cost ranges for Jersey Barriers, which range from $120,000 per mile for prefabricated barriers to $250,000 per mile for slip form, cast-in-place barriers.

As discussed earlier, the total capital costs associated with elevated and underground CMV-only lane facilities will be higher compared to at-grade facilities. Analysis of elevated and underground truckways in the Miami Truckway preliminary feasibility study[35] assumes capital costs of elevated truckways to be around $45 million per mile, and around $180 million to $220 million per mile for underground truckways. The elevated facilities consist of two 12-foot travel lanes, 3-foot inner shoulders, an 8-foot outer breakdown lane, a central Jersey Barrier, and outside sound walls. Thus, the total width of the elevated CMV-only lane cross-section is 50 feet. The cost estimate, which is based on 2007 construction costs, assumes absence of any major interchanges.

The tunnel cross-section features assumed in the cost estimation in the Miami Truckway preliminary feasibility study include a 12-foot lane each way, with 19.5 feet of full-truck-height width each way, which is assumed to be just enough for one truck to pass a disabled truck pulled over on the side of the travel lane. Total outside diameter of the tunnels is assumed to be 49 feet, and inside diameter of 45 feet, and is assumed to be within the capability of the current generation of tunnel boring machines (TBMs). According to the study, the cost of tunnel construction is directly proportional to cross-sectional area, which implies that every doubling in tunnel radius would result in a fourfold increase in the tunnel construction costs. Some of the additional elements considered in the tunnel construction cost estimates in the study include the following:

- Costs associated with excessive ground treatment ahead of the application of the TBM (this is because of the water table problem in Miami);
- Launch pit for the TBM;
- Portals;
- Tunnel with precast segments;

[34] Peter Samuel, Robert W. Poole, Jr., and Jose Holguin Veras, *Toll Truckways: A New Path Toward Safer and More Efficient Freight Transportation,* Reason Foundation, Policy Study 294, June 2002.

[35] Robert W. Poole, Jr., *Miami Toll Truckway: Preliminary Feasibility Study,* Reason Foundation, Policy Study 365, November 2007.

- Concrete invert; and
- Electrical and mechanical equipment.

The study also observes that cut-and-cover tunneling is generally less expensive than the use of TBMs, if there are no surface structures along the way. Analysis of at-grade, elevated and underground CMV-only lane facilities in Atlanta conducted by Poole[36] assumes capital costs for mixed sections (sections with at-grade and elevated lanes) of around $10.4 million per mile, and $66 million per lane-mile for tunnel sections.

A.4.4 Institutional Issues

The objective of this chapter is to look into the following kinds of issues pertaining to CMV-only lanes:

- Use and restrictions of CMV-only lanes (i.e., what classes of trucks have access to the lanes; are the lanes adjacent to existing multipurpose lanes, and if so are trucks restricted to the truck lanes?).
- Trucking Industry Equity Implications: Are the truck lanes more valuable to some segments of the trucking community, and does this raise equity issues if trucks are restricted to the lanes and they are tolled?
- Industry role in planning CMV-only lanes.

Use and Restrictions of CMV-Only Lanes

Institutional decisions regarding the use and restrictions of CMV-only lanes would depend on many key issues, some of which include the following:

- Location and purpose of truck facility: For example, CMV-only lanes along long-haul corridors would typically be implemented to serve large trucks, including LCVs, to increase the productivity and efficiency of goods movement. These facilities typically would restrict smaller trucks, such as those associated with service-related truck traffic. On the other hand, CMV-only lanes implemented along congested intra-urban corridors can be designed to allow smaller trucks as well, due to the high volume of service-related truck traffic in urban areas.
- Safety Implications: The type of restriction applied for trucks on facilities with CMV-only lanes might have safety implications. For example, facilities on which trucks are not restricted from using the general purpose lanes will not be able to completely eliminate truck-auto conflicts. If addressing safety issues along a corridor resulting from truck-auto conflicts is a key rationale for the implementation of CMV-only lanes to achieve truck-auto separation, it will be important to pay attention to the issue of whether to restrict trucks only to the truck lanes, or allow access to the general purpose lanes as well.

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[36] Robert W. Poole, Jr., Reducing Congestion in Atlanta: A Bold New Approach to Increasing Mobility, Reason Foundation, Policy Study 351, November 2006.

- Tolling considerations: The type of restriction applied for trucks would be an important issue in the case of tolled truck facilities. The financial feasibility of tolled facilities would greatly depend on the total truck traffic demand on the facility and the resulting revenue generated from this demand through the payment of tolls. In these cases, if trucks are not completely restricted to the truck lanes, but allowed access on the general purpose lanes as well, some of the trucks might avoid using the truck lanes to avoid paying the tolls (for example, they may not use the facility on certain times of the day, when congestion is not a major problem along the general purpose lanes).

Trucking Industry Equity Implications

Trucking industry equity implications to using CMV-only lanes is expected to be a particularly important issue in the case of tolled truck facilities. The willingness of trucking companies to using tolled facilities and paying tolls is greatly dependent on the perceived benefits of using truck facilities compared to general purpose lanes. Also, more importantly, the issue of applying uniform tolls to all segments of the trucking industry using the tolled truck facility might face industry opposition, since the benefits accrued by using the facility might vary depending on the type of truck operations. For example, for facilities supporting LCV operations, trucking companies operating LCVs would experience significant productivity improvements from using CMV-only lanes, in addition to reduced travel times and increased travel time reliabilities, compared to those operating smaller trucks. Thus, equity issues would be an important factor to be considered in determining tolls based on the type of truck operation, and/or applying restrictions to specific types of trucks to using truck facilities.

Industry Role in Planning CMV-Only Lanes

The issue on the role of the goods movement industry in the planning of CMV-only lanes has been discussed in detail under the Task 2: Planning Process Issues chapter of this report. This chapter supplements the Task 2 information with some additional information on specific considerations on industry involvement in the planning and development of CMV-only lanes. The work conducted by Samuel et al.[37] from the Reason Foundation talks about the importance of involving shippers and carriers, through the development of shipper/carrier forums, in contributing to policy development related to toll truckway standards and interoperability. For example, the study talks about how the FHWA could potentially sponsor an Operators and Shippers Forum for the exchange of ideas related to toll truckway planning and development.

The work conducted by Reich et al.[38] in Florida obtained inputs on the perceptions of various types of motor carriers towards ECL facilities as part of feasibility analysis process. The study observed that motor carriers must be enticed to use these facilities through the provision of sufficient access, desire length of travel, and higher speeds (or reduced travel times). Other observations from the study on motor carrier perceptions included the following:

[37] Peter Samuel, Robert W. Poole, Jr., and Jose Holguin Veras, *Toll Truckways: A New Path Toward Safer and More Efficient Freight Transportation,* Reason Foundation, Policy Study 294, June 2002.

[38] Stephen Reich, Janet Davis, Martin Catala, Anthony Ferraro, and Sisinnio Concas, *The Potential for Reserved Truck Lanes and Truckways in Florida*, Center for Urban Transportation Research, Research Report 21-17-422-LO, May 2002.

- Motor carriers did not perceive particular incentives for separated facilities, especially in cases where additional travel miles or higher operating costs were involve;
- However, the carrier industry was supportive of the concept of adding ECLs to existing highway corridors as long as sufficient passing was allowed, and truck access was not reduced; and
- Motor carriers did not indicate any major concerns regarding crash prevention and safety as a rationale for implementing ECL facilities.

A feasibility analysis study for ECL facilities along the Houston-Beaumont corridor[39] obtained highly specific information on carrier perspectives towards ECLs based on the type of commodity hauled. Table A.14 provides a summary of these results. Some key observations from Table A.14 on perceptions of different carrier types towards ECLs include the following:

- Motor carriers hauling hazardous materials (Hazmat) were highly supportive of ECLs;
- Sand and gravel haulers expressed their willingness to pay tolls for use of ECLs; and
- Carriers hauling household goods and general commodities preferred application of ECLs near urban centers.

Table A.14 Motor Carrier Concerns and Perceptions Regarding ECL Facilities

Motor carrier type	Concerns
General commodity	Constrained by client time schedules, unable to adjust travel/delivery times ETF should be: near urban center, 25-50 miles long Intercity truck facilities needed
Household goods	Constrained by client time schedules, unable to adjust travel/delivery times ETF should be: near urban center, 25-50 miles long
Hazardous materials	Highly in favor of exclusive facilities for trucks Not interested in high-speed travel Favored long facilities because of long hauls Favored improved pavement designs
Pipe and steel	Usually can adjust delivery schedules around congestion Favored increased speeds ETF should be at least 25 miles in length
Sand and gravel	Constrained by client time schedules, unable to adjust travel/delivery times Would consider paying for use of ETF ETF should be at least 25 miles in length

Source: *The Feasibility of Exclusive Truck Lanes for the Houston-Beaumont Corridor*, Research Report 393-3F, pp. 72-76, TTI, March 1987.

[39] *The Feasibility of Exclusive Truck Lanes for the Houston-Beaumont Corridor*, Research Report 393-3F, pp. 72-76, TTI, March 1987.

A.4.5 Summary of Findings

Following are some key conclusions on CMV-only lane configuration and design issues based on the information presented in the above sections:

- This chapter particularly focuses on configuration and design issues pertaining to exclusive CMV-only lanes. Other kinds of truck treatments such as nonexclusive CMV-only lanes, truck lane access restrictions, truck usage of HOV lanes, truck interchange bypasses, truck climbing lanes, and truck ramps have not been discussed in this chapter due to inadequate information on configuration/design issues for these facilities from the Task 1 literature review.

- The chapter provides a detailed review of the key configuration issues associated with different kinds of exclusive CMV-only lane facilities (such as at-grade, elevated, and underground facilities), based on research efforts conducted by the Texas Transportation Institute (TTI) and the Reason Foundation, as well as specific CMV-only lane configurations proposed as part of various planning and feasibility studies conducted across the United States. The specific elements of CMV-only lane configurations presented include the placement of CMV-only lanes relative to general purpose lanes (for example, CMV-only lanes along median ROWs vis-à-vis adjacent to the general purpose lanes), ROW requirements, lane widths, inner and outer shoulder widths, cross-sectional configurations of Jersey Barriers, and cross-sectional configurations for elevated and underground CMV-only lane facilities.

- The chapter presents a useful discussion on some of the key design issues pertaining to the development of CMV-only lanes. These include pavement, geometric, and cross-sectional design issues, specific design elements discussed under which include the following:

  - Pavement design – Issues discussed include types of materials and pavements, and potential applications of advanced pavement design tools, tests and methodologies for the design of pavements for exclusive CMV-only lanes;

  - Geometric design – Issues discussed include stopping sight distances, minimum radii of curvature, superelevation, and grades; and

  - Cross-sectional design – Issues discussed include minimum lane and shoulder widths, and key Jersey Barrier design issues.

- The chapter presents a discussion on capital and O&M costs associated with exclusive CMV-only lane facilities. Some constraints in the discussion on capital costs and O&M costs in this chapter include the inadequacy of information on the contribution of various elements to total costs (such as share of total costs associated with the type of pavement, etc.). However, this discussion can provide useful inputs for the following kinds of planning applications for exclusive CMV-only lane facilities:

  - Conducting alternatives analysis as part of the planning process to determine the incremental costs associated with developing CMV-only lane facilities compared to mixed-flow facilities;

- Determining the impacts of some of the CMV-only lane configuration elements on total facility costs as well as incremental costs compared to mixed-flow facilities (for example, impacts of implementation of Jersey Barriers on costs); and

- Determining O&M costs associated with CMV-only lane facilities.

A.5 Task 4 – Integration with Intelligent Transportation Systems

This chapter describes opportunities to apply Intelligent Transportation Systems/Commercial Vehicle Operations to CMV-only lanes and the benefits that can accrue from these deployments. These opportunities reside in the areas of truck automation, electronic toll collection, and weight and safety enforcement.

A.5.1 Background

Intelligent Transportation Systems (ITS) have been applied to Commercial Vehicle Operations (CVO) in the United States for a number of years to improve the regulation and enforcement of commercial motor vehicles (CMVs) as well as motor carrier operations. The information processing, communications, electronics, and sensors that exemplify ITS have been adapted to the operations associated with moving goods and passengers by commercial vehicles and the activities involved in regulating these operations, giving rise to the area known as ITS/CVO. In other words, ITS/CVO is a segment of ITS focused on CVO.

ITS technologies have been successfully applied in metropolitan and rural areas throughout the country to enhance the safety and efficiency of the surface transportation system. Advanced Traffic Management Systems (ATMS) reduce congestion and promote smoother traffic flow by monitoring roadway conditions and adjusting traffic signal timing and roadway ramp access; Advanced Traveler Information Systems (ATIS) reduce congestion and crashes by delivering accurate and timely traffic and traveler information, as well as information on road and weather conditions, to users so they can make informed decisions regarding their travel, such as method of travel or selection of routes, through cellular phones, the Internet, in-vehicle communication systems, and dynamic message signs; and Advanced Public Transportation Systems (APTS) use ATMS and ATIS technologies to make public transportation more inviting and convenient for travelers.

ITS/CVO applications are designed to improve commercial vehicle safety and enhance the productivity of both the government agencies and the commercial vehicles they regulate. ITS/CVO includes information systems, networks, and sensor systems such as weigh-in-motion, technologies such as brake testers, electronic border crossing systems, and components of the intelligent (automated) commercial vehicle. ITS/CVO technologies primarily are used to provide improvements in four areas:

1. Safety Assurance, for assuring the safety of commercial drivers, vehicles, and cargo, including automated inspections, safety information systems, and on-board safety monitoring systems;

2. Credentials Administration, for improving the procedures and systems for managing motor carrier regulation, including electronic credentialing, electronic tax filing, and electronic payments;

3. Electronic Screening, for facilitating the verification of size, weight, safety, and credentials information, including automated screening at weigh stations, international border crossings, and other inspection locations; and

4. Carrier Operations, for reducing congestion and managing the flow of CMV traffic, including traveler information systems and hazardous material incident response.

The Commercial Vehicle Information Systems and Networks (CVISN) is the major ITS/CVO program in the United States. ITS/CVO and CVISN sometimes are viewed interchangeably, but CVISN is a subset of ITS/CVO containing the collection of information systems and communication networks that support commercial vehicle operations. CVISN includes information systems owned and operated by governments, motor carriers, and other stakeholders. It usually excludes the sensor and vehicle control elements of ITS/CVO. However, because information systems are required to support data sharing of sensors, such as weigh-in-motion (WIM) and control data, WIM and other systems often are viewed as being within the CVISN umbrella.

CVISN projects span all areas of ITS/CVO. Emphasis is placed on the automation of credentials (registration, fuel tax, and oversize/overweight permits); exchange of safety information among agencies and jurisdictions; and use of electronic screening to facilitate the bypass of safety inspections by carriers with good safety histories. Productivity gains for motor carriers and government agencies accrue directly and indirectly as results of CVISN deployments.

A.5.2 ITS/CVO Applications to Increase Capacity and Save Time and Fuel on CMV-Only Lanes

In 2004, Yin, Miller, and Shladover,[40] in affiliation with the California Partners for Advanced Transit and Highways (PATH) program, examined the use of dedicated truck lanes, with and without the application of ITS technologies, to improve the performance of the freight movement system in metropolitan Chicago. Their focus was the feasibility of applying cooperative vehicle highway automation systems (CVHAS). CVHAS technologies are systems that provide driving control assistance or fully automated driving, based on information about the vehicle's driving environment that can be received by communication from other vehicles or from the infrastructure, as well as from their own on-board sensors. Although the authors acknowledged that opportunities exist to improve the efficiency and safety of passenger vehicles as well as trucks through CVHAS technologies, they proposed that implementation on trucks is feasible earlier than on passenger vehicles primarily because professional drivers in professionally maintained vehicles will use these maturing technologies more safely than the general public in vehicles that may be poorly or not at all maintained.

[40] Yafeng Yin, Mark A. Miller, and Steven E. Shladover, *Assessment of the Applicability of Cooperative Vehicle-Highway Automation Systems to Freight Movement in Chicago*, Transportation Research Board Annual Meeting, January 2004.

The authors considered both mixed traffic operations and trucks completely segregated from other traffic for their examination of CVHAS-related truck operations. Their analysis included deployment of barrier separations for segregated truck lanes, with access via dedicated ramps or specified entrances. In addition, truck lanes usable by all trucks were distinguished from truck lanes restricted to CVHAS-equipped trucks. CVHAS technologies included in the analysis consisted of automatic steering, speed, and spacing control and operation of trucks in groups of two or three, called truck platoons. Automatic steering control keeps trucks centered in the traveling lane; automatic speed control controls the truck's speed automatically rather than manually; and automatic spacing control automatically maintains close distances between trucks.

To support their analysis, Yin et al. selected five operational concepts:

1. Baseline concept, i.e., no CVHAS technologies, no CMV-only facilities – "do nothing";

2. CMV-only facility without CVHAS technologies and open to all trucks;

3. CMV-only facility with CVHAS technologies (automatic steering) for equipped trucks only;

4. CMV-only facility with CVHAS technologies (automatic steering, automatic speed, and spacing control with two- or three-truck platoons) for equipped trucks only – "fully automated"; and

5. CMV-only facility without CVHAS technologies before a certain year to be determined (eventually set at 2015) and following that year, upgrade to an automated truckway (automatic steering, automatic speed, and spacing control with two- or three-truck platoons) – "time-staged automation."

The baseline concept incorporated the current and programmed highway network, whereas the CMV-only facilities were located on railroad rights-of-way linking major regional freight hubs and regional points of entry. The proposed truck facilities were added to the network in the Chicago Area Transportation Study (CATS) regional transportation planning model and the network traffic assignment was run to estimate the diversion of truck traffic from the existing highways and arterials to the new facilities.

The CATS model was used to analyze time and fuel savings for each concept in order to recommend the most promising alternative for further investment or engineering study. Comparative analyses across the alternatives, compared to the baseline, produced the results shown in Table A.15 (note that these figures are revisions, provided by Shladover in 2006,[41] to the original numbers presented by Yin et al.).

[41] Steven E. Shladover, *Advanced Vehicle Technologies and Exclusive Truck Lanes: Research from California PATH Program*, Transportation Research Board Annual Meeting, January 2006.

Table A.15 Costs and Benefits of Truck Lane Concepts Compared to Baseline
Millions of Dollars

	Alternative 2 (Without CVHAS)	Alternative 3 (Automatic Steering)	Alternative 4 (Fully Automated)	Alternative 5 (Time-Staged Automation)
Cost Components				
Construction	692	424	424	459
ROW	74	48	48	52
Annual O&M	14	15	16	15
CVHAS – Facility	0	0.4	1.6	0.8
CVHAS – Vehicle	0	146	269	40
Total Costs	**780**	**634**	**758**	**566**
Benefit Components				
Travel Time Savings	2,938	2,186	1,931	2,982
Reduction of Fuel Consumption	10	8	49	28
Total Benefits	**2,949**	**2,194**	**1,980**	**3,010**
Benefit/Cost Ratio	**3.78**	**3.46**	**2.61**	**5.32**

Source: Steven E. Shladover, *Advanced Vehicle Technologies and Exclusive Truck Lanes: Research from California PATH Program*, Transportation Research Board Annual Meeting, January 2006.

The results indicated that all CMV-only lane concepts appear to be cost-effective compared to the baseline. However, the benefits of deploying CVHAS technologies in relation to costs are not clear-cut, as evidenced by the benefit/cost ratio for Alternative 2, which did not employ CVHAS, which is higher than the ratios for Alternatives 3 and 4, which employed CVHAS (In addition, the travel time savings for Alternatives 3 and 4 were poorer than for Alternative 2, and the savings for Alternative 5 were minimally better). Time-staged automation, represented by Alternative 5, showed the best benefit/cost ratio. The authors concluded that automation is able to help improve the performance of the freight movement system, but timing and how it is deployed are important in determining efficiency and success.

The authors attributed the inferiority of Alternatives 3 and 4, compared to Alternative 2, to the limited levels of market penetration of CVHAS-equipped trucks, resulting in CMV-only facilities that were not fully utilized. The implication is that, as the authors noted, the incremental costs of deploying CVHAS *from the start* outweighed the incremental benefits, as compared with the more conventional CMV-only lanes without CVHAS technologies. On the other hand, Alternative 5 deployed CVHAS technologies at the “right” time when the cost of the technologies was reduced and the trucking industry was better prepared for the innovative technologies.

Their research recommended for further investigation a concept consisting of a CMV-only facility open to all trucks before 2015 and then upgraded to an automated highway open only to automated trucks, as represented by Alternative 5.

In 2006 at the Transportation Research Board (TRB) Annual Meeting, Shladover[42] looked at the Chicago case study and a Los Angeles study of nonautomated versus automated dedicated truck lanes on SR 60 (also conducted for the California PATH program) to draw conclusions about advanced technologies and CMV-only lanes. In the Los Angeles study, a cost of $4.3 billion was reported by the Southern California Association of Governments (SCAG) to build a 38-mile, partially elevated (due to right-of-way constraints), four-lane CMV-only facility. When platooning was added, only two lanes, mainly at grade, were needed to support the projected capacity because of the increased throughput afforded by platooning, and the cost was reduced to $1.4 billion (including additional costs for check-in and check-out stations for CVHAS-equipped trucks, based on the need to validate trucks entering automated lanes, while nonautomated trucks join the rest of the traffic, or alternatively, merge into "manual" truck lanes).

In both the TRB presentation and a recapitulation of the Chicago case study (published in the PATH *Intellimotion* periodical, also 2006), Shladover[43] reported that close-formation, three-truck platoons double the throughput per lane of a CMV-only facility. Greater increases are possible with larger platoons. As a result, even in corridors with very high truck volumes, one lane could be built per direction instead of two lanes, saving right-of-way and construction costs. In addition, costs are saved by building at grade in high-density locations. Needed lane width also is reduced from the standard 12 feet to 10 feet due to the accurate steering provided by CVHAS technologies; this reduces the right-of-way and pavement costs. Hence, among the Chicago alternatives, Alternative 2 required one 12-foot lane in each direction and an additional lane in 2015; Alternatives 3 and 4 required a single 10-foot lane in each direction; and Alternative 5, upgraded to full automation in 2015, required one 12-foot lane in each direction. In each of the Alternatives 3, 4, and 5, a shoulder lane was provided to accommodate disabled vehicles so that movement does not come to a halt because of one broken down truck. Shladover also reported significant fuel consumption savings (see figures for Alternatives 4 and 5 of the Chicago study in Table A.15) due to reduced aerodynamic drag on trucks that are electronically linked into platoons, although he said emissions reductions are less certain.

Shladover observed that ITS technologies for automating trucks have been demonstrated on test tracks, but have not yet been introduced into revenue service because they are not designed to coexist with conventional vehicle traffic on existing highways. Concluding his TRB report Shladover commented on the strong synergy between dedicated truck lanes and truck automation. He stated that truck platooning can reduce significantly the cost of providing needed capacity on truck lanes, which in turn offer a "protected environment where implementation of truck automation can be effected with a high probability of trucks being able to follow each other directly, without interference from light duty vehicles, and with reduced technical and safety risks compared to implementations that would require coexistence with unequipped passenger cars."

Time-staged automation, which is Alternative 5, was based on the premise that there is a "right" time to deploy CVHAS technologies. This timeframe was suggested to be 2015, when

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[42]Steven E. Shladover, *Advanced Vehicle Technologies and Exclusive Truck Lanes: Research from California PATH Program*, Transportation Research Board Annual Meeting, January 2006.

[43]Steven E. Shladover, *Improving Freight Movement by Using Automated Trucks on Dedicated Truck Lanes: A Chicago Case Study*, California PATH Intellimotion, Volume 12, No. 2, 2006.

the cost of the technologies was reduced and the trucking industry was better prepared for the innovative technologies, compared to deploying the technologies *from the start*. In 2015, the market penetration of CVHAS technologies was assumed to be 80 percent. There appears to be considerable confidence among the PATH researchers that the motor carrier industry will invest in these technologies, *assuming* the roadway infrastructure can be put in place, because decisions to adopt technologies are motivated by economic reasons (i.e., benefits outweigh costs).

Primary among the benefits is the potential fuel savings from close-formation automated platoons. This incentive is driving the development of truck automation today. Added to this benefit are the relatively small costs of the technologies, which form a small percentage of total vehicle costs and, because the vehicles are used intensively for business purpose, are amortized rather quickly. Industry concerns about the complexity, reliability, and maintainability of the new technologies will have to be addressed by manufacturers, suppliers, and researchers, to support a reasonable (e.g., 2015) staging period for Alternative 5.

Costs would be drastically different in the near term (roughly Alternative 4) compared to the long term (roughly Alternative 5). Table A.16 shows incremental costs of adding CVHAS capabilities to trucks that already have electronically controlled engines and in-vehicle data buses. These are individualized costs that are shown in aggregate in Table A.16.

Table A.16 Platooning Costs per Truck

	Near-Term (Annual Production of Hundreds of Trucks)	Long-Term (Annual Production of Thousands of Trucks)
Forward sensors	$2,500	$500
Wireless communication	$500	$100
Brake actuation	$5,000	$1,000
Driver interface	$1,000	Assume included
Installation/integration	$1,000	$300
Total	**$10,000**	**$1,900**

Source: Steven E. Shladover, *Advanced Vehicle Technologies and Exclusive Truck Lanes: Research from California PATH Program*, Transportation Research Board Annual Meeting, January 2006.

VanderWerf, Shladover, and Miller,[44] in a 2004 PATH report, summarized the key benefits of truck automation that would accrue to commercial vehicle operators, as follows:

- Substantial reduction in fuel consumption, on the order of 10 to 20 percent, would considerably reduce operating costs;
- Reduced and predictable travel times resulting from automated truck platoons would improve the utilization of capital equipment and the ability to meet delivery deadlines; and
- Drivers could travel long-distances while resting and earning payment, thereby resolving some of the current problems with driver fatigue and hours of service.

The argument to be made is that automated highways traveled by automated trucks are a "win-win" situation. While commercial vehicle operators reap substantial economic benefits, roadway owners and operators see increased capacity, reduced right-of-way and construction costs (due to a lesser number of lanes as well as reduced lane width), and fewer collisions involving trucks and smaller vehicles, thus saving lives and reducing injuries.

In his 2006 TRB presentation, Shladover reported significant technical progress in PATH truck automation experiments associated with longitudinal control (platooning) as well as measurements of fuel saved. In particular, automatic steering and speed control have been successfully demonstrated under a limited range of conditions and very close separations have been achieved between trucks on test tracks. Shladover, although optimistic about the future of these deployments, advised that more research is required to "show decision-makers that the opportunities are there." VanderWerf et al. have noted that fully automated trucks on dedicated lanes are being studied in the Netherlands in a prototype project called the Underground Logistics System that links the Amsterdam Flower market with a major train station and the Schiphol airport with fully autonomous electric shuttles for small containers.

A.5.3 ITS/CVO Applications to Support Toll Collection on CMV-Only Lanes

In a 2002 Reason Public Policy Institute report, Samuel, Poole, and Holguin-Veras[45] proposed that self-financing toll truckways dedicated to heavy trucks (10,000 to 150,000 pounds gross vehicle weight, including longer combination vehicles [LCVs]) would significantly reduce the costs of improving United States highways to accommodate greater use of LCVs. Moreover, the separation of automobiles and smaller vehicles from large trucks would increase safety as well as transportation efficiency. Their proposal came on the heels of the 2000 U.S. DOT Truck Size and Weight Study that showed net savings of between $10 billion and $40 billion annually if LCVs were permitted on more major highways. The proposed truckways would be located in their own rights-of-way separate from other roadways, or they would be located within the rights-of-way of limited-access highways but completely separated from mixed traffic lanes by continuous concrete safety barriers, with their own dedicated entrance and exit ramps.

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[44] Joel VanderWerf, Steven Shladover, and Mark A. Miller, *Conceptual Development and Performance Assessment for the Deployment Staging of Advanced Vehicle Control and Safety Systems*, California PATH, 2004.

[45] Peter Samuel, Robert W. Poole, Jr., and Jose Holguin-Veras, *Toll Truckways: A New Path Toward Safer and More Efficient Freight Transportation*, Reason Public Policy Institute, June 2002.

An electronic toll collection (ETC) system would be used by the toll truckway operator to collect tolls. This system would employ an automatic vehicle identification (AVI) device such as an in-vehicle radio frequency transponder or camera recognition system to identify and validate each truck that desires to use the truckway.

Electronic screening of trucks for size, weight, and/or safety compliance using radio frequency transponders already is widely deployed in the United States. Over 566,000 vehicles participate in programs/partnerships such as PrePass, NORPASS, and Oregon Green Light. These electronic screening deployments are the most visible and arguably the most successful of the ITS/CVO and CVISN deployments.

In electronic screening, trucks passing a roadside check station are automatically screened to determine whether further inspection or verification of credentials is required, in which case the truck is signaled into the station. The intent of electronic screening is to allow safe and legal trucks to pass the station while enforcement resources are focused on high-risk carriers and vehicles. Trucks enrolled in a screening program are equipped with dedicated short-range communications (DSRC) transponders that are interrogated by roadside readers as the vehicle approaches the roadside station. DSRC is used to identify the vehicle, store and transfer other screening data, and signal the driver to pull in or bypass. The transponder (also known as a "tag") may contain identifiers specific to the vehicle (carrier and vehicle IDs), plus optional prior screening event information. The transponder has audio and visual indicators that are used to signal the driver.

In their report, Samuel et al. envisioned that toll booths or toll plazas would be eliminated on the toll truckways because every truck would be equipped with a transponder encoded with its size and weight category (which help determine the toll). Participating trucking firms would maintain their own prepaid account with the truckway operator, which would be used to deduct tolls based on miles driven from entry point to exit point on the truckway. Drawing from the electronic screening concept, automatic readers would be located at the entry and exit points. These readers would be connected to computers for toll calculation. Account information embedded in the transponder would be captured along with entry point location at the entry point, and processed at the exit point. The toll is then electronically deducted from the prepaid account. Elimination of toll booths and plazas can be expected to improve efficiency and speed of trucking operations on the tollway.

The authors observed that tolling on these truckways could use transponders in use by PrePass carriers. In fact, it is known that PrePass Plus allows participating carriers to electronically pay tolls at E-ZPass toll plaza facilities in the Eastern United States using the same transponder used to bypass weigh or inspection stations. NORPASS also allows carriers to do electronic toll collection in the E-ZPass states with the same transponder used for NORPASS.

Clearly, the opportunity exists to "piggyback" ETC on tolled truckways with ETC and electronic screening already deployed in many states. DSRC transponders have excellent accuracy at highway speeds. Because all trucks on the tolled truckways will be required to have transponders, the effects of nonparticipation (queuing, safety issues from vehicles sorting into automatic versus manual lanes) largely resolve themselves. A problem that continues to plague CVISN deployments is that of interoperability. Although PrePass and NORPASS utilize the same physical transponder (supporting technical interoperability), PrePass does not allow its transponders to be used to bypass NORPASS facilities (compromising program

interoperability). This situation becomes a state-by-state problem for interstate carriers because jurisdictions join PrePass or NORPASS, and carriers enrolled in PrePass are not able to bypass facilities in NORPASS states. NORPASS, on the other hand, allows its transponders to be enrolled in PrePass. The toll truckway operator will need to address interoperability with electronic screening as well as other ETC systems.

As noted by Samuel et al., tolling on the truckways could use the existing 915 MHz transponders used in the PrePass and NORPASS programs, but they should transition to the new 5.9 GHz DSRC standard. DSRC at 5.9 GHz advances the standardization of data exchange beyond the existing DSRC standard. It allows United States, Canadian, and Mexican ITS programs to evolve to a new generation of radio frequency communications between vehicles and the roadside, and between vehicles, that enables a new set of applications to support transportation and public safety systems and needs.

Electronic screening and ETC will not change with the new DSRC standard. Interoperability issues likely will improve and more applications will be supported due to the new standard. The very high data transfer rates at 5.9 GHz, which provide accurate and valid message delivery with communication units on fast-moving vehicles, can support a number of applications beyond electronic screening and ETC available at 915 MHz. The enhanced applications include safety message services, emergency vehicle services, and Internet access services. In particular, 5.9 GHz DSRC can support CVO applications such as transfer of on-board safety data to the roadside, downloading the driver's daily log, and remote vehicle safety inspections (applications described in the next chapter).

Samuel et al. also mention the potential use of technologies other than DSRC transponders for tolling purposes, including camera recognition and global positioning system (GPS) tracking. The authors do not provide any details on how these other technologies could be used, but Cothron, Skowronek, and Kuhn (2003)[46] commented briefly on the interaction of AVI, including license plate recognition, with ETC systems. Most of the discussion below is based on the general literature available on license plate readers.

A license plate reader (LPR), an alternative form of AVI, also is deployed as part of CVISN in a growing number of states. It identifies vehicles by their license plate. LPRs are a type of optical character recognition (OCR) technology, using illumination and a camera to take the image of the front or rear of the vehicle; image-processing software analyzes the image and extracts the plate information. The plate number can be automatically linked to a database to look up carrier or vehicle information, or it can be manually entered to obtain more information. A number of states are deploying LPRs to complement transponder-based electronic screening because nontransponder-equipped trucks can be screened, thereby increasing the number of trucks that can be automatically processed.

License plate readers suffer from fair to poor accuracy rates – i.e., successfully reading a license plate – that vary from 30 to 60 percent. As a result, they are arguably better for toll violation enforcement than for primary vehicle identification. For example, LPRs could be used to automatically capture the license plates of vehicles that do not have a usable transponder. The

[46] A. Scott Cothron, Douglas A. Skowronek, and Beverly T. Kuhn, *Enforcement Issues on Managed Lanes*, Texas Transportation Institute, January 2003.

plate number could be associated with the truck owner in a state (or preferably, multijurisdictional) CMV database that resides locally or remotely. Because not all vehicles will be successfully identified automatically, some license plates may require visual (manual) identification. In addition, out-of-state vehicles or vehicles with expired plates may not appear in the database.

GPS is not an ITS technology per se, but GPS-based ETC systems do not require any road infrastructure for operation. On the other hand, its comparatively high costs are a significant disadvantage.

A.5.4 ITS/CVO Applications for Weight and Safety Enforcement on CMV-Only Lanes

High-speed, mainline WIM systems offer states the opportunity to automatically verify weights of trucks traveling at highway speeds on CMV-only lanes. Weight limits can be monitored actively on truck facilities to assure pavement preservation and, when used on toll truckways, equitable collection of truckway tolls. Samuel et al. indicated that a truck's size and weight category would be encoded in the transponder. A truck's significantly higher gross weight on the road compared to the encoded weight could be determined through the use of WIM installed on the truckway, recognizing that high-speed WIM systems measure approximate weights and are not currently used for direct enforcement in the United States (what is meant by "significant" is dependent on the accuracy and calibration of the weighing system).

Mainline WIM deployments are common elements of states' ITS/CVO and CVISN infrastructures. They enable the measurement of approximate axle weights as a vehicle moves across the sensors and determine the gross vehicle weight and classification based on the axle weights and spacing. Newer WIM systems are integrated with an automatic vehicle classification (AVC) system to perform weight, size, and length checks. Mainline WIM systems may be deployed in association with electronic screening systems (i.e., where approximate weights of transponder-equipped trucks can be determined), or they may be independent data collection tools for traffic monitoring purposes (e.g., freight planning, pavement management, scheduling enforcement resources).

Many states are deploying unstaffed, remote, or virtual weigh stations that feature mainline WIM, camera systems, and near real-time data transmissions. These deployments have the advantage of capturing the weights of all trucks, regardless of whether they are equipped with transponders. Violators are visually identified through the automatic matching of a weight record with a camera image. Virtual weigh stations provide transportation and roadside enforcement agencies with a cost-effective tool to monitor and enforce truck weights on routes where weigh stations are not located effectively and inexpensively. They utilize and transmit WIM and photographic image information to remotely located enforcement personnel. Based on the information supplied by the ITS technologies, vehicles suspected of being overweight can be stopped and weighed using portable scales or can be directed to the nearest weigh station for weighing, while allowing vehicles in compliance to continue on their way. States can enhance the camera system with LPR technology. The plate information can be used in automatic queries for additional carrier or vehicle information contained in a CMV database to make a safety- and credentials-based screening decision, i.e., whether or not to intercept a vehicle for inspection.

Such a virtual weigh station can be deployed on dedicated truck lanes to spread the enforcement net of the state. On toll truckways, because LCVs would be required to travel on the truckways in states and on routes that do not currently allow LCV operations, it would enable the state to monitor weights of vehicles cost-effectively. On any CMV-only lanes, all vehicles would be weighed-in-motion, and potential violators could be intercepted at special pull-out areas constructed along the CMV-only facility, or as they exit the facility. The state would be able to monitor and enforce weights of a large population of commercial vehicles, using effective and relatively low-cost technologies. Many of the trucks would not be monitored using conventional means such as weigh stations and ad hoc roadside inspections. Deployment of a virtual weigh station on a toll truckway, however, may be a disincentive to a portion of the industry. The self-financing structure of the facility will cause enforcement options to be scrutinized at least as heavily from the industry viewpoint as the government viewpoint.

In the future, direct or automated enforcement of CMV weight limits (or dimension, safety-related, or credentials regulations) is possible using electronically collected weight (or dimension, safety, or credentials) data. Low-speed WIM is used for direct enforcement in Belgium and France, and the U.S. DOT Federal Highway Administration is examining the feasibility of direct enforcement in the United States – albeit it is not expected in any timeframe except the long term. Using high-speed WIM for direct enforcement could be supported using a buffer of, for example, 10 percent deviation from the recorded weight, given current accuracy. With the large numbers of trucks that would travel on CMV-only lanes, deployment of WIM systems and automated enforcement, along with a method for identifying each truck (e.g., DSRC, OCR), would be an ideal way to enforce truck weights with minimal labor. In addition to WIM and AVI, which are very inexpensive compared to the cost of building traditional weigh stations, violation recording software and a citation generation system would be needed.

Over 3 million roadside inspections are conducted in the United States each year. Of these, many CMVs are infrequently inspected, and many are never inspected at all. Clearly, alternative concepts are needed to ensure the safety of CMVs and the roadways. A wireless roadside inspection (WRI) program has been commissioned by the U.S. DOT Federal Motor Carrier Safety Administration (the sponsoring agency of the ITS/CVO and CVISN programs) to validate technologies that can improve safety by leveraging on-board sensor systems and wireless communication of the condition of vehicles and their drivers. The WRI concept of operations has been validated, and a pilot test and field operational test are being planned. The WRI program is expected to be fully deployed in 2012. It is believed that wireless inspections could increase the number of inspections to approximately the same level of weight inspections (82 million) and thereby reduce the percentage of vehicles with violations. Overall, the number of unsafe CMVs and drivers will be reduced, as will crashes. WRI technologies could be applied to CMV-only lanes to maximize CMV inspections with minimal roadside investment costs.

The WRI concept centers on three main components: 1) CMV, wherein driver and vehicle information (e.g., driver license number, driver log book, vehicle fault codes) are packaged into a safety data message set by equipment on the vehicle and transmitted wirelessly to the roadside; 2) roadside law enforcement and compliance systems, which receive the data and use it to support inspections, trigger roadside interception, or contribute to a screening decision; and 3) back-office systems, which verify, archive, and distribute the safety data message set, for use for real-time enforcement, compliance, and assessment; the data also will be used to update

a company's safety rating and a driver's safety status. DSRC at 5.9 GHz is seen as a viable option for wireless inspections because it is designed for vehicle-to-infrastructure communications, and has high data rates (up to 27 MBPS).

The roadside components of WRI are envisioned to include equipment, positioned along highways, that supports wireless communications to collect safety data message sets from properly equipped CMVs and provide the message sets to the rest of the WRI system. Roadside equipment will include receiver units and mobile enforcement vehicles. CMV-only facilities can be equipped with the necessary roadside units, and because all the traffic consists of CMVs, there is potential for optimal numbers of inspections, constrained only by the level of participation on the part of CMVs (unless equipment is mandated).

Costs of WIM systems and virtual weigh stations (including WIM plus camera and optional LPR systems, and high-speed communications), as well as costs of other, individual ITS/CVO technologies including transponders and LPRs, are obtainable from technology vendors. In addition, the ITS Benefits, Costs, and Lessons Learned Databases (www.benefitcost.its.dot.gov) are user-friendly web sites that provide valuable information to support research and project planning activities. Since December 1994, the ITS Joint Program Office has been collecting information on the benefits and costs of intelligent transportation systems. These databases provide access to the growing collection of information on the benefits and costs of implemented ITS including ITS/CVO.

The Benefits Database includes summaries of ITS benefits described in evaluations, conference papers, and other reports. Reference information is provided for each entry, along with a link to the reference document if available electronically. Users can search the Benefits Database by ITS subsystem or application (e.g., commercial vehicle operations), goal area (e.g., safety), state, or other links. The Costs Database includes unit costs for ITS elements and system costs of sample ITS deployments. The Costs Database contains two types of cost data: unit and system. The database is a central site for estimates of ITS costs that can be used for policy analyses, benefit/cost analyses, and project planning. Unit cost is associated with an individual ITS element (e.g., mainline WIM scale, electronic sign for weigh station). System cost is associated with multiple ITS elements and typically represents the total cost of an ITS project (e.g., electronic screening). Costs are available as adjusted for the most current year, or unadjusted.

A.5.5 Summary of Findings

In the area of CVHAS, VanderWerf et al. proposed that the technologies will be deployed on CMVs operating on CMV-only lanes earlier (and possibly effectively for a longer period of time) than on lighter vehicles for a number of economic, institutional, and safety-related reasons:

- Benefits in travel-time reduction, trip reliability, and safety are more easily translated into cost savings than for private cars;
- Technology costs are a smaller fraction of total vehicle costs and vehicles are used much more intensively than private cars, so the costs are amortized much faster;

- Maturing technologies are more safely used by professional drivers on professionally maintained vehicles than by the general public on cars that may be poorly or not at all maintained;

- Acquiring rights-of-way for public purposes such as removing trucks from mixed traffic roads is comparatively easy;

- Customized, small-lot production of vehicles facilitates introduction of advanced technologies into the production process compared to mass production of cars; and

- Commercial vehicles are already equipped with precursor electronic equipment as a foundation for more advanced capabilities.

The authors used the adage of a "solution looking for a problem" to suggest that CVHAS – instead of being that solution looking for a problem – can *provide* solutions to existing as well as forecasted traffic safety, freight mobility, fuel consumption, infrastructure cost, and other transportation problems associated with mixed traffic facilities. Noting the considerable benefits offered by CVHAS to commercial vehicle operators, truck drivers, infrastructure owners and operators, and the general public, the authors proposed that these beneficiaries, who may not necessarily be aware of these benefits, need to be educated about the opportunities to be gained from truck automation deployments.

The separation of trucks and cars may not improve the technical aspects of collecting information by other ITS/CVO technologies for enforcement or tolling purposes. AVI, WIM, and WRI technologies are designed to work in a variety of traffic environments, and would not "work better" technically in CMV-only facilities. However, the separation of trucks and cars would ease the challenges of concentrating trucks in weigh stations or in the outermost lanes of multilane highways in order to capture information from them. In this "captive" environment, few if any trucks would be able to avoid size, weight, and/or safety monitoring. As larger numbers of trucks use the CMV-only facilities, enforcement agencies will be able to ensure the compliance of a greater percentage of the CMV population.

Overall, Intelligent Transportation Systems/Commercial Vehicle Operations (ITS/CVO) technologies can be applied to operations on CMV-only lanes to produce operational and weight and safety enforcement benefits. In addition, the technologies in some cases can be integrated with ITS/CVO deployments already in place. The primary potential deployments include:

- Cooperative vehicle highway automation systems (CVHAS) that provide driving control assistance or fully automated driving, such as automated steering, automated speed control, automated spacing control, and truck platoons, to increase capacity on automated lanes and offer fuel savings to automated trucks;

- Automatic vehicle identification (AVI) technologies to support electronic toll collection (ETC), such as in-vehicle radio frequency transponders using dedicated short-range communications (DSRC) and license plate readers, which can improve efficiency and speed on the tolled truck lanes; and

- High-speed weigh-in-motion (WIM) systems that support automatic, approximate weight verification of trucks traveling at highway speeds; virtual weigh stations that monitor and enforce truck weights without on-site staff; and wireless roadside inspections (WRI) that communicate information from on-board vehicle systems wirelessly to roadside equipment of enforcement agencies; which can increase the levels and effectiveness of weight and safety enforcement of CMVs traveling on CMV-only lanes.

A.6 Task 5 – Longer Combination Vehicle Operations

The Intermodal Surface Transportation Efficiency Act (ISTEA) defined longer combination vehicles (LCVs) as "any combination of a truck tractor and two or more trailers or semitrailers which operate on the National System of Interstate and Defense Highways with a GVW greater than 80,000 pounds." Because of their larger size, and higher weight limit several potential advantages have been tied to operating LCVs over smaller, lighter commercial vehicles, including increased productivity, reduced truck traffic, reduced cost per unit cargo, and reduced emissions.

"In 1983, Caltrans tested and videotaped the performance of each LCV type on California highways along the same 1,200-mile route. The test included freeway interchanges, open-road travel, urban traffic, narrow lanes, two-lane roads, rest areas, weigh scales, off-tracking, speed on grades, braking, acceleration, travel in rain and wind, noise generation, and fuel economy. Some of the problems encountered included 1) the whip and sway action of the Triples on the open road, 2) the off-tracking of the Rocky Mountain Doubles and Turnpike Doubles on curves, and 3) the difficulty parking in rest areas of all three LCV types."[47] For these reasons, logically, LCVs have been restricted to only the most appropriate routes on existing interstates (e.g., those with lower volumes in western United States), however CMV-only lanes may provide a balance between productivity gains and safety concerns of LCVs.

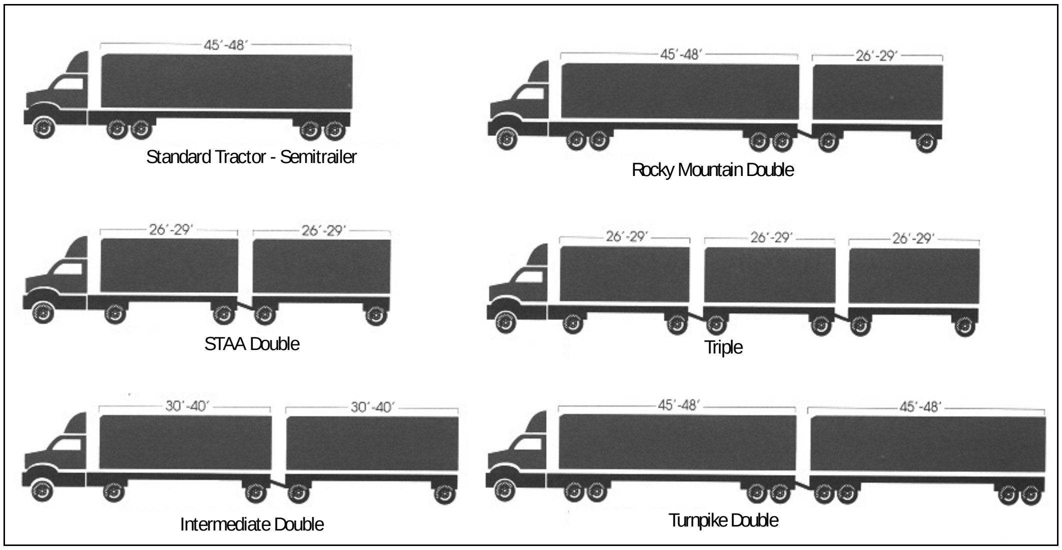
A.6.1 Current LCV Operations

In 1991, ISTEA prohibited states from increasing the size and weight of combination vehicles beyond that already allowed through a "freeze." LCVs were allowed by a grandfathering clause only in states where they were in operation before June 1, 1991. This freeze also prohibited states that allowed LCV operations at the time of the "freeze" from removing these allowances.

Figure A.12 shows a variety of LCV configurations as compared to a standard semitrailer. Many states of semitrailer lengths that have been grandfathered and can range between 48 and 59 feet. Table A.17 provides the associated productivity for each of these truck types. As shown, the turnpike double can move a 500,000 load in the fewest trips.

[47] http://www.dot.ca.gov/hq/traffops/trucks/exemptions/lcvs.htm (accessed July 7, 2008).

Figure A.12 Standard Semitrailer versus Various LCV Configurations



Source: Toll Truckways: Increasing Productivity and Safety in Goods Movement, presentation by Robert W. Poole, Jr. and Peter Samuel.

Table A.17 Comparative Productivity of Existing Truck Configurations

	Tractor/ Semitrailer	STAA Double	Rocky Mountain Double	Turnpike Double	Triple
Configuration	3-S2	2-S1-T2	3-S2-T2	3-S2-T4	2-S1-T2-T2
	5-axle	5-axle	7-axle	9-axle	7-axle
Trailers (Feet)	to 53 feet[a]	2 x 28 feet	48 + 28 feet	2 x 48 feet	3 x 28 feet
Gross weight (Thousands of Pounds)	80	80	119	148	132
Empty weight (Thousands of Pounds)	30	30	43	47	44
Payload (Thousands of Pounds)	50	50	76	101	88
Payload Ratio (Relative to Tractor/Semi)	1.0	1.0	1.52	2.02	1.76
Trips to Move 500,000 Pounds	10	10	7	5	6

Source: Toll Truckways: A New Path Toward Safer and More Efficient Freight Transportation, The Reason Foundation.

[a] Longer lengths have been "grandfathered."

Table A.18 shows the LCV weight limits by state for truck tractor and two and three trailing units, as applicable. At the time of CFR 23 publication only 22 states allowed LCVs in some shape or form. And, between these states, the weight limits vary from the low- to high-end by nearly 100 percent. This large weight difference diminishes the efficiency of high-weight movements even between neighboring LCV states.

Table A.18 LCV Weight Limits by State

Weight (Pounds)	Truck Tractor and Two Trailing Units	Truck Tractor and Three Trailing Units
86.4	NM	
90	OK	OK
95	NE	
105.5	ID, ND, OR, WA	ID, ND, OR,
110	CO	CO
115		OH
117	WY	
120	KS, MO	KS, MO
123.5		AZ
127.4	IN, MA, OH	IN
129	AZ, IA, NV, SD, UT	AZ, IA, NV, SD, UT
131.06		MT
137.8	MT	
143	NY	
164	MI	

Source: Code of Federal Regulations, Title 23, Section 658.23.

Similarly, Table A.19 shows the LCV length limits by state for truck tractor and two and three trailing units, as applicable. The allowable lengths vary between 58 and 115.5 feet, depending on configuration. Like the weight differences in Table A.18, these length differences diminish the efficiency of movements as trucks need to be staged for allowable configuration when entering/exiting LCV/non-LCV states.

Table A.19 LCV Length Limits by State

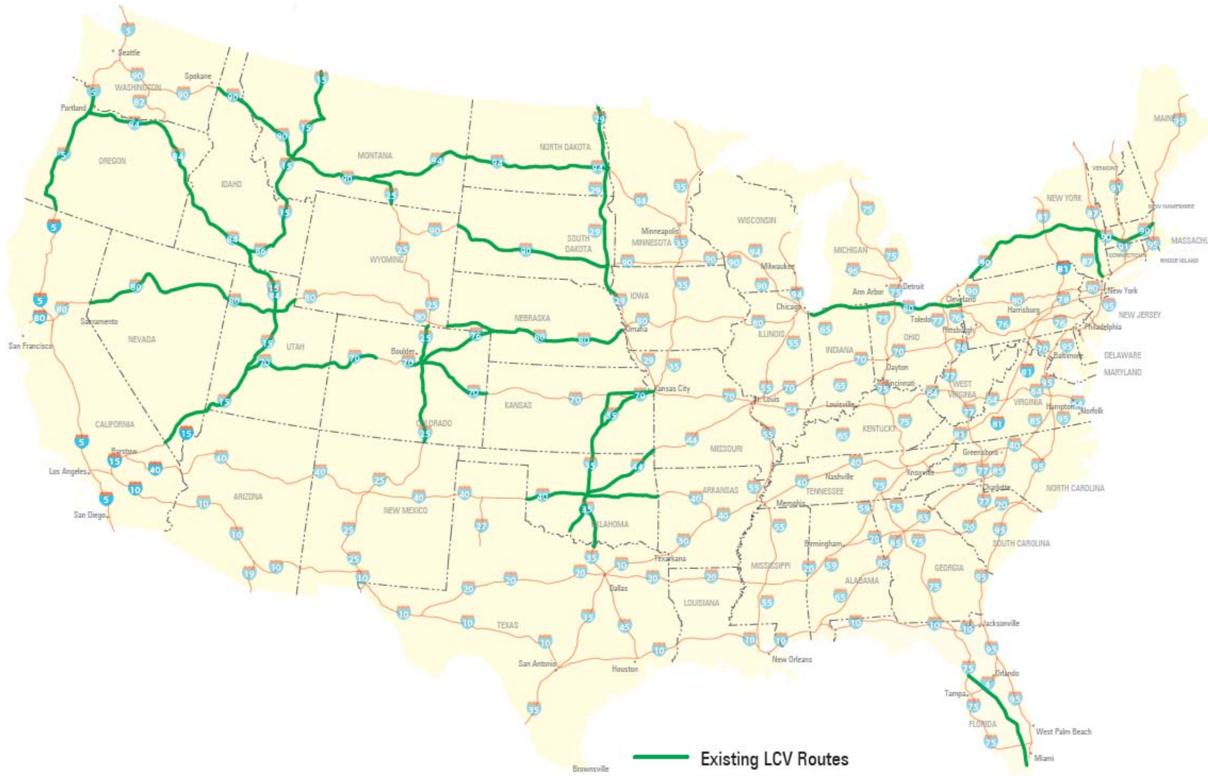
Length (Feet)[a]	Truck Tractor and Two Trailing Units	Truck Tractor and Three Trailing Units	Other
			AZ, ID, MT, SD, UT, WY
58	MI		IN
68	OR, WA		NB, WA
70.42			OR
78			CO, IA
81	WY		
83			AK
93	MT		
95	AZ, ID, NB, NV, UT	AZ, ID, NV, OH, OK, UT	
96		OR	
98			NV
100	IA, SD	IA, MT, ND, SD	
102	NY, OH		
103	ND		ND
104	MA		
104.5		IN	
106	IN		
109	KS	KS, MO	
110	MO		
111	CO		
115.5		CO	

Source: Code of Federal Regulations, Title 23, Section 658.23.

[a] State submission includes multiple vehicles in this category – see individual state listings.

Complementing this table is research conducted by The Reason Foundation. Presented in Figure A.14 is a graphic description of existing LCV routes from the Foundations' *Corridors for Toll Truckways: Suggested Locations for Pilot Projects* study. As Figure A.14 clearly illustrates, the existing United States LCV network is fragmented. While our economy is dependant on global supply chains and efficient goods movement, our internal network for commercial vehicle operations does not support the supply chain either at a national level, or between states. As noted in the figure, while the western U.S. states have the beginnings of an interstate LCV network, there are no LCV routes that provide connectivity between the western United States and the eastern United States over the Mississippi River.

Figure A.14 Existing LCV Routes



Source: Corridors for Toll Truckways: Suggested Locations for Pilot Projects, Reason Foundation.

When discussing the use of LCVs and implementation of multi-state LCV corridors, it is natural to probe the issue of truck-rail competition. Trucking remains by far the largest freight transportation mode, carrying two-thirds of the tonnage for all primary goods shipped. This is due to the fact that nearly 56 percent of all freight shipped (measured in tons) travels less than 50 miles, and more than 75 percent travels less than 250 miles.[48] Shorter trip lengths with lower lane densities are dominated by trucks, while longer trip lengths with higher lane densities are dominated by rail. In recent years containerizations has turned rail intermodal into more of a long-distance trucking competitor, however, whether a shipper chooses to use truck or rail to transport goods depends on several key factors including transit time, service quality, price and customer preference. Potentially implementation of LCVs could influence these factors, however it is not the purview of this study to investigate them.

A.6.2 Future LCV Operations under Consideration

Reason Foundation

As the previously stated disadvantages indicate, LCV operations are perceived to not be as safe as operating shorter, lighter commercial vehicle. Thus, many advocacy groups are concerned

[48] USDOT *Comprehensive Truck Size & Weight Study*, 2000.

about LCVs being added to busy highways where they would mix with cars and potentially pose greater risks of car truck accidents. In addition, state DOTs are concerned that intercity highways are not designed to take the loads placed by today's LCV configurations. To mitigate these perceived disadvantages, the Reason Foundation proposes that heavy-duty toll truckways be constructed to compliment the existing LCV network, as shown in Figure A.15.[49]

Figure A.15 Existing and Proposed LCV Routes

Source: Corridors for Toll Truckways: Suggested Locations for Pilot Projects, Reason Foundation.

The toll truckways would be constructed with the highest regard for pavement, geometric and safety requirements to allow for use by LCVs. These lanes are proposed to be voluntary to all trucks; however they would be mandatory for LCVs in non-LCV states. According to the return on investment calculated, these lanes would also be self-funding using the following assumptions:

- Two (14-foot) lanes each way;
- Concrete Jersey Barrier separation;

[49] *Toll Truckways: A New Path Toward Safer and More Efficient Freight Transportation*, The Reason Foundation, Peter Samuel, Robert W. Poole, Jr., and José Holguin-Veras, June 2002.

- Separate access/egress ramps;
- Nodes (make-up/breakdown yards);
- Variable tolling, all-electronic;
- Voluntary for conventional rigs, mandatory for LCVs; and
- Located in existing freeway corridors.

While truckers are leery of paying tolls in addition to the other fees and taxes already required, the Reason Foundation concludes that productivity gains made possible by truckways would be so large that trucking companies would be willing to pay tolls to use them. Table A.20 provides an overview of the productivity improvements truckways would make possible.

Table A.20 Urban Toll Truckway Productivity

		Mixed Freeway Semitrailer	Truckway Semitrailer	Truckway Triple Short	Truckway Turnpike Double
A	Payload (pounds)	45,000	45,000	67,500	90,000
B	Metric tons	20	20	30	40
C	100-mile delivery (2004 freight rates)	$500	$500	$750	$1,000
D	Average speed on the road	38 mph	60 mph	60 mph	60 mph
E	Miles driven in 8-hour shift (six hours driving)	228 miles	360 miles	360 miles	360 miles
F	Revenue from six hours payload at 2004 rates	$1,140	$1,800	$2,700	$3,600
G	Variable costs	$684	$684	$1,007	$1,165
H	Available for overhead, profits, tolls	$456	$1,116	$1,693	$2,435
I	Extra earnings from using truckways per shift per day	N/A	$660	$1,237	$1,979
J	Assume extra productivity split three ways	N/A	$220	$412	$660
K	Shippers savings on 100-mile delivery	N/A	$61/12.2%	$76/15.2%	$91/18.3%

Source: Toll Truckways: Increasing Productivity and Safety in Goods Movement, presentation by Robert W. Poole, Jr. and Peter Samuel.

Table A.20 shows a comparison of costs between a standard semitrailer on an existing freeway configuration, and several configurations on a truckway including; a standard semitrailer, a triple, and a turnpike double. The semitrailer is the most common long-haul truck in all

48 contiguous states, while the turnpike double is the largest currently operational LCV. The results of this comparison show that significant gains in productivity are possible, when trucking companies take advantage of the truckways; revenue from 6 hours of payload transport increases from just over $1,100 with a standard semitrailer in mixed traffic to $3,600 using a turnpike double on a truckway.

I-35 Trade Corridor Study[50]

The I-35 Trade Corridor Study: Recommended Corridor Investment Strategies study reviewed a variety of alternative scenarios aimed at improving local, intrastate, interstate, and international service on I-35 from Texas to Minnesota. Because of the multimodal transportation hubs located through out the corridor and the connectivity the route provides to both Mexico and Canada, I-35 is positioned for increasing levels of international trade activity.

I-35 Study Alternative 4, Trade Focus Strategy (Partial NAFTA), centered on emphasizing the NAFTA function of the corridor. The alternative proposes to upgrade highways and use truckways to carry commercial vehicles with larger size and weight limits, where practical, for saving in purchase of additional right-of-way. The highest truck volumes within the corridor are in the south, between Dallas/Forth Worth and Laredo, Texas, where two alternative configurations were considered; a separate facility and a truckway within the I-35 right-of-way. Through the use of LCVs within the I-35 Corridor, freight would likely be diverted from smaller truck configurations to larger configurations, resulting in reduced truck travel. LCV moves were only assumed for the designated truckway portions.

The study resulted in the Trade Focus Strategy being recommended with best scores in categories of socioeconomic, environmental, traffic (i.e., operating cost, accident cost savings, and travel time savings) and feasibility. This alternative scored highest in these categories (over Alternative 2 – Highway Upgrade within Existing ROW and Alternative 6 – Highway Upgrade with Rail Implementation) because of the cost effectiveness of being able to add additional exclusive lanes for trucks, only where they are required. Alternative 4 scored second-best in the category of development cost. While Alternative 6 presents the option of removing trucks completely from the corridor through rail diversion, the alternative scored lowest in all categories. The feasibility of this alternative is low due to the large number of private sector parties that need to participate at a variety of levels (including cost sharing) in the future for implementation.

The I-35 study noted that there would be several obstacles to promoting the Trade Focus Strategy through this multijurisdictional study corridor. However by creating a seamless corridor the biggest benefits will be derived. Some of the key factors that will impact the effectiveness of LCV operations include: organizational complexity, regulatory complexity, carrier participation, credentials, and truck size and weight uniformity.

[50] I-35 Trade Corridor Study, Recommended Corridor Investment Strategies, HNTB & Wilbur Smith Associates for the Texas Department of Transportation, September 1999.

Western Uniformity Scenario Analysis[51]

As noted in previous maps, the western United States has the beginnings of a fairly robust LCV network; however, each state continues to maintain its own length and weight restrictions, oftentimes in conflict with trade partners in neighboring states. To try and develop a remedy to this situation, the Western Governors' Association commissioned the U.S. DOT to assess impacts of lifting the LCV freeze and allowing harmonized LCV weights, dimensions, and routes among only those western states that currently allow LCVs. Impacts on safety; pavement, bridge, and other infrastructure costs; shipper costs; energy consumption; environmental quality; traffic operations; and railroad revenues and costs associated with expanded LCV use in western states were estimated. The assumption was made that weights would be limited to a maximum gross vehicle weight of 129,000 pounds, and that any benefits achieved would be limited because of the limited scope of the study (i.e., did not take into account whole nation).

As a starting point the study forecast that in 2010 just over 25 percent of short- and long-haul truck traffic would divert to LCVs, and less than 0.1 percent of the rail traffic would divert. As shown in Table A.21, even though LCVs are allowed to operate in these states, the vast majority of vehicle miles traveled (VMT) is via conventional tractor trailers. This may be attributed to the variety of restrictions each state has, and the relative ease in operating standard vehicles between states, versus LCVs.

Table A.21 Forecasts of 2010 Base Case VMT by Vehicle Configuration and Western Uniformity VMT Impact for 13 Analyzed States

Vehicle Configuration	Base Case VMT (Millions)	Scenario VMT (Millions)	Scenario Percent Change
Five-Axle Tractor Semitrailer	14,476	3,442	-76%
Six-Axle Tractor Semitrailer	1,924	938	-51%
Five- or Six-Axle Double	1,351	750	-44%
Six-Axle Truck Trailer	626	607	-3%
Seven-Axle Double	188	2,190	+1,065%
Eight-or-More-Axle Double	213	5,626	+2,541%
Triples	45	473	+951%
Total	**18,823**	**14,028**	**-25%**

Source: Western Uniformity Scenario Analysis: A Regional Truck Size and Weight Scenario Requested by the Western Governors' Association, U.S. DOT, April 2004.

[51] Western Uniformity Scenario Analysis: A Regional Truck Size and Weight Scenario Requested by the Western Governors' Association, U.S. DOT, April 2004.

Additionally, as a result of reduced VMT, environmental impacts of the Western Uniformity Scenario are predicted to result in reductions of energy consumption (12 percent), noise cost (10 percent), and emissions (12 percent).

Table A.21 shows that if LCVs were harmonized in these states, it is predicted that there would be a 76 percent reduction in travel by conventional five-axle tractor-semitrailers, a 44 percent reduction of STAA doubles (five- or six-axle twin trailers with maximum trailer lengths of 28.5 feet) travel, and a 25 percent reduction in total heavy truck travel. "Because shipments that would divert to LCVs are longer than shipments that would not divert, the decrease in total travel is greater than the decrease in shipments by tractor-semitrailer. On a tonnage basis less than half of tractor-semitrailer shipments were estimated to divert to LCVs."[52]

This study also reviewed the added infrastructure cost of harmonizing western state LCV operations, a summary of which is shown in Table A.22. While costs increase due to bridge and geometric improvements, it is expected that pavement costs will be reduced, due to the reduced number of VMT. Also note that many of the LCV routes are currently designated as such, and already have strengthened pavement and bridges. These costs may not be typical of new, exclusive CMV-only applications.

Table A.22 Added Infrastructure Costs Attributable to the Western Uniformity Scenario
Millions of 2000 Dollars

Infrastructure Element	Base Case Improvement Costs	Total Incremental Cost	20-Year Annual Incremental Cost	Percent Change in Base Case Costs
Pavement Improvements	65,934[a]	-2,769	-138	-4.2%
Bridge Improvements	High 3,257 Low 1,586	4,125 2,328	206 116	+127.0% +147.0%
Geometric Improvements	864	776	65	+90.0%

Source: Western Uniformity Scenario Analysis: A Regional Truck Size and Weight Scenario Requested by the Western Governors' Association, U.S. DOT, April 2004.

[a] Total estimated pavement preservation cost in scenario states. Base case cannot be linked to vehicle with particular weights and dimensions as can bridge and geometric costs.

Finally, one of the most significant benefits highlighted in this study is that of shipper savings. Considering the majority of freight on the system travels by truck (approximately $610 billion per year business), even a modest saving in shipper cost, can make a significant difference. This study suggests that by expanding LCV operations shipper costs may be reduced by as

[52] Western Uniformity Scenario Analysis: A Regional Truck Size and Weight Scenario Requested by the Western Governors' Association, U.S. DOT, April 2004.

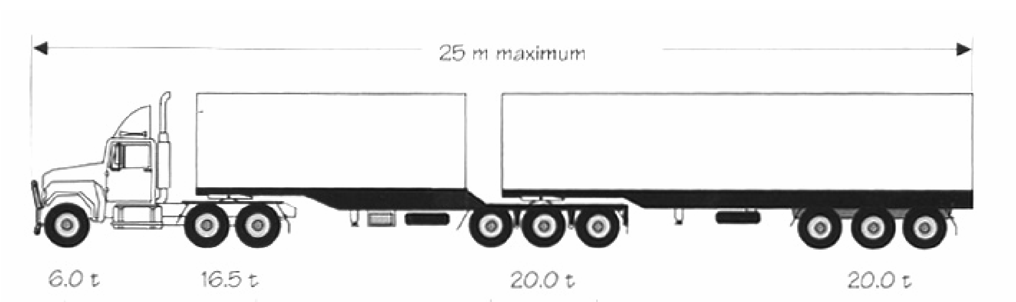
much as $2 billion per year, representing an almost four percent saving of total shipper costs with the region.

International Experiences[53]

The Reason Foundation conducted research on LCV operations in Canada and Australia as part of their toll truckways project. These countries were selected because of their large area expanse and the need for goods movement from coast to coast. Over the course of the last two decades each of these countries has implemented longer and heavier weight allowances, enabling them to compete more effectively with the United States. While neither country has implemented a true CMV-only lane concept, through truck size and weight reform, each county has achieved successes that can be fed in to United States consideration for CMV-only lanes.

Key to both Canada's and Australia's success is the use of the "B Train," or "B Double," an LCV combination that uses tridem axle groupings, allowing improved handling and safety while being able to haul larger loads (i.e., 49,600 pounds in most of Canada and Australia, and up to 52,900 pounds in some parts of Canada). Figure A.16 provides and example of the tridem axle grouping used in Canadian and Australian configurations.

Figure A.16 B-Train with Tridem Axle Grouping



Source: Toll Truckways: Increasing Productivity and Safety in Goods Movement, presentation by Robert W. Poole, Jr. and Peter Samuel.

In Australia a national road network has been built to accommodate B Doubles in all six Australian states and two territories, on all freeways, tollways, and expressways, and many of the principal arterials in major metropolitan areas like Sydney and Melbourne. This network allows trucks to be loaded to a gross vehicle weight of 150,000 pounds. While safety is always a concern, the Australian Automobile Association notes that accidents have been reduced. And, the National Road Transport Commission (NRTC) estimates that "the 1999 increases in truck weights have resulted in economic benefits that far outweigh the costs associated with heavier trucks; the benefits of more liberal weight limits have resulted in economic benefits to the trucking industry of approximately (U.S.) $279 million per year, plus $6 million in lower

[53] *Toll Truckways: A New Path Toward Safer and More Efficient Freight Transportation*, The Reason Foundation, Peter Samuel, Robert W. Poole, Jr., and José Holguin-Veras, June 2002.

pavement costs for total savings of $285 million per year. Costs include $6 million annually for road-friendly suspensions, $13 million for bridge upgrades, and $5 million in extra compliance costs for total costs of $24 million. Net benefits are therefore $261 million annually, and the benefit/cost ratio is 11.9."[54]

A.6.3 Policy Changes Required for LCV Implementation

Based on the information presented in this chapter, it is evident that several policy changes will need to be made in order for expanded LCV operations to come about, including LCV operations on CMV-only lanes. While U.S. DOT reports state the need for reform of truck sizes and weights in order to increase freight system productivity and efficiency, and provide cost savings to the end consumer, implementing legislation has not emerged. Part of the difficult piece of the conversation is the topic of private enterprise, and the railroads versus the trucking companies. Another part of the conversation relates to how much involvement the government should have in placing (or lifting) restrictions – particularly in cases where highway safety may be compromised.

The Reason Foundation, in their research has posed several recommendations with respect to LCV operations that concur with the findings within this chapter. These recommendations are as follows:[55]

- **Provision of right-of-way in interstate and freeway corridors (Federal and state) –** The Federal government to encourage states to make available right-of-way within existing intercity highway corridors on the Interstate system and other routes in the National Network to allow LCV corridors to be established.

- **Liberalized size and weight limits on truckway lanes (Federal and state) –** For any new lanes designated as truckways, the current LCV freeze on truck sizes and weights should be lifted.

- **Removal of ban on interstate tolling for truckway lanes (Federal and state) –** The current prohibition on charging tolls on Interstates should not apply to new truckways, and it is predicted that LCVs will use these truckways because of productivity gains.[56]

[54] *Toll Truckways: A New Path Toward Safer and More Efficient Freight Transportation*, The Reason Foundation, Peter Samuel, Robert W. Poole, Jr., and José Holguin-Veras, June 2002.

[55] *Corridors for Toll Truckways: Suggested Locations for Pilot Projects*, Reason Public Policy Institute, Robert W. Poole, Jr. and Peter Samuel.

[56] *Toll Truckways: A New Path Toward Safer and More Efficient Freight Transportation*, The Reason Foundation, Peter Samuel, Robert W. Poole, Jr., and José Holguin-Veras, June 2002.

A.7 Task 6 – Tolling and Privatization

7.1 Introduction

This chapter presents a discussion on tolling and privatization issues pertaining to the development of CMV-only lanes. There has been a growing interest in the application of tolls for the financing of highway projects, and numerous projects have already been implemented in the United States as well as other parts of the world through the application of toll financing. One of the primary factors driving the growth of interest in tolls for the development of highway projects is the limited public sector funds available through traditional revenue sources such as gas taxes to finance large-scale multimillion-dollar highway projects. According to transportation officials across many States, tolls in many cases are the only way they can finance new road capacity because most of their budget already goes into maintenance and reconstruction of existing highways. Tolling allows States the capability to build new highways that otherwise would remain on the drawing board for many years if they had to be funded with traditional pay-as-you-go financing. Interestingly, this view also appears to be shared by the public. According to a recent AAA nationwide survey[57] conducted in November 2006 to understand public perceptions about the most favorable financing options for transportation system improvements, 52 percent of respondents were in favor of some form of tolling to help finance transportation facilities, while increasing motor vehicle fuel taxes received support from only 21 percent.

As discussed in other chapters of the report, there are currently no toll financed CMV-only lanes in operation in the United States. However, numerous studies have been conducted on analyzing the feasibility of toll financed CMV-only lanes. The application of tolls for trucks operating on CMV-only lanes, and use of the toll revenues to finance them, has been reported to be a particularly promising concept in various studies, due to the higher value of time and reliability of trucks compared to passenger vehicles, and the congestion reduction benefits for trucks operating on CMV-only lanes. Studies conducted by the Reason Foundation have supported the implementation of toll truckways with LCV operations, based on the rationale that operating LCVs on dedicated truckways offer truckers not only travel time and reliability benefits, but increased productivity, for which truckers would be willing to pay higher tolls. Other studies conducted on the planning and feasibility analysis of tolled CMV-only lanes include a toll truckway feasibility study in Miami, a study on the feasibility of a metropolitan truck-only toll (TOT) lane network in Atlanta, the Trans-Texas Corridor (TTC) study, and planning and feasibility studies for dedicated truck-only lanes in Southern California. Subsequent chapters of this chapter provide a brief discussion on the tolling and privatization considerations for some of these projects.

The information presented in this chapter is organized as follows: Chapter 7.2 presents a discussion on the feasibility of the application of tolls on CMV-only lanes, based on value of time, reliability, and productivity considerations; Chapter 7.3 presents privatization opportunities for the development and operation of CMV-only lanes with tolls – specifically, this chapter talks about the benefits of private sector participation in the development of CMV-only lanes, the major types of toll financing opportunities, uses of revenues from tolling, and

[57] Transportation Omnibus Pockets of Pain Survey, November 2006.

perceptions of the private financial community on privatization of CMV-only lanes; Chapter 7.4 presents a discussion on tolling and privatization issues associated with some of the major toll truckway projects being planned in the United States; and Chapter 7.5 presents a discussion of examples of truck tolling approaches from other countries.

A.7.2 Feasibility of Tolls on CMV-Only Lanes

This chapter attempts to address the question on whether it is feasible to apply tolls on trucks operating on CMV-only lanes, and what the implications of applying tolls would be on the trucking industry, as well as potentially on the public sector. An analysis of the feasibility of tolls on CMV-only lanes would be incomplete without understanding the dollar value of benefits accruing to the trucking industry from CMV-only lanes, specific elements under which include travel time benefits, and productivity benefits from the operation of LCVs. The following chapters discuss value of time for trucks, including potential variations in values of time across different segments of the trucking industry, and value of productivity improvements. Information on implications of tolls on trucks and addressing of issues such as double taxation on trucks (payment of tolls in addition to taxes), and their impacts on public sector funds (such as the highway trust fund) are also presented in this chapter.

Truck Value of Time Estimates

According to Hsing-Chung[58], a trucker's value of time is a function of many factors, which include, but may not be limited to, the type of trucking business operation (for example, for-hire and private carriers), truck trip length characteristics (short-haul versus long-haul trips), the type of truck (medium versus heavy trucks), the type of delivery schedule (not fixed delivery schedule and penalty on late delivery), as well as the type of highway facility (noncongested rural highways and urban heavily congested areas). Several methods have been employed to measure a trucker's value of time, including:

- Revenue or net operating profit method: This method estimates truck value of time in terms of the net increase in profit resulting from reduction in travel times.
- Cost-saving method: This method estimates truck value of time in terms of the cost savings to truck operators per unit of time.
- Cost-of-time method: This method calculates the cost of providing time savings for a specific project (Adkins et al.59).
- Willingness-to-pay method: This method measures the "market" or "perceived" value of time for trucks based on observed or stated choices under tradeoff situations involving time and money.

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[58] Hsing-Chung Chu, *Implementing Truck-Only Toll Lanes at the State, Regional and Corridor Levels: Development of a Planning Methodology*, Georgia Institute of Technology, PhD Dissertation, December 2007.

[59] Adkins et al., *Value of Time Savings of Commercial Vehicles,* Highway Research Board, Washington, D.C., 1967.

Kawamura[60] computed value of time for trucks using the willingness-to-pay method by conducting stated-preference surveys of 70 truck operators in California. The value of time was calculated by estimating a modified logit model in which the coefficients to be estimated were assumed to be distributed lognormally across the population. The random coefficient logit model developed from the survey data indicated that the mean and standard deviation of the value of time were $23.4 per hour and $32 per hour respectively. Comparison of survey data sets segmented based on business type, size of shipment, and the method of driver compensation provided some useful insights into variations in truck value of time, such as:

- For-hire trucks were observed to have higher value of time than private carriers;
- Truckload carriers are observed to have a higher value of time compared to Less-than-Truckload (LTL) carriers; and
- Companies paying hourly wages to drivers were observed to have higher values of time than those who pay by commission or fixed salary.

Kawamura assumed that the value of time data obtained from a survey can be modeled as a random variable with a lognormal distribution. Table A.23 summarizes the differences in value of time statistics for various truck categories, where the value of time estimates are in 1999 dollars.

Table A.23 Value of Time Distributions

Data Group	Mean	St. Dev.	Mode	Median
All	23.4	32.0	4.8	13.9
Private	17.6	24.8	3.4	10.1
For-Hire	28.0	32.4	7.8	18.3
TL	25.0	40.4	3.6	13.1
LTL	22.6	25.0	6.8	15.2
Hourly Pay	25.4	33.5	5.6	15.3
Other Pay Scale	15.1	14.9	5.5	10.7

Note: Values are in $/hour.

Source: Kazura Kawamura, *Commercial Vehicle Value of Time and Perceived Benefit of Congestion Pricing*, UC Berkeley Dissertation, 1999.

Another example of work conducted on truck value of time estimation using the willingness-to-pay method is the research conducted by Smalkoski et al.[61] In this study, interviews of truck operators were conducted using an adaptive stated-preference (ASP) survey to derive an

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[60] Kazura Kawamura, *Commercial Vehicle Value of Time and Perceived Benefit of Congestion Pricing*, UC Berkeley Dissertation, 1999.

[61] Smalkoski, Brian, and Levinson, D. (2005), *Value of Time for Commercial Vehicle Operators*. Journal of the Transportation Research Forum 44:1 89-102.

estimate for truck value of time to the nearest dollar using a tobit model constructed from survey data. The mean truck value of time was estimated to be $49.42, with a 95 percent confidence interval from $40.45 to $58.39. The study observed that the variation in the distribution of values was largely a function of the type of fleet operation (for-hire truck fleet or private carriers). Table A.23 summarizes truck value of time estimates observed from various sources.

A study conducted by Parsons Brinckerhoff on the feasibility of truck-only toll (TOT) facilities in the Atlanta region[62] assumed value of time for light-duty and heavy-duty trucks, in 2005 dollars, of $18 per hour and $35 per hour, respectively, for the purpose of estimating the feasibility of tolls on the TOT lanes.

As described earlier, another approach to estimating truck value of time, which is particularly applicable to truck value of time estimation for port truck trips, is the net operating profit or revenue method, which calculates truck value of time as the net operating profit resulting from travel time savings. This method finds applications in evaluating the feasibility of toll truckways for ports, and was used in the Miami toll truckway feasibility study[63] completed in November 2007 by the Reason Foundation. In this study, the travel time savings for drayage truck trips from the use of the toll truckway were estimated, and converted into equivalent increase in total daily drayage trips. The revenue generated from the increase in daily trips (which is equal to the revenue per trip times the number of additional drayage trips) less the costs involved from operating on the toll truckway resulted in the net operating profit estimates, which were used along with the travel time savings to calculate port truck value of time. The truck value of time from the study was estimated to be around $25 per hour.

Owing to the inherent complexities in estimating the value associated with increases in travel time reliabilities resulting from operations on truck-only lanes, some studies on truck-only lanes have attempted to account for value of travel time reliabilities within value of time estimates. Notable among these studies is the I-710 Major Corridor Study (MCS).[64] In this study, the value of time estimate of $30 per hour was doubled to account for value of travel time reliabilities, and test the feasibility of applying higher toll rates on the truck-only lanes.

Impact of Truck Value of Time on Tolls

Truck value of time is a key input in estimating the magnitude of tolls that can be applied on truck-only lanes. Estimating the magnitude of tolls is an important element in the planning and feasibility analysis for truck-only lanes, to evaluate the revenue generation potential and financial feasibility of these facilities. Variations in value of time by type of truck and type of trucking operation, as observed earlier, are also important in understanding equity implications of tolls on the trucking industry, and determining variability in tolls for different trucking industry segments.

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[62] Parsons Brinckerhoff Quade & Douglass, Inc., *Truck-Only Toll Facilities: Potential for Implementation in the Atlanta Region*, July 2005.

[63] Robert W. Poole, Jr., *Miami Toll Truckway: Preliminary Feasibility Study,* Reason Foundation, Policy Study 365, November 2007.

[64] I-710 Major Corridor Study (MCS), Final Report, March 2005.

The Reason Foundation study[65] on toll truckways provides a methodological example of estimating tolls based on truck value of time considerations. In the absence of survey data on trucker's willingness to pay tolls and the unavailability of detailed demand modeling tools, the tolling analysis in the study assumes that "trucking firms would be willing to pay a toll of up to one-half of the cost savings that would be generated from the use of toll truckways." The cost savings generated from toll truckways are estimated based on the net travel time savings for trucks operating on the toll truckways, and average truck value of time assumptions.

The I-710 MCS performed a detailed financial feasibility analysis of dedicated truck lanes along the I-710 corridor by evaluating the revenue potential from the application of tolls. The analysis was based on considerations of the tradeoff for truckers between travel time savings on the dedicated truck lanes and the cost of the tolls. The analysis relied on travel time data estimated from the I-710 subarea focus travel demand forecasting model (which estimated the net travel time savings for truckers operating on the dedicated truck lanes) and truck value of time data obtained from a stated-preference survey by researchers at the University of California at Berkeley. For the purpose of the tolling analysis, trucks were split into five value-of-time categories for each of two gross vehicle weight (GVW) ranges – 8,500 to 33,000 pounds, and greater than 33,000 pounds. The study illustrated the impacts of truck value of time assumptions on toll values for a desired utilization of the dedicated truck lanes. For example, to capture 50 percent of the truck traffic on I-710 on the truck lanes, the toll values were estimated to vary based on value of time assumptions, as follows:

- $0.105 per mile for value of time of $18 per hour;
- $0.175 per mile for value of time of $30 per hour; and
- $0.35 per mile for value of time of $60 per hour.

The above variations are representative of the differences in truck value of time based on truck type. As described earlier, toll rate for a $60 per hour assumption was tested to account for value of travel time reliability benefits accruing from truck operations on the dedicated truck lanes.

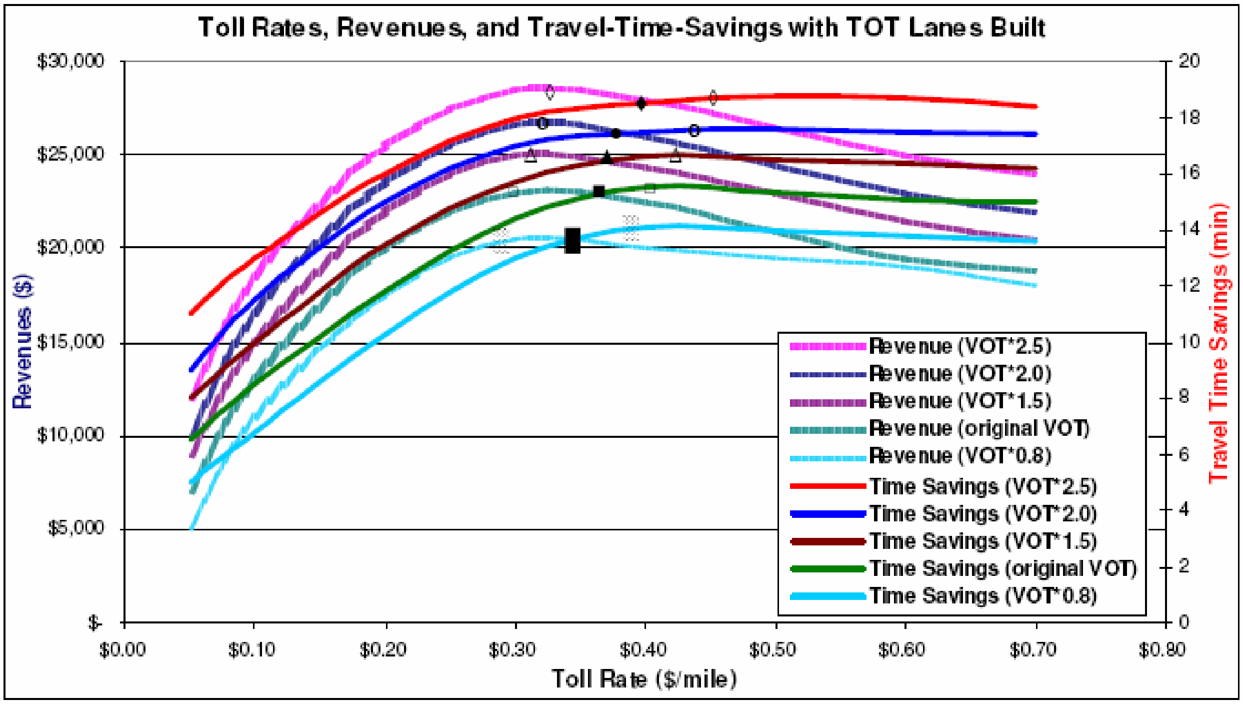
Holguin et al.[66] in their research on the economic and financial feasibility of toll truckways also emphasize the importance of considering trucker's marginal costs associated with traffic congestion, which is directly related to truck value of time, among other factors (such as capacity constraints, and user's willingness to pay) in the estimation of tolls. Their research also makes the assumption, like the Reason Foundation study discussed earlier, that "the maximum toll that would be attractive to trucking companies would be one that captures 50 percent of the direct operational cost savings," implying that the remaining 50 percent of the savings in operational costs would serve as an incentive for trucking companies to use the toll truckways.

[65] Peter Samuel, Robert W. Poole, Jr., and Jose Holguin Veras, *Toll Truckways: A New Path Toward Safer and More Efficient Freight Transportation,* Reason Foundation, Policy Study 294, June 2002.

[66] Jose Holguin Veras, David Sackey, Sajjad Hussein, Victor Ochieng, *On the Economic and Financial Feasibility of Toll Truckways,* TRB 2003 Annual Meeting.

Hsing-Chung Chu[67] conducted sensitivity analysis of various trucker's value of time to understand the relationships between toll rates, and key performance measures for truck-only toll lanes, such as revenue generation potential, congestion (travel time savings), and TOT lane utilization rates. Figure A.17 illustrates these relationships, for various value of time scenarios.

Figure A.17 Relationship between Toll Rates, Revenues, and Travel Time Savings for Various Truck Value of Time Scenarios



Source: Hsing-Chung Chu, *Implementing Truck-Only Toll Lanes at the State, Regional, and Corridor Levels: Development of a Planning Methodology,* Ph.D. Dissertation, Georgia Institute of Technology, December 2007.

Figure A.18 depicts optimal toll rates for various value of time scenarios that would result in maximum revenues. As expected, toll rates higher than the optimal values would result in a decrease in total revenues due to a reduction in utilization of the toll truckway. These relationships can serve as important inputs as part of financial feasibility analyses of TOT lanes to determine optimal toll rates and revenue generation potential of TOT lanes.

[67] Hsing-Chung Chu, *Implementing Truck-Only Toll Lanes at the State, Regional and Corridor Levels: Development of a Planning Methodology*, Ph.D. Dissertation, Georgia Institute of Technology, December 2007.

Productivity Benefits from LCV Operations and Associated Tolling Implications

In August 2000 the U.S. DOT, conducted a truck size and weight study,[68] which documented the significant productivity gains that could be realized by the trucking industry with the permitted operations of Longer Commercial Vehicles (LCVs) on more of America's highways. The study reported a potential to realize net savings of between $10 billion and $40 billion per year for the trucking industry from expanded LCV operations. However, the study failed to address the safety implications associated with allowing longer and heavier LCVs to use the nation's highway system.

The Reason Foundation study on toll truckways discussed earlier is the first comprehensive study that looks at the feasibility of developing toll truckways to support LCV operations, based on considerations of productivity benefits of LCV operations. The study analyzes how productivity benefits from LCV operations on toll truckways would provide the incentive for the application of tolls on these truckways as a way of financing these facilities. Toll truckways, owing to their physical separation from general purpose lanes, also address safety concerns of operating LCVs on general-purpose lanes, by completely eliminating the interaction between autos and LCVs.

A PowerPoint presentation given by Robert Poole and Peter Samuel from the Reason Foundation on the productivity and safety benefits of toll truckways specifically accounts for the value of productivity gains from LCV operations in the estimation of tolls on toll truckways. The analysis compares the value of productivity gains for the following truck configurations on toll truckways relative to current trucking operations on mixed freeways:

- Semitrailers on toll truckways;
- STAA-doubles on toll truckways;
- Triples on toll truckways; and
- Turnpike-doubles on toll truckways.

A description of the physical characteristics of the above truck configurations has been presented in Section A.5 on LCV Operations. The Reason Foundation approach for the quantification of productivity benefits from LCV operations is based on the estimation of the incremental earnings for truck operators per day and the average number of miles driven per day on toll truckways, to arrive at the incremental earnings per mile. Thus, the approach not only considers the increase in payload due to LCV operations, but also the productivity gains associated with higher speeds on toll truckways, in the quantification of productivity benefits. Based on the estimation of the value of productivity benefits, the study goes on to estimate the feasible toll rates that could be applied, based solely on the productivity gains to trucking firms from LCV operations on toll truckways. The inherent assumption in this analysis is that trucking firms would be willing to pay one-third of the value of productivity benefits from LCV operations in the way of tolls. Table A.24 summarizes the results from this analysis, providing estimates for the value of productivity benefits as well as the feasible toll rates for various operational scenarios on toll truckways.

[68] http://www.fhwa.dot.gov/reports/tswstudy/tswfinal.htm.

Table A.24 Toll Truckway Productivity Benefits and Associated Toll Scenarios

	Mixed Freeway		Toll Truckway			
	Semitrailer	**Double-Shorts**	**Semitrailer**	**Double-Short**	**Triple-Short**	**Double-Long**
Payload	45,000 pounds	45,000 pounds	45,000 pounds	45,000 pounds	67,500 pounds	90,000 pounds
Metric tons	20 tons	20 tons	20 tons	20 tons	30 tons	40 tons
100-mile delivery – 2004 freight rates	$500	$500	$500	$500	$750	$1,000
Average speed on the road	38 mph	38 mph	60 mph	60 mph	60 mph	60 mph
Miles driven in 8-hour shift (6 hours driving)	228 miles	228 miles	360 miles	360 miles	360 miles	360 miles
Revenue from 6 hours payload at 2004 rates	$1,140	$1,140	$1,800	$1,800	$2,700	$3,600
Variable costs	$684	$684	$684	$684	$1,007	$1,165
Available for overhead, profits, tolls	$456	$456	$1,116	$1,116	$1,693	$2,435
Extra earnings from using truckway per shift per day			$660	$660	$1,237	$1,979
Drop assumption of no change in freight rates			–	–	–	–
Assume the extra productivity split 3 ways			3 x $220	3 x $220	3 x $412	3 x $660
Shipper's savings on 100-mile delivery, percent			$61 (12.2%)	$61 (12.2%)	$76 (15.2%)	$91 (18.3%)
Additional for trucker overhead and profit per day			$220	$220	$412	$660
Truck tollway – possible toll per mile			$.61 per mile	$.61 per mile	$1.15 per mile	$1.83 per mile

Source: Robert W. Poole Jr. and Peter Samuel, *Toll Truckways: Increasing Productivity and Safety in Goods Movement*, PowerPoint Presentation.

Based on the results in Table A.24, double-long LCV operations on toll truckways yield maximum productivity benefits, and consequently, the maximum toll rates, followed by triple-short LCV operations. Operations of standard trucks (semitrailers and double-shorts) also yield productivity benefits due to higher speeds on toll truckways, even though there is no net increase in payloads. The maximum feasible toll rate is observed for double-long trucks of $1.83 per mile, followed by $1.15 per mile for triple-short trucks. As discussed earlier, this is based on the assumption that trucking firms would be willing to pay up to one-third of the total value of productivity gains achieved from operating on toll truckways. This is also based on the assumption that trucking firms would translate one-third of the remaining productivity gains to shipper benefits in terms of offering reduced freight rates to shippers, and the remaining one-third of the productivity gains as net profit.

Feasibility of Tolls Based on Tax Considerations

As presented in the earlier chapters, the most viable method for the estimation of tolls on dedicated truck-only lanes is based on the quantification of the value of travel time savings and productivity benefits from operations on dedicated truck-only lanes. Most of the studies that have applied this method for the estimation of feasible tolls have done so based on generic assumptions about trucker's willingness to pay tolls, without detailed stated-preference data from trucking companies, and without the application of advanced travel demand models. However, as discussed in Samuel et al., it is important to consider other factors such as taxes in the analysis of the feasibility of tolls on dedicated truck-only lanes. They state that taking a look at the current taxes paid by trucks can provide reliable insights into trucker's willingness to pay tolls, and serve as key inputs in a toll feasibility analysis.

The study, conducted in June 2002, reports that heavy trucks pay diesel fuel taxes and other taxes and fees of the order of around 16 cents per mile (in 2000 dollars), which is split about 7 cents per mile for Federal taxes, and 9 cents per mile for state/local taxes and fees. It also states that, according to FHWA data, LCVs currently operating on designated routes pay about one-third more than average combination trucks (semitrailers and double-shorts), implying that LCVs pay approximately 21 cents per mile in Federal and state/local user taxes. These figures can be used to understand the willingness to pay of standard combination trucks as well as LCVs currently allowed on United States highways.

Consideration of current Federal and state/local taxes paid by trucks in the feasibility analysis of tolls on dedicated truck-only lanes is particularly important in the case of mandatory enforcement of truck operations on toll truckways (without the choice to operate on general purpose lanes), which is pertinent in the case of LCV operations. The Reason Foundation study states that, under these conditions, a strong case exists for not charging user taxes for trucks on toll truckways. The study argues that applying tolls for trucks on toll truckways in addition to levying Federal and state/local user taxes would be equivalent to "double taxation," and would potentially encounter strong trucking industry opposition. The study proposes the following potential solutions aimed at resolving the "double taxation" issue, and making tolls feasible for application on toll truckways:

- **Providing rebates to trucking companies for the user taxes paid for all recorded miles traveled on the toll truckways**. Electronic toll collection systems used by toll truckway operators along with transponders fitted on each truck operating on the truckway would be used to record the total miles driven by each truck on the toll truckway. Subsequently, trucking company-specific mileage records would be provided on a periodic basis (e.g.,

monthly) to the relevant state taxing authority, which would, in turn, issue the equivalent rebates to the trucking companies.

- **Providing rebates to the toll truckway operator instead of to individual trucking companies**. Under this scenario, the truckway operator would charge each truck user a net toll, which would be equivalent to the toll rate per mile minus fuel taxes per mile for each truck class. Total miles driven by each truck class would be recorded by the truckway operator, and transmitted periodically to a state agency. The agency would, subsequently, remit the appropriate amount of Federal and state fuel tax revenues to the truckway operator to help cover its operating costs. The advantage of this scenario compared to the former one is that the state agency would need to deal only with the truckway operator, rather than having to deal with numerous trucking firms.

Impact on Highway Trust Funds

A concurrent issue arising from the solutions proposed above to dealing with "double taxation" for trucks operating on toll truckways is the public sector (such as state DOTs) concern regarding the prospect of losing fuel-tax revenues from the trucking industry. This chapter addresses the question on would the implementation of tolls on dedicated truckways, concomitant with tax rebates for trucks operating on these truckways, potentially cause harm to State Highway Trust Funds (HTFs), by making them less able to meet their states' highway investment needs. The Reason Foundation study on toll truckways provides some useful insights to help answer this question. The study, based on quantitative estimates of the net benefits and costs associated with applying tolls along with tax rebates, reports that the addition of a self-supporting toll truckway would benefit a state DOT in two fundamental ways, which are discussed below:

- The addition of a toll truckway to an existing highway corridor would provide new lane capacity at a location where it was needed, and where the state DOT would otherwise, presumably, have to spend its own funds to realize that capacity. Thus, through the implementation of a toll truckway, the DOT would avoid the cost of adding that lane capacity.

- The toll truckway would lead to significant reductions in wear and tear on general purpose lanes by attracting between 25 and 100 percent of existing heavy duty truck traffic off of these lanes. This would, in turn, result in significant reduction in the DOT's maintenance and rehabilitation expenditures.

The study compares the above state DOT benefits to the loss of fuel-tax revenues resulting from the diversion of trucks to the toll truckway. This analysis was based on the consideration of four scenarios, in which the toll truckway attracts 25, 50, 75, and 100 percent of the heavy duty trucks away from the general purpose lanes. The analysis is based on the assumption that the Federal and state fuel taxes paid by heavy duty trucks equal 16 cents per mile. The net cost to the DOT of adding a toll truckway to an existing highway corridor would include the difference between the fuel-tax revenue losses and the total cost savings. The total cost savings, as described above, have two components, which include 1) savings in operational and maintenance (O&M) costs due to diversion of trucks from general purpose lanes to the toll truckway, and 2) savings in costs avoided by the DOT by virtue of the fact that a third party (such as a private firm under a long-term concession agreement) assumes the risks associated

with financing, building, operating, and maintaining the new truckway (a task the state DOT would have had to take on otherwise).

Table A.25 presents the results from the benefits and costs analysis. As can be seen from the table, the DOT's annual costs avoided (implementation and O&M costs) are greater than the net fuel tax revenue losses, implying that the addition of toll truckways paid for solely by tolls would be a positive-sum game for state DOTs.

Table A.25 Annualized Impact of Toll Truckway Implementation on State DOT
Per Lane-Mile of Toll Truckway

Truck % in TTW	Truck ADT in TTW	Fuel tax loss to DOT	O&M savings to DOT	Net cost to DOT	Avoided cost of new lane
25%	1,000	$58,400	$6,090	$52,310	$352,428
50%	2,000	$116,800	$13,298	$103,502	$366,250
75%	3,000	$175,200	$37,558	$137,642	$381,478
100%	4,000	$233,600	$47,101	$186,499	$389,788

Source: Peter Samuel, Robert W. Poole, Jr., and Jose Holguin Veras, *Toll Truckways: A New Path Toward Safer and More Efficient Freight Transportation,* Reason Foundation, Policy Study 294, June 2002.

Use of Revenues from Tolls

The use of revenues from tolls applied on dedicated truck-only lanes would depend on the type of financing approach used to develop these facilities. Traditional approaches to highway financing include application of state and Federal funds and toll revenue bonds (in the case of toll financed highways). Toll revenue bonds for financing toll roads are defined as bonds issued to generate funds for developing a toll road, whose principal and interest are secured solely by the tolls paid by users of the facility. Toll revenue bonds are more speculative compared to "general obligation" bonds, which are guaranteed by state or local government tax revenues. However, one of the advantages of revenue bonds is that these bonds allow the bond issuer to avoid reaching legislated debt limits.

In the case of traditional financing of truck-only toll (TOT) lanes using toll revenue bonds, the public entity undertaking the development of the project, such as a state toll authority, would issue toll revenue bonds to investors, to generate funds for the project. The toll revenues obtained from trucks operating on the TOT lanes in this case would be used for the annual debt service for the bonds. Additionally, toll revenues could also help cover the annual O&M costs associated with the TOT lanes. The Reason Foundation study on toll truckways reports that for a rural, two-lane toll truckway having a capital cost of approximately $2.5 million per route-mile, tolls must generate revenues of around $365,000 per mile per year to cover $250,000 in annual debt service and $115,000 in annual O&M costs. These estimates are, however, intended to serve as a rough rule of thumb, in the absence of resources to conduct more rigorous analyses.

An alternative approach to the development of TOT lanes, which is gaining widespread attention and favorability, is the application of a Public Private Partnership (PPP). Under a

PPP, a public entity would enter into a long-term franchise agreement with the private sector (represented in the form of a private entity or consortium) to finance, build, and operate the facility for a specific timeframe specified under the franchise agreement, at the end of which, the ownership of the facility would be reverted back to the public entity. The private consortium would use toll revenues from the facility to repay its debt as well as derive profit. The application of tolls on TOT lanes as a revenue generation mechanism is critical to the realization of the return on investment (ROI) required by the private sector to participate in the financing and development of TOT lanes.

An approach to assessing the viability of private sector participation in the financing and development of TOT lanes is through the estimation of the private ROI. A positive ROI would imply that the toll revenues would be sufficient to cover the capital and operating costs of the truckways, and also provide a return on the funds invested. Typical inputs required for the estimation of private ROI for TOT lanes include toll rates (in terms of dollars per mile), private capital costs (in terms of dollars per mile), total traffic volumes (in terms of average daily traffic (ADT)), total truck traffic volumes, and share of truck traffic diverted to the toll truckway. Samuel et al., using these inputs, provide estimates for the private ROI for various toll rate, truck traffic diversion, and capital cost scenarios, to assess the feasibility of private sector investment in toll truckways. Table A.26 presents these estimates.

Table A.26 Private ROI for Toll Truckways for 40,000 ADT

a) $1 million/mile capital cost		
TRAFFIC	Toll=$0.40	Toll=$0.80
25% Trucks (1000)	8.60%	17.26%
50% Trucks (2000)	16.85%	33.12%
75% Trucks (3000)	23.92%	48.46%
100% Trucks (4000)	32.72%	64.52%
b) $2 million/mile capital cost		
TRAFFIC	Toll=$0.40	Toll=$0.80
25% Trucks (1000)	4.12%	9.17%
50% Trucks (2000)	8.85%	17.34%
75% Trucks (3000)	13.04%	25.31%
100% Trucks (4000)	16.97%	33.19%
c) $3 million/mile capital cost		
TRAFFIC	Toll=$0.40	Toll=$0.80
25% Trucks (1000)	2.26%	6.23%
50% Trucks (2000)	5.97%	12.02%
75% Trucks (3000)	9.03%	17.40%
100% Trucks (4000)	11.76%	22.66%

Source: Peter Samuel, Robert W. Poole, Jr., and Jose Holguin Veras, *Toll Truckways: A New Path Toward Safer and More Efficient Freight Transportation,* Reason Foundation, Policy Study 294, June 2002.

The ROI estimates can be used to assess the ability of toll truckways to attract private sector investment. Positive ROIs in Table A.26 indicate that the toll truckway would enable the complete recovery of costs, which are encouraging from a private sector's perspective for investment in these facilities.

A Government Accountability Office (GAO) report[69] points to the many advantages of toll financing of highway projects, which include:

- Provision of new revenues;
- Promotion of more effective investment strategies;
- Better targeting of spending for new and expanded capacity; and
- Leveraging of existing revenue sources, via private-sector investment.

The following chapter discusses some of the advantages of privatization of truck-only toll facilities, and provides summary information on how the private financial community has reacted to proposals for truck-only toll lanes.

A.7.3 Privatized Truck-Only Toll (TOT) Facilities

The potential for private sector participation in the financing and development of TOT lanes has already been described in the previous chapter. Public sector budgetary constraints are a major factor that have led to an increasing focus on attracting private capital investment for the development of multimillion-dollar highway projects. As an example, FHWA's 2004 Conditions and Performance Report[70] provides a clear picture of the magnitude of public sector funding shortfall, of the order of $6 billion per year to maintain asset value, and $51 billion per year to maintain system performance.

In addition to monetary issues, there are a host of other advantages to privatization of TOT lanes, compared to traditional approaches to developing these facilities. According to a presentation[71] given by Robert Poole from the Reason Foundation to the National Surface Transportation Policy and Revenue Study Commission in October 2006, private sector involvement in developing TOT lanes has the following advantages:

- Large pool of new capital;
- Ability of raise more capital for a given project;
- Transfer of risk from the public to the private sector;
- Potential to develop multistate projects (this can be a key issue in the case of states that do not have public toll authorities);

[69] GAO-06-554, June 2006.

[70] http://www.fhwa.dot.gov/policy/2004cpr/.

[71] http://www.transportationfortomorrow.org/pdfs/commission_meetings/1006_meeting_washington/poole_presentation_1006_meeting.pdf.

- A more commercial approach to the development of TOT lanes, which implies less probabilities associated with cost and schedule overruns; and

- Potential for innovation.

Private sector involvement also offers some degree of flexibility, to the extent allowed under a long-term concession agreement, to increase toll rates to control demand, fund needed improvements, or raise rates based on inflation, without the fear of political interference. Table A.27 summarizes the risk transfer advantages (from tax payers to investors) associated with TOT lanes developed through private concession agreements as part of a PPP.

Table A.27 Risk Transfer in Private Concession Agreements

	Traditional	Long-Term PPP
Funding Source	Highway trust funds	Toll revenue bonds, equity
Procurement Process	Design-Bid-Build	Design-Finance-Build-Operate
Cost Overruns?	Taxpayers	Investors
Schedule Slips?	Drivers	Investors
Traffic Risk?	Taxpayers	Investors
Maintenance Funds	Annual appropriations	Toll revenues
Maintenance Incentive	Public complaints	Asset value

Source: http://www.transportationfortomorrow.org/pdfs/commission_meetings/1006_meeting_washington/poole_presentation_1006_meeting.pdf.

Some of the key issues from a public sector's perspective in the private sector financing and development of TOT facilities would include 1) how to ensure that the public sector's long-term interests in TOT facilities are protected?, and 2) how the private concession agreements can be designed and implemented to provide equitable public and private sector benefits? As discussed in the Gilroy et al. report[72] from the Reason Foundation, the public sector would address these issues by incorporating enforceable and detailed provisions and requirements in the concession agreement, focusing on key issues such as:

- Payment responsibilities for future expansions and rebuilding; and decisions regarding scope and timing of these projects;

- Performance requirements for the TOT lanes and the private toll operator (such as safety, operations, maintenance, etc.);

[72] Leonard C. Gilroy, Robert W. Poole, Jr., Peter Samuel, and Geoffrey Segal, *Building New Roads Through Public-Private Partnerships: Frequently Asked Questions,* Reason Foundation Policy Brief No. 58.

- Contract amendment provisions without unfairness to either party;
- Dealing with failures to comply with the concession agreement;
- Provisions for early termination of the concession agreement;
- Protection to the private toll operator from any state-funded competing routes, if any; and
- Limits on toll rates and rate of return.

A discussion on privatization of TOT lanes would be incomplete without taking a look at the types of private sector financing options available to build TOT lanes. Private concession agreements can typically raise more funding for TOT lanes for a given toll revenue stream compared to traditional toll agency financing. A private concession agreement can leverage the following kinds of capital investment for the development of TOT lanes:

- Taxable debt market.
- Bank financing.
- Equity:
  - Corporate/sponsor equity; and
  - Public share offerings.
- Institutional investors:
  - Pension funds;
  - Insurance companies; and
  - Buyout firms.

As reported in Poole,[73] private financing can generate more funding from a given traffic projection through more aggressive growth projections, longer financing periods (more than 40-year financing period), the willingness of equity providers to take traffic risks, and depreciation benefits.

Owing to the increasing attention towards privatization of tolled highways and the advantages of private sector financing of these facilities through concession agreements compared to traditional financing methods, private capital markets in the United States are beginning to realize the attractiveness of toll road concessions in realizing long-term investment returns. Many private equity funds, hedge funds, investment banks, commercial banks, and other global investors are beginning to take interest in investing in highway infrastructure in the United States. Some notable examples of private sector participation in toll road projects in the United States are discussed below:

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[73] http://www.americanexperiment.org/uploaded/files/poole_minnesota_highways_powerpoint_presentation.pdf.

- **Chicago Skyway –** The privatization of the Chicago Skyway through a long-term lease agreement between the City of Chicago and a global consortium in 2005 represented the first long-term lease of an existing toll road in the United States, involving private investors signing a 99-year lease on the 7.8-mile Chicago Skyway for $1.83 billion. The global consortium comprises of Cintra (a Spanish company and one of the largest infrastructure development firms in the Europe), and Macquarie Infrastructure Group (MIG – a subsidiary of Macquarie Bank Limited, Australia's largest investment bank), and is referred to as the Skyway Concession Company (SCC). SCC assumed operations of the Chicago Skyway in January 2005, being responsible for all the O&M costs of the highway. However, SCC is entitled to all the toll revenues. The capital financing structure for this agreement involves private equity holdings from Cintra and MIG, and bank loans.

- **Trans-Texas Corridor (TTC) –** A key segment of the TTC (segments of the SH 130 toll road between San Antonio and Austin) in Texas is being developed as part of a concession agreement with a private consortium led by the Spanish company Cintra Concesiones Infraestruturas SA (Cintra). Cintra plans to invest around $1.36 billion in this segment of the TTC, comprising of $197 million coming from consortium partners, and the rest from a bank loan and debt from the U.S. DOT. The financed segment is part of the TTC, which is a 4,000-mile corridor comprising of 12 passenger vehicle lanes, 4 truck lanes, 2 passenger train tracks, 2 commuter train tracks, and 2 freight train tracks.

The prominent role being played by overseas investors in the development and operations of toll road projects in the United States, as seen from the above examples, is fueling interest among United States banks and investment funds in participating in toll road investments. Many United States financial institutions have already established, or are now in the process of establishing infrastructure investment funds, which can be potentially applied to toll road investments. The authority provided under SAFETEA-LU to issue tax-exempt private activity bonds for the development of transportation projects, is expected to be particularly favorable to United States investors as they focus their attention towards the domestic toll road market.

A.7.4 Current Proposals for Tolled Truck Lanes and Privatization Opportunities

Trans Texas Corridor (TTC) Truck-Only Lanes

The Trans Texas Corridor (TTC), the largest engineering project to be ever undertaken in Texas, comprises of a 4,000-mile network of super corridors up to a quarter mile in width consisting of toll roads for passenger vehicles and trucks, among other facilities such as intercity passenger and commuter rail, freight rail, and pipelines. Each segment of the TTC would consist of four 13-foot truck-only lanes, with an aggregate width of 84 feet, including inner and outer shoulders.

The two main segments of the TTC being considered for initial implementation include 1) TTC-35 (Oklahoma to Mexico/Gulf Coast): This corridor segment would generally parallel the existing I-35 corridor between Laredo and Gainesville, passing through the Dallas-Fort Worth, Austin, and San Antonio metropolitan areas; and 2) I-69/TTC (Northeast Texas to Mexico): This corridor would generally follow U.S. 59, from Texarkana through Houston to either Laredo or the Rio Grande Valley. Other high-priority corridors in the TTC system

include corridors that would parallel I-45 from Dallas to Houston, and I-10 from El Paso to Orange.

The entire 4,000-mile network of corridors in the TTC system is expected to cost between $145.2 billion and $183.5 billion, based on the assumption that right-of-way (ROW) costs range between $11.7 billion and $38 billion, construction costs amount to around $125.5 billion at the rate of $31.4 million per centerline-mile, and miscellaneous costs range between $8 billion and $20 billion.

Owing to the monumental costs of developing the highway segments of the TTC, a key focus of the Texas Department of Transportation (TxDOT) is to attract private sector participation in the development of corridor segments through PPP agreements. In March 2005, TxDOT signed a comprehensive development agreement with a private consortium (Cintra-Zachry) comprising of Cintra and Zachry Construction Corporation (Zachry), authorizing $3.5 million for planning of the TTC-35 segment. This agreement, however, does not designate the alignment, authorize construction, or set toll rates for the TTC-35 corridor. TxDOT plans to enter into future construction contracts if TTC-35 is given Federal environmental clearance. The final Environmental Impact Statement (EIS) for TTC-35 is currently ongoing,[74] and Federal review and decision/approval is expected in fall 2008.

In June 2006, TxDOT entered into a long-term concession agreement with Cintra-Zachry to build Segments 5 and 6 of State Highway 130 (SH 130), which is proposed to represent the TTC 35 corridor alignment between I-10 at Sequin (east of San Antonio) and U.S. 79 near Taylor. The financing plan for this corridor comprises of $412 million in Federally guaranteed loans under the Transportation Infrastructure Financing and Innovation Act (TIFIA), and private sector financing in the form of equity contributions by Cintra-Zachry, and bank loans from private lenders. The financing approach being undertaken for segments 5 and 6 of SH 130, which would be representative of the entire TTC 35 corridor network, is part of a larger financing plan[75] developed by TxDOT for the development of the TTC 35 corridor, some of the key elements of which, include the following:

- The corridor would use no public funds;[76]
- The private concessionaire would invest over $1.3 billion in equity in five near-term self-performed corridor facilities with estimated construction costs of around $6 billion;
- The private concessionaire would pay concession fees to TxDOT of over $1.2 billion for the right to design, build, finance, operate and maintain the corridor for a period of 50 years; and

[74] http://ttc.keeptexasmoving.com/projects/ttc35/timeline.aspx.

[75] ftp://ftp.dot.state.tx.us/pub/txdot-info/ttc/exhibit_c/ttc-35_cda_exhibit_c.pdf.

[76] Public funds include state and Federal highway funds, and do not include State Infrastructure Banks (SIBs), TIFIA credit instruments, or local sources.

- TxDOT would establish a not-for-profit TTC 35 Trust Fund to receive concession fee payments from the concessionaire, for the purpose of reinvesting the funds in additional corridors in the State in the future.

TxDOT has not entered into any contracts to-date for the financing and development of the I-69 segment of the TTC (I-69/TTC). Federal environmental studies are currently ongoing[77] to determine the final alignment of this segment of the TTC.

Based on a detailed traffic projections and toll revenue analysis, the toll rates, in 2006 dollars, for chapters 5 and 6 of SH 130 were estimated to be 12.5 cents per mile for light vehicles and 50 cents per mile for heavy vehicles (trucks), to be increased in-line with Texas' per capita GDP growth rate each year.

A.7.5 Examples of Truck Tolling Approaches from Other Countries

This chapter presents some key examples of tolling approaches applied specifically to trucks from other countries. An analysis of these approaches can provide useful insights into the types of technologies used for truck tolling, and some of the key characteristics of the truck tolling approaches (for example, mileage-based tolling, and factors impacting the variability of tolls such as the type of truck). The truck tolling mechanisms discussed include the following:

Austria's Nationwide Truck Tolling System

The implementation of a nationwide truck tolling system in Austria was initiated in 2001 with the issuing of a tender by ASFINAG, the national road authority which is wholly owned by the Federal Republic of Austria for a national toll collection system for heavy goods vehicles with a maximum permissible laden weight in excess of 3.5 tons. The key requirements of the system included suitability for rapid nationwide implementation, the capability to handle initial truck volumes of around 400,000 vehicles of over 3.5 tons, interoperability with other European systems, and nondiscrimination of users. The system went into operation on January 1, 2004.

The technology used for the truck tolling system is a Dedicated Short-Range Communication (DSRC) system that uses easily installable On Board Units (OBU) on trucks, in conjunction with communication points located throughout Austria's inter-urban highway network. Microwave transceivers placed on gantries above highway lanes communicate with OBUs installed on the windscreen of passing trucks. The system allows for electronic toll collection (ETC) of trucks while in motion, leading to unimpeded driving conditions.

Trucks are charged tolls based on the number of axles (which is used as a proxy for the weight of the truck; higher the number of axles implies heavier truck, and higher tolls) and the distance traveled on the highway. The system collects and processes over 2 million transactions every day.

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[77] http://ttc.keeptexasmoving.com/projects/i69/contracts.aspx.

Switzerland's Distance-Related Heavy Vehicle Fee (LSVA)

Switzerland's distance-related heavy vehicle fee (LSVA) was implemented in 2001 to meet three primary objectives: 1) to internalize external freight transportation costs, 2) to obtain revenues from users to finance key transportation projects such as the transalpine railroad tunnels, and 3) to act as an instrument to encourage diversion of freight from truck to rail. LSVA is levied on all trucks exceeding 3.5 tons of authorized weight. The magnitude of the fee is determined by the following key factors:

- The distance traveled on the highway system;
- The highest authorized weight of the truck; and
- The pollutants emitted by the truck.

LSVA uses DSRC and Global Positioning Systems (GPS) technologies along with sophisticated OBUs on trucks to charge tolls. Tachographs on trucks are used to automatically register the distance traveled. The implementation of GPS technologies enable effective monitoring of the functioning of tachographs as well as monitoring truck border crossings. The DSRC system allows for automatic activation/deactivation of the toll collection system for trucks at border crossings.

Germany's "Toll Collect" Truck Tolling System

Germany's nationwide truck tolling system successfully began operations on January 1, 2005 after a more than two-year delay from the initial planned implementation of August 2003. The truck tolling system is managed and operated by Toll Collect GmbH, a consortium led by DaimlerChrysler, Deutsche Telekom, and French motorway operator Cofiroute.

The Toll Collect system uses GPS technology to track the distance traveled by trucks on Germany motorways (Autobahn) and Global System for Mobile (GSM) communications wireless networks to transmit data for billing purposes. OBUs installed on trucks interact with GPS systems and sensors installed on control bridges on highway lanes to track truck routes and distances, calculate toll fees, and transmit the data via GSM to a central data processing center for billing.

Toll charges are applied to all trucks weighing more than 12 tons, and vary depending on the number of axles, truck emission characteristics, and the distance traveled, and range between 9 and 16 cents per kilometer (equivalent to between approximately 14 and 26 cents per mile).

A.8 Data Assessment

One objective of this first phase of research on CMV-only lanes was to compile data and sources that can be used in the Phase II analysis. Phase II of the research will focus on a performance evaluation of CMV-only lanes and a benefit/cost evaluation. The performance evaluation will compare CMV-only lanes in various applications to other common alternatives to increasing roadway capacity and improving operations to determine if CMV-only lanes are a more effective way of achieving performance improvements. The benefit/cost evaluation takes this one step further to determine if CMV-only lanes can be a more cost-effective way of achieving performance improvements.

This chapter of the Interim Report presents the data assessment. The chapter begins with a summary assessment of the data that are available on CMV-only lanes. These data are an important resource for planners and traffic engineers who are evaluating and designing various CMV-only lane projects and the assessment contained in this report provides an indication of the strengths and weaknesses of the current data and points to gaps that may be filled with additional research. A compilation of data tables, charts, and graphs is presented in the attachment to the report for those who wish to refer directly to these data as planning resources. The summary assessment is followed with a more focused assessment of how the data compiled in Phase I of the research can be used to conduct the performance evaluations and benefit/cost evaluations required in Phase II. The general conclusion of this assessment is that while there are clearly gaps in the data (most notably in the case of reliability and safety performance measures and operations and maintenance cost data) there does appear to be sufficient data on a wide range of CMV-only lane applications to allow for the performance evaluations and benefit/cost evaluations contemplated in Phase II.

A.8.1 Summary Assessment of Available Data on CMV-Only Lanes

This chapter provides a summary assessment of the available data on CMV-only lanes focusing on what types of data are available, the quality of these data, and any gaps that need to be filled in future research. Before providing this assessment, it is important to note that most of the data are drawn from feasibility studies, design studies, and other planning efforts rather than from empirical observations of the performance of CMV-only lanes. There are almost no examples of CMV-only lanes from which to draw empirical data, although there are some studies of truck-auto separations that are of use in drawing inferences about how the CMV-only lane configurations described in the referenced studies would perform. The data reported in this assessment are largely modeled data. This observation should not be construed as diminishing the value of these studies since the analytical foundation of the studies is often strong enough to draw conclusions about how CMV-only lanes are likely to perform in actual applications.

General Planning Data

Data collected to support the discussion of general planning issues germane to CMV-only lanes can be found within the following planning categories: Project Planning and Evaluation, Congestion and Mobility/Operational Efficiency, Safety, Economic, Environmental, and Constructability.

While several of the tasks within this report are research-oriented, the Task 2 Planning Process Issue task (on which this summary is based) collected best practice information from CMV-only lane feasibility planning studies that have been conducted over the past decade by DOTs and regional planning agencies. Within each of these studies are examples of how to collect, compare, and analyze data to determine appropriate course of action (i.e., to build, or not to build, CMV-only lanes). The feasibility studies typically define a number of alternatives to be compared with CMV-only lanes and the application settings (urban access roads versus long-haul intercity corridors, various design configurations) are highly varied. The data come from analyses typically performed using travel demand forecasting models that in some cases are supplemented with sketch-planning tools. Performance measures and model outputs are often calibrated with actual data on vehicle speeds, crash rates, and vehicle population profiles (for

emission analysis) that reflect observed characteristics of the facilities that are analyzed. Tables and graphs drawn from the literature are compiled and presented in Attachment C.

Project Planning and Evaluation

Sample data tables and figures can be found within the following general groupings:

- **Goals, Objectives, and Performance Criteria –** Essential to the CMV-only lane planning process is development of a set of goals, objectives, and performance measures to guide the planning process and ensure that the proposed project is compatible with local and regional plans and policies. This may include criteria such as truck ADT or VMT thresholds, crash rate thresholds, or other indicators that can be used to screen different corridors for high potential CMV-only lane applications.

- **Construction of Build and No-Build Alternatives –** A CMV-only lane "build" alternative should be taken into consideration with a variety of CMV-only configuration as, well as several non-CMV-only alternatives to aid in understanding to what degree the alternative provides benefit. The variations in CMV-only alternatives may differ, within the same study, with respect to characteristics such as number and location of interchanges, capacity, method of lane separation, etc. These characteristics will affect representation and performance in travel demand models and may also be inputs into sketch planning tools for the evaluation of nontraditional travel impacts. The non-CMV-only alternatives typically include comparable levels of capacity expansion with traditional mixed-flow lanes. It should be noted that most of the feasibility studies are in existing Interstate alignments so there already are mixed-flow lanes that may or may not be expanded as part of the analysis.

- **Evaluation Methods –** A variety of evaluation matrices have been developed to aid in comparing alternatives against goals and objectives, as well as comparing modal alternatives against each other.

Congestion and Mobility/Operational Efficiency

Sample data tables and figures can be found within the following general grouping:

- **Existing and Future Conditions Data –** A variety of factors influence the operational efficiency of a facility, including travel demand and roadway capacity. Feasibility studies reviewed provided much detail on these basic parameters for both passenger cars and trucks, including ADT, VMT, VHT, and hours delay. The data are typically outputs from travel demand models that have the ability to differentiate performance measures by vehicle class (at least differentiating autos and trucks) and some provide time-of-day analysis taking into account the different time-of-day characteristics of trucks and autos.

- **Truck Specific Data –** Due to the nature of these feasibility studies each contains a fairly detailed breakdown of truck data points, including: truck traffic as a percent of vehicle travel, truck forecasted growth, truck lane utilization, truck diversion potential, a.m./p.m./annual truck distribution analysis, and locations of major truck activity centers.

- **Operational Analysis –** Each of the feasibility studies used travel demand modeling to conduct operational analyses. The results of these analyses were provided in comparative matrices and focused on key factors such as V/C ratios, level of service, average travel speed, and service flow rate. The most recent of the feasibility studies, the GDOT study,

was the first to begin placing a "rank" on several qualitative measures as part of their operational analysis, including market assessment and freight bottleneck assessment.[78]

Safety

- **Existing and Future Conditions Data –** A variety of factors influence the operational efficiency, and probably the most important factor from a public perception point of view, is safety. Feasibility studies reviewed provided data on the number of crashes, type of crashes and extent of truck involvement in crashes on facilities prior to implementation of CMV-only lanes. Data on the impact of CMV-only lanes on crash rates was more limited due the lack of predictive methodologies and empirical data on auto-truck separations.

- **Safety Analysis –** Includes travel time savings and crash reductions as a result of CMV-only lane implementation. The most recent of the feasibility studies, the GDOT study, was the first to conduct a security assessment that includes a qualitative evaluation of access of truck stops, rest stops, and weigh stations.

Economic

- **Costs –** It is important to break projects up by segment and attribute costs to each – for right-of-way, capital, and operations and maintenance costs – to make it easier to determine whether benefits are commensurate with resource commitment. Data on capital costs was provided for most of the feasibility studies with breakdowns of cost components.

- **Benefits –** Similarly, benefits were also often provided by segment. Examples provided include travel benefits, safety benefits, and 30-year cumulative benefits.

Environmental

- **Environment –** Air, noise, and water quality data have been reviewed for most of the feasibility studies and to a lesser extent, but still noted, are land use impacts. The greatest level of attention was paid to emissions impacts with a focus on criteria air pollutants using travel demand model inputs for activity data and standard emission factor models.

- **Socioeconomic –** The GDOT study began to qualitatively assess the cultural environment, including equity issues; impacts of projects on historic, cultural, and archaeological resources; and displacement of residences and businesses. However, since most of the studies were feasibility studies and not NEPA environmental, impact studies, the extent of environmental analysis tended to be limited.

Constructability

- A variety of quantitative and qualitative factors have been reviewed to determine the constructability and construction effects of CMV-only lane projects. These include available right-of-way, typical sections, bridge replacement, environmental and overall constructability.

[78] *Truck Only Lanes Needs Analysis and Engineering Assessment*, Georgia Department of Transportation, April 2008.

Key Data Gaps

Following are some of the key data gaps associated with planning of truck-only lanes:

- While CMV-only lane feasibility studies are prevalent, there is a lack of formal process outlined to address the unique circumstances of this type of facility.
- While there exists seemingly endless records of truck ADT, level of service, VMT, VHT, etc., there are not extensive best practice thresholds for many of these categories to provide early guidance on whether CMV-only lanes should be moved on to further consideration. Basic threshold information exists for peak-hour volume, off-peak volumes, and heavy vehicle mix, but there is opportunity to develop thresholds for additional measures that could include crash rates, levels of service, V/C ratio, etc.
- While safety is touted as one of the biggest benefits of CMV-only lane implementation only basic numbers of crashes and crash rates were provided for existing conditions with more limited data on predicted safety benefits. The studies reviewed did not conduct an exploratory review of whether or not, or to what extent, truck crashes were deemed a problem on roadway segments compared to other types of crashes. Again, this type of analysis could lead to a "best practice" recommendation for how to use information about crash levels as a criterion for screening potential CMV-only applications.
- In most cases all trucks were seen as "trucks" and there was no provision made for truck classification, OD information, commodity flow survey, supply chain factors, major freight activity centers, or routing as explicit criteria for screening potential CMV-only applications.
- The benefit analyses should take into wider account additional benefits aside from those of travel and safety. While the beginnings of qualitative analyses have been shown in the areas of environmental and social analysis, additional benefits (costs) could be quantified for energy consumption.

Data on Design and Configuration Issues

This chapter provides a summary assessment of the data available related to design and configuration issues. Extensive data are available on facility design criteria based on the operational characteristics of trucks. Most of these data are obtained from design handbooks and standards applied to a CMV-only setting. Data on facility configurations include the various methods for providing lane separations. Data on facility right-of-way impacts takes into account the requirements for different lane and separation configurations as well as considering interchange and geometric requirements. Finally data are provided on physical and operational characteristics and how these need to be considered in designs. More detail on the types of data available for each of these different categories of data is provided below. Tables and graphs drawn from the literature are compiled and presented in Attachment C.

Truck Facility Design Criteria

This category includes data on design parameters for exclusive truck-only lanes, such as design speeds, maximum grades, geometric alignment (stopping distance, horizontal curvature, and superelevation), cross-sectional design parameters (lane, shoulder, and barrier widths), vertical and lateral clearances, and cross-slopes. Data on pavement design parameters, to the extent

available, were also compiled under this category. Douglas provides one of the most comprehensive sources with data, including truck-only lane design criteria such as lane and shoulder widths, grades, design speeds, and horizontal curvatures.[79] This source also provided a synopsis of the geometric characteristics of existing truck facilities in the U.S, as well as truck facility design criteria from other sources such as Institute of Traffic Engineers (ITE).[80] Tables from other sources that include information on cross-sectional design criteria for various types of truck-only lane configurations and pavement design parameters for toll truckways are provided in Attachment C.

Truck Facility Configurations

This category includes data on geometric configurations of existing and proposed truck facilities such as lane widths, outer and inner shoulder widths, width of Jersey Barriers, and grades. Many of the feasibility studies include cross-sectional configurations for a variety of design concepts, including information on lane and shoulder widths, dimensions of barriers, and location and configuration of structures for elevated and below-grade sections. Middleton provided data on typical cross-sectional configurations of dual-dual roadways such as the New Jersey Turnpike. Cross-sectional drawings from several of the studies are provided in Attachment C.[81]

Truck Facility Right-of-Way (ROW) Requirements

This category includes data on ROW requirements for exclusive truck-only lanes based on consideration of factors such as the type of facility (at-grade, elevated, or underground), location of facility (median or outside); number of lanes; and lane, shoulder, and barrier widths. Data on ROW requirements for proposed truck-only lanes, to the extent available, were also compiled under this category. The data for this category were fairly limited but there was some analysis of ROW requirements in the I-710 Major Corridor Study.[4]

Truck Facility Costs

This category includes data on capital costs, and operations and maintenance (O&M) costs associated with exclusive truck-only lanes. Data on comparative capital costs of mixed-flow facilities, and facilities with truck-only lanes were compiled to assess the incremental costs associated with the development of truck-only lanes. Data collected on capital costs associated with the surface, elevated, and tunnel sections of the proposed Miami toll truckway provides useful information on differences in capital costs based on the type of facility. Data on relative shares of ROW and construction costs associated with proposed truck-only lanes were also compiled, to the extent such data were available.

Truck Physical and Operational Characteristics

Data on truck physical and operational characteristics were compiled since these data elements serve as useful inputs in the design of truck-only lanes. Specific data elements under this

[79] James G. Douglas, *Handbook for Planning Truck Facilities on Urban Highways,* August 2004.

[80] Institute of Transportation Engineers (ITE), *Geometric Design and Operational Considerations for Trucks*, Pub. No. IR-062, Washington, D.C., 1992.

[81] Dan Middleton, *Texas Transportation Institute (TTI) Truck Accommodation Design Guidance: Policy Maker Workshop,* TTI Research Report 4364-3, October 2003.

category include truck operational characteristics such as speed-distance characteristics, relationship between truck speeds and grades (percent and length of grades) and braking distance, and physical characteristics of trucks for truck facility design such as height, weight, and length.

Data Gaps

Following are some of the key data gaps associated with truck-only lane configuration/design issues and costs:

- There are inadequate data on operations and maintenance (O&M) costs associated with exclusive truck-only lane facilities, which take into account the incremental costs associated with operations of systems such as ITS for electronic toll collection (ETC).

- There are inadequate data on the specific breakdown of capital costs of exclusive truck-only lanes by component. For example, incremental capital costs associated with higher grade and/or thicker pavement for truck-only lanes, compared to general purpose lanes are generally not provided.

Data on ITS/CVO Applications and CMV-Only Lanes

Cooperative Vehicle Highway Automation Systems Data

Data concerning the application of ITS/CVO technologies to truck-only lanes centers on cooperative vehicle highway automation systems (CVHAS). CVHAS provide driving control assistance or fully automated driving to increase capacity on automated lanes and offer fuel savings to automated trucks. Recent California PATH research (Yin et al., Shladover, and VanderWerf et al.) indicated that truck-only facilities with CVHAS technologies are cost-effective. In the Chicago case study, Yin et al. devised a baseline alternative ("do nothing") and four operational concept alternatives with which were performed quantitative comparative analyses based on regional transportation models to calculate benefit and cost ratios.[82] The analyses comprised cost components, including construction, right-of-way, O&M, CVHAS facility, and CVHAS vehicle costs; and benefit components of travel time savings and fuel consumption reduction. PATH also has supported field experiments to verify the accuracy of longitudinal control in platooning and directly measure fuel saved and emissions. Automatic steering and speed control has been demonstrated in the field under a limited range of conditions, with close separations achieved between trucks on test tracks. In addition, results showed significant fuel consumption savings but less certain emissions effects.

Significant albeit limited findings on the feasibility of applying CVHAS to truck-only lanes are available. The data fall into three categories:

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[82] Yafeng Yin, Mark A. Miller, and Steven E. Shladover, *Assessment of the Applicability of Cooperative Vehicle-Highway Automation Systems to Freight Movement in Chicago*, Transportation Research Board Annual Meeting, January 2004; Steven E. Shladover, *Advanced Vehicle Technologies and Exclusive Truck Lanes: Research from California PATH Program*, Transportation Research Board Annual Meeting, January 2006; Steven E. Shladover, *Improving Freight Movement by Using Automated Trucks on Dedicated Truck Lanes: A Chicago Case Study*, California PATH Intellimotion, Volume 12, No. 2, 2006; and Joel VanderWerf, Steven Shladover, and Mark A. Miller, *Conceptual Development and Performance Assessment for the Deployment Staging of Advanced Vehicle Control and Safety Systems*, California PATH, 2004.

1. **Cost Data –** Estimated total construction, right-of-way, O&M, CVHAS facility, and CVHAS vehicle costs of deploying truck-only facilities restricted to CVHAS-equipped trucks (with costs of truck-only facilities open to all trucks also estimated for comparison); and costs of adding CVHAS capabilities to individual trucks.

2. **Benefit Data –** Estimated total dollar value of truck travel time savings and reduced fuel consumption on truck-only facilities restricted to CVHAS-equipped trucks; and direct measurements of fuel savings resulting from reduced aerodynamic drag when trucks are driven with small separations between them.

3. **Technical Progress Data –** Measurements of truck speed and position errors in platoons.

Representative cost and benefit data are provided in the tables and figures in Attachment C.

Data on Other ITS/CVO Applications for CMV-Only Lanes

Descriptions of additional advantageous ITS/CVO applications on truck-only lanes are based on real-world deployments of the technologies in other operating environments. Automatic vehicle identification (AVI) devices such as in-vehicle radio frequency transponders or camera recognition systems could be used to identify and validate trucks on truck-only lanes for purposes such as electronic toll collection. High-speed, mainline weigh-in-motion (WIM) systems offer the opportunity to automatically verify weights of trucks traveling at highway speeds on truck-only lanes. Radio frequency transponders and WIM systems are widely used in mixed-traffic conditions, and these experiences were used in Task 4 to illustrate their application to truck-only lanes for electronic toll collection and roadside enforcement, respectively.

Over 550 WIM systems are installed in the U.S. on mixed-traffic lanes to gather truck information for planning purposes. Many other WIM installations weigh trucks for enforcement of weight regulations. Depending on the type of WIM equipment that is used, accuracy in measuring gross vehicle weight varies from 85 to 95 percent at highway speeds. At lower speeds, accuracy increases.

Data on AVI and WIM applications on truck-only lanes were based on Samuel et al. and Cothron et al. enhanced by the generous general literature on these technologies. Because technologies such as in-vehicle transponders and WIM systems are widely deployed in mixed-traffic facilities these "mainstream" experiences can readily be transferred to truck-only lanes. Technical performance, technical requirements, costs, vendors, locations, integration with other technologies, and other details can be found through Internet searches.

Dedicated short range communications (DSRC) transponders are in widespread use today for electronic toll collection and electronic roadside screening in mixed-traffic conditions. Accuracy is generally reported to be in the area of 99 percent. Samuel et al. envisioned that toll booths or plazas would be eliminated on the toll truckways because every truck would be equipped with a transponder encoded with its size and weight category.[83] License plate readers, a type of camera recognition system, currently suffer from accuracy rates that vary

[83] Peter Samuel, Robert W. Poole, Jr. and Jose Holguin-Veras, *Toll Truckways: A New Path Toward Safer and More Efficient Freight Transportation*, Reason Public Policy Institute, June 2002.

from 30 to 60 percent. For identifying vehicles in motion, license plate readers are far less common, and successful, than DSRC transponders. Samuel et al. as well as Cothron et al. mention the possibility of employing license plate readers instead of – or in addition to – in-vehicle transponders on toll truckways, as they can capture the license plate of trucks without a usable transponder.[84]

Data on LCV Applications

Data collected for this task can be found within the following general categories: Data Collection, Design Considerations, and LCV Productivity.

While numerous references are available on CMV-only lane applications, few delve into the details of longer combination vehicles (LCV). However, in 2004 a study was requested by the Western Governors' Association to the U.S. DOT to conduct the *Western Uniformity Scenario Analysis*. And while discussion of LCV operations was not entirely in concert with CMV-only lanes, this research provides much guidance that can be applied to future CMV-only lane feasibility studies. Tables and graphs drawn from the literature are compiled and presented in Attachment C.

Data Collection

- Very detailed truck data has been collected to study LCV operations. Standard ADTT and crash rates have been provided, but so too provided are VMT breakdown by truck type and commodity group, crash rates by truck type, truck use by configuration type, and predicted truck type shift to LCVs.

Design Considerations

- Pavement and bridge capital and O&M costs were evaluated as part of the *Western Uniformity Scenario Analysis.* This analysis looked at the costs of retrofitting existing roadways to be LCV compatible.

LCV Productivity

- LCVs are touted for the productivity gains they provide over standard semitractor trailer configurations. Information is provided on a variety of LCV characteristics, including weight/horsepower ratio, fuel economy, passenger car noise equivalents, air pollution, and urban toll truckway productivity.

Data Gaps

Following are some of the key data gaps associated with LCV operations on CMV-only lanes:

- Detailed analysis of LCV operations (preferably with a travel demand model) directly tied to CMV-only lanes should be conducted to get a firm grasp on operational data (i.e., V/C ratios, level-of-service, average travel speed, and service flow rate).

[84] A. Scott Cothron, Douglas A. Skowronek, and Beverly T. Kuhn, *Enforcement Issues on Managed Lanes*, Texas Transportation Institute, January 2003.

- Detailed analysis of LCV operations directly tied to CMV-only lanes should be conducted to get a firm grasp on productivity enhancements to the system through use of LCVs, including shift to LCVs, ties to specific industries, shipper costs, etc.

- A review of capital and O&M cost impacts of LCV operations on new, CMV-only facilities.

Data on Tolling and Privatization

The following types of data were collected to support analysis of tolling and privatization options for CMV-only lanes:

- Truck Value of Time;
- Truck Value of Productivity (associated with LCV operations);
- Private Return on Investment (ROI);
- Truckway Toll Rates and Revenue Potential; and
- Data on Toll Truckway Financing.

Data on each of the above categories are presented in Attachment C in the form of tables and graphs.

Truck Value of Time

Truck value of time is a critical input for assessing trucker's willingness to pay tolls, as well as estimating the magnitude of tolls that can be levied on truck-only lanes. The following types of truck value of time data were reported in the literature reviewed for this study:

- Truck value of time distributions: Probability density functions (PDF) for truck value of time for various types of trucking operations (private versus for-hire, truckload versus LTL, and hourly versus other pay base);

- Average truck value of time data by type of trucking operation; and

- Average truck value of time data by region.

Truck Value of Productivity

As discussed under the section of this report on LCV operations, an important rationale for the economic and financial feasibility of truck-only lanes is the ability to operate LCVs, and realize significant productivity benefits for trucking companies. Quantification of productivity benefits to trucking companies from LCV operations is an important step in analyzing the economic feasibility of truck-only lanes, as well as in the estimation of tolls. The following types of truck value of productivity data were compiled:

- Truck unit costs as a function of distance: Graphs depicting truck unit costs per ton as a function of distance (in miles and kilometers). These graphs can be used to estimate the monetary value (in terms of cost savings) of productivity benefits from operations on truck-only lanes.

- Truck value of productivity in terms of additional earnings per shift per day for truckers resulting from productivity enhancements due to operations on toll truckways.

Private Return on Investment (ROI)

Private ROI is a statistic frequently used to assess the feasibility of private sector financing of truck-only lanes. Some of the key factors impacting private ROI for truck-only lanes include the level of private sector investment, toll rates, diversion of truck traffic from mixed flow to truck-only lanes, and truck shift characteristics (for example, the implementation of truck-only lanes could potentially lead to a reduction in truck volumes on the truck-only lanes compared to the mixed-flow lanes, as a result of the use of a smaller number of trucks to transport a given volume of commodities due to the higher weight limits allowed on the truck-only lanes). Holguin-Veras et al. and Samuel et al. provided data on private ROI for various private investment, toll rate, truck diversion, and truck shift scenarios, which have been included in Attachment C.

Truckway Toll Rates and Revenue Potential

One of the primary reasons for applying tolls on truck-only lanes is to generate revenue to leverage funds for financing these facilities. The revenue generation potential of truck-only toll (TOT) lanes is a direct function of toll rates and the amount of truck traffic diverted to these lanes. The following types of data on toll rates and revenues for truck-only lanes were compiled:

- Relationship between toll rates, travel time savings, and revenues;
- Net Present Value (NPV) estimates for revenues, and sensitivity of NPVs to inflation rates; and
- Impact of tolls on state DOT funds.

Data on Financing Approaches for Truck-Only Lanes

There are many innovative options for the financing of truck-only lanes, which could involve equity investment from the public and private sector, bond financing, bank loans, and institutional investments. Data available from a SCAG briefing paper illustrates the financing mechanism proposed for the development of the SCAG regional toll truckway system, which is presented in Attachment C.[85]

Data Gaps

Following are some of the key data gaps associated with tolling and privatization of truck-only lanes:

- **Truck Value of Reliability –** There is inadequate data on truck value of reliability benefits. Since truck-only lanes can provide significant travel time reliability benefits to truckers, the monetary value of these benefits accruing to truckers are critical inputs in the estimation of tolls on truck-only lanes.

[85]SCAG, *User Supported Regional Truckways in Southern California,* Briefing Paper, January 2004.

- **Combined Impacts of Travel Time, Reliability, and Productivity Benefits on Toll Rates –** None of the studies reviewed for this project have undertaken a comprehensive analysis looking at the combined effects of all the different kinds of benefits to truckers (such as travel time savings, reliability improvements, and productivity enhancements) from truck-only lanes in the estimation of feasible truck toll rates.

A.8.2 Uses of Available Data to Conduct Performance Evaluations and Benefit/Cost Analysis

In Phase II of the research, the consultants will conduct comparative evaluations of the performance of various CMV-only lane applications as compared to alternative approaches to improving freight and general mobility, operations, safety, and environmental impacts of freight operations. This chapter assesses the available data for conducting performance evaluations and benefit/cost evaluations.

The research plan for this project identified the following key performance indicators that are often targets for CMV-only lane projects:

- General congestion relief (recurrent congestion) for both trucks and the general motoring public;
- Travel time reliability improvement (nonrecurrent or incident-related congestion);
- Safety (crash reduction); and
- Emissions reductions.

In addition to these performance indicators, the Phase I research identified the following additional performance indicators relevant to the evaluation of CMV-only lanes:

- General operational improvements (reduced impacts of truck-auto interactions);
- Right-of-way (ROW) impacts; and
- Energy use impacts.

Benefit/cost evaluations of CMV-only lane concepts require methods to monetize the benefits described above as well as a comprehensive analysis of the costs of constructing, operating, and maintaining CMV-only lanes. The issues that must be addressed include:

- Costs need to include capital costs of construction, equipment costs for ITS applications, operating costs for both facility owners and users, and maintenance costs; and
- Monetization of benefits needs to address the value of time to users which should incorporate revenue generation potential for motor carriers and other costs to shippers.

In all performance and benefit/cost evaluations the comparisons need to consider the nature of the application, including options such as:

- Urban access routes versus long-haul intercity corridors;
- LCV applications as compared to conventional truck size and weight restricted systems;
- ITS/CVO applications as compared to conventional vehicle applications; and
- Tolling versus conventional financing.

The assessment of the available data suggests that while there are some data gaps, the available data should provide sufficient basis in Phase II for conducting reasonable evaluations of the performance impacts and benefit/cost opportunities associated with a variety of CMV-only lane options. An assessment of the key data needs is presented below.

Data for Performance Evaluations

Mobility/Congestion Performance

There have been a substantial number of feasibility assessments and corridor studies that evaluate CMV-only concepts relative to other alternatives for congestion relief. These include evaluations of intercity corridors (such as the I-81 study in Virginia and the I-35 study in Texas), general urban applications (such as the analysis of I-75 in Atlanta as part of the Georgia DOT study and the SR 60 and I-15 studies in Southern California), and urban access routes to port and intermodal terminals (such as the Miami port access tunnel and the I-710 study in Southern California). Most of these studies looked at improvements to existing freeways and, in many cases, trucks would be allowed to use the general purpose lanes in addition to the CMV-only lanes. In only a very few cases were CMV-only lanes evaluated in totally new alignments. As noted in Chapter 7.0, many of the studies also evaluated the potential for tolling the CMV-only lanes, so the impact of tolling on lane utilization and traffic and revenue has been evaluated. A limited number of studies have evaluated the mobility benefits of CMV-only lanes with LCV operation and at least one study has been conducted to estimate travel time savings in automated highway situations.

For most of the feasibility studies, the general approach to evaluating congestion relief benefits was to use a regional or statewide travel demand model. Standard metrics for congestions relief (such as reductions in VHT, average travel speeds, or travel times between selected origin-destination pairs) were used to evaluate congestion benefits. Since most of the studies used existing travel demand models with minimal adaptation for the analysis of CMV-only lanes, they vary with respect to how they handle the unique time-of-day characteristics of trucks (if they address time-of-day variation in benefits at all) and how they handle the impact of truck size on capacity (e.g., the use of passenger car equivalents (PCE) to model trucks). Most of the studies were able to differentiate the performance improvements for trucks as distinguished from other vehicles using the mixed-flow lanes. Further, most of the studies do compare a CMV-only lane option with a more traditional approach to increasing highway capacity.

Analysis of the potential performance impacts of LCV operations on CMV-only lanes may be more difficult because of the limited number of studies addressing LCVs at all and because of

the variety of approaches used to assess utilization rates. Very few studies used an explicit market-based approach to estimate the fraction of total truck traffic in a corridor that would be likely to use CMV-only lanes. The most extensive studies have been conducted by the Reason Foundation but these studies have focused more on the productivity benefits of LCV operation than on an explicitly market-based approach to estimating potential utilization of the lanes. The I-15 Comprehensive Corridor Study in Southern California used a combination of commodity flow data and analysis of commodity markets where triple trailers were in use to estimate potential utilization rates for this corridor. However, none of these studies conducted travel demand model analysis with the resulting LCV demand data to estimate impacts on congestion levels or travel time savings for the LCV operators.

As noted previously, there are a large number of studies that have attempted to evaluate the traffic and revenue potential of tolled CMV-only lanes using standard travel demand models often coupled with other toll diversion techniques. The approach used most often is to build the cost of the toll into the link impedances in the travel demand model and build the route assignments directly. Using this approach, the results of many different studies could be compared. However, there are a wide variety of "value of time" factors used for CMV-only lane studies and these would have to be adjusted across studies to make the results comparable. Since new traffic assignments cannot be conducted as part of this NCHRP project, the resulting adjustments will need to be very approximate.

Based on this assessment of the available data, we believe that there are sufficient data covering a fairly wide range of application alternatives to allow for the evaluation of congestion impacts of CMV-only lanes as called for in the proposed research plan for Phase II of the study.

Reliability Performance

Reliability impacts refer generally to the variability in travel time on a roadway. This has been noted as a critical performance measure for freight movement in many studies due to the on-time sensitivity of tightly controlled logistics systems. If a freight delivery is subject to a significant penalty (either in terms of mixed connections or an actual cost penalty to the motor carrier), the trucker may need to build in extra time as compared to an average travel time to insure that he/she is not subject to the penalty. Thus, nonrecurrent congestion may add more cost to freight delivery than does recurrent congestion.

The problem with performance evaluations involving reliability is that there is not a commonly accepted performance metric nor are there very good analytical techniques for estimating reliability affects. In fact, very few of the sources reviewed in Phase I provide much data on the reliability benefits of CMV-only lanes. The I-710 Major Corridor Study and the I-15 Comprehensive Corridor Study in Southern California both used lookup tables that relate incident-related delay to V/C and roadway characteristics (e.g., number of lanes, facility class).[86] The lookup tables were developed using extensive data on incident-related delay collected from facilities around the U.S. But these lookup tables are not based on data from actual CMV-only lanes and therefore do not take into account the unique characteristics of CMV-only lanes (this is discussed further in relation to safety evaluations later in this chapter).

[86] The lookup tables used in these studies were drawn from the data library incorporated in the FHWA's Intelligent Transportation System (ITS) Deployment Assessment System (IDAS).

An alternative approach to evaluating the reliability benefits of CMV-only lanes was offered by Killough in his analysis of the value of truck toll lanes in Southern California.[87] Killough used the buffer index, travel time index, and planning time approach developed by the Texas Transportation Institute to evaluate potential reliability benefits of a system of truck lanes. Data from permanent loop detectors in Southern California highways provide real-time speed data and traffic volume data that can be used to compute the buffer index and travel time index for different roadway segments. TTI estimated a regression relating the two variables that could be used to estimate buffer time given predicted levels of traffic congestion for different periods of the day. Travel demand model results comparing truck lanes and mixed-flow lanes for different periods of the day were then used to estimate the affects of reliability. Killough's paper showed that in Southern California, the impact of reliability on total travel time (assuming a goal of 95 percent on-time performance) was greater than was that of recurrent congestion. While this approach shows promise for future studies, it is unlikely that there will be sufficient data to develop the relationship between buffer time index and travel time index for the areas where prior feasibility studies have been conducted in order to be able to apply the approach. However, it would be possible to use the lookup tables that were used in the I-710 study and the I-15 study to estimate reliability benefits for other studies to allow for a consistent comparison of CMV-only lanes in a wider range of applications than those represented by these two studies.

Safety Performance

A significant benefit of CMV-only lanes that most studies allude to is the reduction in crashes that result from auto-truck separations. In particular, the Georgia DOT study notes the reduction in fatalities when the possibility of truck-auto crashes is eliminated. Unfortunately, there are no published data that document the actual reductions in crash rates from truck-auto separations in most situations because of the lack of operating experience. The Georgia study did make efforts to develop clear correlations between the percentage trucks on a facility and crash rates, but the data were inconclusive.

Nonetheless, many of the feasibility studies described previously do provide a variety of approaches to estimate crashes on CMV-only lanes as compared to other alternatives evaluated in these studies. In the Georgia study, it was assumed that overall crash rates do not change between multipurpose lanes and truck lanes and that crashes can be estimated as a function of VMT. Because autos are likely to divert from parallel arterials to the mixed-flow lanes and because crash rates are different for freeways and arterials, there is a benefit in the diversion of VMT that was estimated in this study. The major safety benefit noted in the Georgia study was the reduction in fatal crashes on the truck lanes. This was estimated by noting the difference in fatal crash rates for truck-auto accidents and auto-only accidents and applying the auto rates to the CMV-only lanes. This approach could clearly be replicated using the data in other studies to provide a basis for comparing CMV-only lane concepts in a wide range of applications.

An alternative approach was used in the I-710 and I-15 studies in Southern California. These studies used the IDAS lookup tables to estimate crashes in three categories: property damage only (PDO), injury only, and fatality. Crashes are estimated as a function of VMT and speed for

[87] Keith L. Killough, *Value Analysis of Truck Toll Lanes in Southern California*, TRB Annual Meeting, January 2008.

different vehicle types. Crash rates for the I-710 study were calibrated to observed crash rates on this facility.

While the techniques described above probably underestimate the safety impacts of CMV-only lanes, they do provide an indication of relative performance and the available data will support the analysis required in Phase II of this study.

Emissions Performance

Most of the feasibility studies reviewed for this project incorporate some analysis of relative emissions impact at either a corridor, subregional, or regional level. These analyses are a function of VMT and average speeds, so inputs come directly from standard travel demand models. Emission factor models such as MOBILE 6 and EMFAC (California) are used to develop default emission rates for criteria pollutants. The data for conducting comparative performance evaluations in terms of emissions impacts is sufficient for Phase II.

Other Performance Factors

There were no consistent performance measures used by enough studies to develop comparative analyses. The CVAHS studies by the PATH program at UC Berkeley were the only studies to consider energy impacts explicitly. Presumably these could be derived from speed and VMT data as are emissions in most of the general feasibility studies. Right-of-way impacts were considered in the California studies (SR 60, I-710, and I-15). However, these impacts are extremely sensitive to the specific alignment, interchange configurations, and geometric constraints and thus comparisons across studies would be difficult to make.

Data for Benefit-Cost Analysis

Cost Data

To conduct a complete benefit-cost analysis a detailed accounting for CMV-only costs as compared to other alternatives must be available. This should include a complete breakdown of capital costs (including facility construction, right-of-way, engineering, any toll facilities), equipment capital costs (appropriate for advanced vehicle technology options), operating costs (both facility operations and user costs), and maintenance costs (bridge and pavement maintenance). Many of the studies, including the feasibility studies and policy studies, do provide capital cost analysis of a wide range of CMV-only applications, including various means of lane separation (at-grade and elevated), urban and intercity, various degrees of access limitation (interchange costs are broken out), various pavement types, LCV configurations, standard and electronic tolling, and advanced vehicle infrastructure interface configurations. The capital cost data are broken out with quite a bit of detail in most of the studies.

Operations and maintenance (O&M) data are more limited in many of the studies. The LCV studies and the tolling studies tend to deal with O&M costs in more detail because the productivity-cost tradeoff is the critical factor in most of these studies and in the case of LCVs, pavement impacts are a significant concern. With respect to user costs of operations, these tend to be dealt with in the benefits calculation (reduced travel time, energy costs, etc.).

In spite of the limited O&M data, we believe that there are sufficient data to complete the cost analyses required in Phase II of the study.

Benefits Data

As noted above, the primary source of information on benefits comes from the performance evaluation of direct user and nonuser impacts of CMV-only lanes as compared to other alternatives. To the extent that any of these performance measures are missing from an analysis, corresponding benefits analysis cannot be accomplished.

A key issue that must be addressed in the analysis of benefits of CMV-only lanes is the monetization of benefits. In the case of emissions benefits and safety benefits, many of the policy studies provide monetization techniques developed from standard highway benefit-cost evaluation tools. In the case of congestion and productivity benefits, the approaches are more varied. The issue centers largely around the approach to estimating the value of time. A more extended discussion of the various approaches is incorporated in Chapter 7.0 in the discussion of tolling. Several of the studies use a value of time distribution while others use a single average value of time. The latter studies may include a cost-based approach or a revenue-based approach. The cost-based approaches will either focus on the operating costs of motor carriers or they may include total logistics costs for shippers (including such cost items as buffer inventory costs and costs of goods in transit). Studies that use total logistics cost approaches required some data on the commodity distribution of trucks using the CMV-only lanes and since this is often unavailable in the travel demand models that are used in the analysis it will be difficult to implement this type of approach in Phase II of the study. A related issue which comes up in the case of LCV analysis and in some studies looking at general congestion benefits is the analysis of the additional revenue generation potential that can be derived from reduced travel time. In the case of LCVs this equates to reduced operating costs per unit of a commodity hauled whereas in the case of general congestion studies the analysis must be able to show that additional trips can be generated in a typical driving shift. This latter approach was used in the Reason Foundation's study of the Miami Tunnel project, where additional drayage trips to and from the Port of Miami were calculated and revenue per trip was the basis of the benefits estimate.

Overall, the data available for benefit-cost evaluations seems sufficient to accomplish the Phase II analysis although some adjustments to account for variations in monetization methods and data will need to be incorporated in the analysis.

A.9 Next Steps

A.9.1 Panel Meeting

A meeting of the NCHRP 3-73 Panel will be held on September 8, 2008. It is anticipated that by that date the Project Panel will have had 30 days to review this Interim Report. During the Panel Meeting findings from this Interim Report will be presented and comments and questions from the Project Panel will be received. In addition, the consultant will present the adequacy of the data reviewed and the ability of the project to proceed without any work plan adjustments. Remaining tasks will also be presented and future meetings of the Project Panel scheduled.

A.9.2 Work Plan Adjustments

Prior to completion of Phase I (the focus of this Interim Report), the consultant team considered the possible need for work plan adjustments pending CMV-only lane data availability, i.e., either adding or subtracting to the Phase II Performance and Benefit/Cost Evaluations. However, as presented in Chapter 8.0, the general conclusion of the data assessment is that while there are clearly gaps in the data (most notably in the case of reliability and safety performance measures and operations and maintenance cost data) there does appear to be sufficient data on a wide range of CMV-only lane applications to allow for the performance evaluations and benefit/cost evaluations contemplated in Phase II. Thus, adjustments to the Phase II work plan for this study are not necessary.

A.9.3 Remaining Tasks – Phase II

The remaining tasks, as described in the proposal, include Task 8 – Performance Evaluation, Task 9 – Benefit/Cost Evaluation, and Task 10 – Final Report. A description of each task follows.

Task 8 – Performance Evaluation

In this task, Cambridge Systematics will compile all of the available performance data (including modeling evaluations of proposed projects) to assess the general performance characteristics of truck-only lanes of different configurations and operational characteristics. The first step in this process will involve identification of the key performance indicators and the best metrics for conducting the evaluation given the available data. The primary sources of information in this step will be the modeling and analytical studies of truck-lane concepts in different regions in the United States, as previously listed. The experience gained by Cambridge Systematics while working on major corridor studies in Southern California, Chicago, and Washington, involving analysis of truck-lane concepts, will be particularly useful in carrying out this task. Another useful source of information will be J. D. Douglas' *Handbook for Planning Truck Facilities on Urban Highways*, which discusses six key performance evaluation elements pertaining to truck-only facilities, including traffic operations and congestion, truck mobility, safety, emissions, noise, and facility costs, along with the evaluation methods and tools applicable for each element.

It is likely that the performance evaluations will need to be specific to the type of usage anticipated (e.g., looking at congestion benefits of truck-only lanes may be relevant only for systems in congested urban areas, while travel time benefits may be more relevant for truck climbing lanes). Also, the performance evaluations always will need to be conducted in comparison to an alternative without the truck lanes. Since this comparison will be specific to the application/case that is the source of the data, it is likely that when the data are compiled to characterize the performance of truck lanes looking across many different projects/studies that a range of percentage changes in the relevant performance indicator may prove most useful. It is expected that the primary performance indicators will include reductions in travel time or recurrent delay, changes in reliability (travel time variability), and changes in accident rates (property damage, personal injuries, and fatalities). Proposals for other performance indicators suggested by the research panel will be considered at the time of the interim report and may be incorporated at that time.

Prior to compiling the performance data in a consistent format, it will be critical to examine and critique the various methodologies that were used to collect and/or model the performance data. To the extent that particular aspects of performance were measured/modeled using different indicators (for example, there are many different approaches that have been used to look at reliability impacts using different metrics for what constitutes reliability), the Cambridge Systematics team will try to adjust the data to a common metric. Where different methodologies were used to calculate or measure the same metric, Cambridge Systematics will evaluate the approaches and comment on the impact of choice of methods on the results. If possible, adjustments will be made to the data to provide a common point of comparison.

Recurrent *Congestion*

In the case of congestion impacts, the primary performance metrics are likely to be changes in average speeds or changes in vehicle hours of recurrent delay. As noted previously, these should include changes for both the trucks using the truck-only lanes and the mixed-flow traffic in the mixed-flow lanes. In situations where the data have been modeled, several key factors will need to be considered, including:

- Volume delay functions assumed for trucks versus autos;
- Consideration of PCE factors;
- Assumptions that affect diversion from the truck-only lanes; and
- Whether the analysis considers time-of-day characteristics of truck traffic.

While traditional travel demand models may be the most often used methods for examining recurrent congestion impacts of truck-only lanes, they may underestimate the benefits of truck-auto separation in improving the capacity of what previously was a mixed-use facility. Thus, simulation models that can take into account the effects of improved operations on flow conditions and capacity may provide a useful adjunct to traditional travel demand models. If any simulation studies have been conducted, Cambridge Systematics will examine potential opportunities to use the results to adjust performance studies that have not used simulation.

Reliability

Measuring or predicting the potential reliability benefits of truck-only lanes is likely to be very difficult with existing data. However, most of the studies of truck-only lanes in Southern California have tried to estimate reliability benefits, and the approaches used by Cambridge Systematics and those used by staff at SCAG represent some interesting options. In the I-710 Major Corridor Study and I-15 Comprehensive Corridor Study, Cambridge Systematics used relationships built into the ITS Deployment Assessment System (IDAS) databases to estimate reliability measured as changes in vehicle hours of incident-related delay. The IDAS databases have developed regression relationships that relate incident-related delay from reported data to factors, including volume-to-capacity (v/c) ratios, facility type, and number of lanes. The SCAG studies use the approach developed by the Texas Transportation Institute (TTI) that introduces the concept of buffer time (i.e., the time that needs to be built into a trip to ensure that it is made on time some fixed percentage of time). In the SCAG studies, buffer time was calculated based on the 95th percentile travel time for a particular corridor. Again, relationships can be estimated between buffer time in the region and other traffic characteristics that can be modeled.

While we do not propose to calculate reliability using either of these methods for the studies in which it has not been calculated already, we will be able to compare the results of the calculations using the two different methods in Southern California (these studies involve the same truck-only lane facilities) to determine what the potential range of benefits may be given particular congestion and lane configuration assumptions.

Safety

Safety benefits are considered one of the strongest reasons for constructing truck facilities, as also corroborated by the *Handbook for Planning Truck Facilities on Urban Highways*. However, evaluating the safety benefits of truck-only lanes is likely to be a particularly difficult benefit to measure. The most common approaches involve regression techniques that relate accident rates to variables, such as v/c ratio, facility type, number of lanes, and even percent trucks. The biggest problem is that very few of these relationships have been estimated using data where trucks and autos are separated. This is where the limited actual cases of traffic separation will provide some of the most critical data to be used in evaluating the benefits of truck-only lanes.

The primary data element that will be used to evaluate the safety benefits of truck-only lanes will be the accident rates for fatalities, injuries, and property damage, typically measured in terms of the number of accidents by type per million vehicle-miles. To the maximum extent possible, we will compile these data for different facility types and traffic conditions to determine if any relationships can be derived from the data.

Environmental Impacts

The focus of the evaluation of environmental impacts will be primarily on reduced emissions from improved traffic flows. It also will look at some of the potential environmental impacts of changing (and concentrating) truck flows and the creation of local hot spots; and pollution dispersion related to elevated lanes as a way of grade-separating truck lanes from mixed-flow lanes.

As described earlier, the results of the performance evaluations will be compiled so that truck-only lane performance can be compared to a baseline mixed-flow condition for each of the major types of truck-only lane configurations uses. Likely ways that these results will be compiled include:

- Area type (urban versus rural);
- Through traffic orientation versus local traffic orientation; and
- Type of separation.

Tables will be prepared that show the actual data and how it was derived, as well as tables comparing percentage changes in key indicators. Sources of data will be noted for all of the summary tables so that readers can use the report as a data source for conducting their own analyses.

Task 9 – Benefit/Cost Evaluation

As noted previously, development of truck-only lanes does not come without costs. In this task, Cambridge Systematics will compile information about those factors associated with truck-only lanes that will result in increased costs to construct and operate the facilities. The

task also will translate the benefits analyzed in Task 8 into monetary benefits for benefit/cost comparisons. This will include a detailed enumeration and valuation of public benefits, including reduction of congestion for passenger traffic on the mixed-flow facilities, emissions reductions, and safety improvements. Since many current proposals for truck-only lanes include discussion of tolling, the benefit/cost analysis will examine private sector benefits in order to determine the degree to which value can be captured through tolling/user fees and how this compares to both capital and operating costs.

A major aspect of the cost evaluation will focus on the cost to construct and maintain truck-only lanes of various configurations. This will include translating information from previous tasks related to ROW requirements, special pavement requirements, unique geometrics, interchange design, and method of separation into a series of cost indicators (most likely a normalized cost per mile). In addition to the analysis of capital costs, wherever the data are reported, we will compile information on actual or predicted costs of pavement maintenance and any unique changes in operating costs (such as potential reductions in costs for incident management).

The analysis of monetary benefits will begin with an evaluation of the value of reductions in both recurrent and nonrecurrent delay. Cambridge Systematics will use the range of values calculated as described above for the Southern California case, and review the literature on truck value of time to develop a range of values of time that can be used to estimate potential private-sector benefits associated with congestion reduction and reliability improvements. A similar analysis will be conducted compiling data on potential benefits for LCV operations.

The Reason Foundation studies cited earlier have conducted a number of evaluations of the potential benefits of LCV operations using data on estimated revenues per load and the amount of increase in load (and thus increased revenue per trip) that could be handled in LCV operation. They also have provided examples of potential cost implications of LCV operations in different configurations of truck lane. This includes capital costs for the thicker pavement, operating costs, and operating costs for the motor carrier.

Task 10 – Final Report

At the conclusion of the study, Cambridge Systematics will prepare a final report that summarizes the results of the analysis. The final report will include a chapter that provides an overview of the different examples of CMV-only lanes in practice, as well as the major studies that have been conducted. There will be a chapter that talks about the different types and configurations of CMV-only lanes and what critical factors affect their feasibility. There also will be a chapter that provides performance data and comparisons and a report that summarizes benefits and costs of different types of CMV-only lane systems.

Attachment A

Literature Review Matrix

Attachment A. Literature Review Matrix

Ref. No.	Reference Name	Publication Title	Publication Date/Time Period	Useful Source for NCHRP 03-73?	Applicability to NCHRP 03-73: Existing Truck Lane Project	Feasibility/ Planning/ Analytical/Modeling Study	Types of Facilities	Performance Measures	Data Inputs and Tools for Evaluation of Performance Measures	Physical Criteria/Design Considerations	Costs	User Fee/Tolling Considerations	Planning Process Issues	ITS Applications	LCV Applications	Abstract
1	SCAG	SR 60 Truck Lane Feasibility Study	2000/2001	Yes		√	√	√	√	√	√	√	√	√		
2	FHWA, and DOTs of Texas, Oklahoma, Kansas, Missouri, Iowa, and Minnesota	I-35 Trade Corridor Study	1998/1999	Yes		√	√	√	√	√	√	√		√	√	
3	Yang, Choon Heon	Evaluation of General Truck Management Strategies Based on Integrated Simulation Studies: Case Study of Truck Lane Restriction on I-710 in Southern California	20070000	Yes		√		√	√					√		Accurate evaluations of general truck management strategies (GTMS) are required in order to identify positive benefits that can be expected to result from implementation. Most GTMS have been studied with primary or even exclusive consideration of the public-sector standpoint. Traffic agencies have primarily focused on addressing operational and safety aspects of GTMS. These are important but insufficient, because they do not accurately describe the full effects of GTMS. In our research, multicriteria performance measures are used to reflect and evaluate overall benefits, including the public- and private-sector standpoints. This study was performed on an approximately 10-mile section of the I-710 corridor in Southern California. This corridor has some of the highest truck volumes in the U.S. We considered a truck lane restriction strategy, because it is regarded as the most appropriate option for this facility. Three types of scenarios were developed to examine the proper number of restricted lanes. The micro traffic simulation models TransCAD and PARAMICS were the primary analytical tools employed in this research. We concluded that Scenario 3, in which two lanes out of four to six are restricted, would provide the maximum positive benefits to the public and private sectors. This study also demonstrated the number of restricted lanes is an important factor in the success of the implementation of this strategy. Our simulation model is fairly general and can be used to evaluate other possible GTMS, such as weigh in motion and the addition or conversion of one or more lanes to allow trucks only.
4	SCAG, SANBAG, and Caltrans	I-15 Comprehensive Corridor Study	2003/2004	Yes		√	√	√	√	√	√	√	√		√	
5	Georgia DOT	Georgia Statewide Truck Lane Needs Identification Study	Ongoing	Yes		√	√	√	√	√	√		√			
6	Chicago DOT	Mid-City Freightway Corridor Study	2005/2006	Yes		√	√	√	√	√		√				
7	FHWA and Virginia DOT	I-81 Corridor Study	2005-2007	Yes		√	√	√	√	√	√	√				

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					Existing Truck Lane Project	Feasibility/ Planning/ Analytical/Modeling Study	Types of Facilities	Performance Measures	Data Inputs and Tools for Evaluation of Performance Measures	Physical Criteria/Design Considerations	Costs	User Fee/Tolling Considerations	Planning Process Issues	ITS Applications	LCV Applications		
8	Fischer, M. J.	Planning Truck-Only Lanes: Emerging Lessons from the Southern California Experience	20030000	Yes		√	√	√	√	√	√	√					Recent efforts to develop truck-only facilities in the U.S. are discussed. The rationale for truck-only highways is described, and the history of efforts to separate trucks and automobiles on the nation's roadways is presented. The truck lane program of SCAG is one of the most ambitious programs of its type in the U.S. Preliminary analysis of truck lanes for SR 60 and I-710 is described. SR 60 is an east-west corridor linking downtown Los Angeles, with the warehouse and manufacturing districts of the San Gabriel Valley and the Inland Empire. I-710 is the major access route to the Ports of Los Angeles and Long Beach. Both freeways each have one of the highest truck volumes in California, and truck mobility on these corridors is a significant problem. Truck lane projects on SR 60 and I-710 are in the feasibility analysis stage, and much has been learned in these early studies. Various issues are addressed, including the tradeoff between limiting access to improve operational costs and limit capital costs, need to generate demand, time-of-day distribution of truck traffic and its relationship to potentially benefit truck mobility, and need for improved analytical tools. Also described are issues related to facility design and configuration, demand analysis, and toll analysis.
9	Garber, N. J., and R. Gadiraju	Effects of Truck Strategies on Traffic Flow and Safety on Multilane Highways	1990	Yes	√	√		√									Recent legislation has encouraged the increased operation of trucks (defined here as vehicles having six or more wheels in contact with the road and a gross vehicle weight greater than 10,000 lbs) on Interstate and primary highways. This has affected safety and the quality of traffic flow on multilane highways. Imposing certain restrictions on truck operations on these highways has been identified as a way to reduce this effect. However, the overall impact of these restrictions on safety and traffic flow has not been fully studied. For example, restricting trucks to specific lanes or lowering their speed limit could have varied effects on traffic. The primary objective of the research described in this paper was to provide information on the nature and extent of the effects of such truck control strategies on traffic flows, speeds, headways, and accident patterns. Simulation was used to study these effects on multilane highways. The results did not indicate any safety benefits from the imposition of these strategies, but suggested that the potential for an increase in accident rates would be created, particularly if the strategies were imposed on highways with high volumes and a high percentage of trucks.
10	Borchardt, D.	TTI Evaluates Lane Restrictions for Houston Demonstration Project	20020000	Yes		√		√									Employing a Texas law allowing local governments to institute 'no truck' lanes, the Texas DOT worked with the Texas Transportation Institute (TTI) to conduct a study to evaluate the success of a highway lane restricted to only passenger vehicles. After a 36-week monitoring period, it was found that the crash rate on the selected 8-mile stretch of I-10 East Freeway was reduced by 68 percent as a result of lane restriction. Due to this success and an 85-percent approval rating of the project in a survey of drivers, the Texas DOT is considering implementing the restrictions on additional freeways in Houston.

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					Existing Truck Lane Project	Feasibility/ Planning/ Analytical/Modeling Study	Types of Facilities	Performance Measures	Data Inputs and Tools for Evaluation of Performance Measures	Physical Criteria/Design Considerations	Costs	User Fee/Tolling Considerations	Planning Process Issues	ITS Applications	LCV Applications	
11	Davidian, V.	Development of a Heavy-Duty Truck Model for Southern California	19990000	Yes		√		√	√							This paper describes the results of a project that developed a travel demand model to forecast the movement of heavy-duty trucks through the five-county SCAG modeling region. This model is fully integrated with SCAG's existing five-county travel demand forecasting model, and will be used to evaluate the impacts of trucks on traffic flow and air quality, as well as to test potential capital improvements such as truck-only lanes. The model generates truck trips from socioeconomic data traditionally forecast by SCAG; and includes an update of commodity flow forecasts, detailed surveys of shippers, and truck counts throughout the region. It also includes focused efforts to quantify truck trips generated by special generators, such as airports, seaports, intermodal terminals, and major industrial employers. The study collected empirical data regarding the passenger car equivalents (PCE) of trucks in Southern California; and developed a dynamic traffic assignment procedure for trucks, simultaneous with automobiles, which accounts for the effects of heavy-duty trucks through the use of truck PCE factors.
12	Davidian, V.	Southern California's Heavy-Duty Truck Model	20020000	Yes		√		√	√							This paper describes the results of a project that developed a travel demand model to forecast the movement of heavy-duty trucks throughout the five-county SCAG modeling region. The model is fully integrated with SCAG's existing five-county travel demand forecasting model, and will be used to evaluate the impacts of trucks on traffic flow and air quality, as well as to test potential capital improvements such as truck-only lanes. The model generates truck trips from socioeconomic data traditionally forecast by SCAG; and includes an update of commodity flow forecasts, detailed surveys of shippers, and truck counts throughout the region. It also includes focused efforts to quantify truck trips generated by special generators (airports, seaports, etc.). The study collected empirical data regarding the PCE of trucks in Southern California, and developed a dynamic traffic assignment procedure for trucks, simultaneous with autos, which accounts for the effects of heavy-duty trucks by use of truck PCE factors.

Ref. No.	Reference Name	Publication Title	Publication Date/Time Period	Useful Source for NCHRP 03-73?	Applicability to NCHRP 03-73: Existing Truck Lane Project	Feasibility/ Planning/ Analytical/Modeling Study	Types of Facilities	Performance Measures	Data Inputs and Tools for Evaluation of Performance Measures	Physical Criteria/Design Considerations	Costs	User Fee/Tolling Considerations	Planning Process Issues	ITS Applications	LCV Applications	Abstract
13	Jo, Gan, and Bonyani	Impacts of Truck-Lane Restrictions on Freeway Traffic Operations	2002	Yes		√		√								Highways are generally designed to serve a mixed traffic flow that consists of passenger cars, trucks, buses, recreational vehicles, etc. The impacts of these different vehicle types are not uniform; thus, create special problems in highway operations and safety. One common approach to reducing the impacts of truck traffic on freeways has been to impose certain lane restrictions on trucks. Truck-lane restrictions may increase the overall operational efficiency of freeways, lead to improved traffic safety on these facilities, and provide uniform pavement wear. A variety of truck restriction methods have been implemented throughout the U.S. Most restrictions, however, have been used without detailed planning or evaluation through before and after studies. The purpose of this study was to analyze changes in various measures of effectiveness (MOEs), including speed, capacity, density, and lane changes under various traffic conditions and restriction strategies. The CORSIM simulation model was used to model the effects of various truck-lane restrictions on basic freeway sections. For model development, car-following sensitivity factors were calibrated to emulate the freeway speed-flow curves in HCM 2000. Various scenarios were constructed to replicate prevailing conditions with combinations of number of lanes, free-flow speed, volumes, truck percentage, and restriction methods. Paired t-test was used to assess the changes in MOE before and after truck-lane restrictions. It was found that: (1) truck-lane restrictions reduce average speed and capacity and increase density; (2) truck-lane restrictions reduced the lane changes for all cases, except when there is a high number of restricted lanes; and (3) changes in density, speed, capacity, or lane changes after truck-lane restriction increased with increasing number of restricted lanes.
14	LA Metro, Caltrans, Gateway Cities COG, and SCAG	I-710 Major Corridor Study	2001-2005	Yes		√	√	√	√	√						
15	Middleton, D., K. Fitzpatrick, and D Jasek	Case Studies and Annotated Bibliography of Truck Accident Countermeasures on Urban Freeways, FHWA-Rd-92-040	1994	Yes		√	√	√	√	√						To address the growing problem of congestion caused by incidents, especially truck-involved incidents, this study was undertaken to identify truck accident countermeasures, which have been used nationwide. Desired conditions surrounding implemented countermeasures in this study included urban freeway volumes of 95,000 vehicles per day or higher, a significant number of trucks in the traffic stream (typically 5 percent or more), and countermeasures involving road design. The study omitted countermeasures directly related to the vehicle and the driver. This project included the following steps: literature search, telephone survey, and field visits to selected sites. The information collected by this project is intended to assist agencies in identifying, selecting, and implementing truck accident countermeasures. Information was gathered on the following truck accident countermeasures: lane restrictions, separate truck roadways, urban inspection stations, ramp treatments, major incident response and clearance, and truck bans/diversion and time restrictions. The detailed information found in this document is summarized in the final report, FHWA-RD-92-059 (TRIS 662764).

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					Existing Truck Lane Project	Feasibility/ Planning/ Analytical/Modeling Study	Types of Facilities	Performance Measures	Data Inputs and Tools for Evaluation of Performance Measures	Physical Criteria/Design Considerations	Costs	User Fee/Tolling Considerations	Planning Process Issues	ITS Applications	LCV Applications	
16	Reich, S. L.	Exclusive Facilities for Trucks in Florida: An Investigation of the Potential for Reserved Truck Lanes and Truckways on the State Highway System	20030000	Yes		√		√	√							This paper reports on a study to investigate the feasibility of separating large trucks out of the traffic mix through the use of exclusive highway facilities for trucks (EFTs) in Florida. Researchers conducted a literature review, identified national cases studies, and visited sites where special treatments had been implemented. Input was obtained from state and local transportation officials, highway safety professionals, planners, enforcement agencies and truck driver public interest groups. A methodology was developed to select sites in Florida that warranted further consideration for EFTs. Geographic information system models were developed to identify potential sites based on truck crashes, truck volume and percent, and level of service. Both rural and urban locations were considered. At identified sites, local officials were consulted to document additional details about local streets and interstate highways, and the feasibility of countermeasures for each site were considered. Findings suggested that most of Florida's interstate system was suitable for EFT consideration, especially where the right of way exists to create new lanes for a facility. An ideal separated facility would provide for ease of passing and adequate shoulders, and would be most appropriately situated in the median in areas where interchanges are far enough apart to avoid the long weave sections that would be required for entering and exiting trucks.
17	Rodier, Caroline J.	A Comparison of High-Occupancy Vehicle, High-Occupancy Toll, and Truck-Only Lanes in the Sacramento Region	19990000	Yes		√		√	√							This paper presents a comparison of a regionwide system of new high-occupancy vehicle (HOV) lanes, high-occupancy toll lanes (HOT), and truck lanes in the Sacramento, California metropolitan area. Travel effects and emissions results are simulated with models. The economic benefits for both personal travel and commercial vehicle are obtained from economic welfare models. The scenarios are evaluated against travel, emissions, total economic benefit, and equity criteria. While the results did not vary much among scenarios regarding travel and emissions, the economic benefit results did have more significant variation. The scenarios that included HOT lanes produced economic benefits that were noticeably superior to the other scenarios.
18	Darrell W. Borchardt, Deborah L. Jasek, and Andrew J. Ballard	Monitoring of Texas Vehicle Lane Restrictions	Sept 2004	Yes				√		√						This research evaluated truck lane restrictions in Texas and further developed guidelines for future implementations on the freeway system. The truck lane restrictions on the I-10 East Freeway in Houston have had a long-term (since September 2000) impact in reducing crashes during peak traffic periods. Although vehicle restrictions may not be necessary on all freeways, the restrictions should be implemented 1) if the guidelines are met, 2) if it is the opinion of the local traffic engineers that crashes may be reduced, 3) if commitment of local law enforcement has been assured, and 4) if there are no diverse impacts to truck movement and commerce in terms of goods movement.
19	Douglas, James, G.	NCHRP Synthesis 314, Strategies for Managing Increasing Truck Traffic, A Synthesis of Highway Practice	2003	Yes			√	√		√						Transportation Research Board's (TRB) National Cooperative Highway Research Program (NCHRP) Synthesis 314: Strategies for Managing Increasing Truck Traffic documents recent efforts by transportation organizations that construct, operate, and manage the transportation system; and identifies truck-related challenges, planning activities for goods movement being undertaken, truck management strategies being considered, factors that have influenced the selection of particular strategies, and benefits expected from selected strategies.

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20	Fancher, Paul S. Jr., and Thomas D. Gillespie	NCHRP Synthesis of Highway Practice 241, Truck Operating Characteristics	1997	Yes				√	√							This synthesis will be of interest to engineers and administrators responsible for the design, construction, and maintenance of highways and bridges, as well as to engineering design consultants. It will also provide useful information to the trucking industry, especially to designers, as they consider the highway interface with regard to the design and operation of heavy trucks. It provides information on the influence of the design and operating characteristics of heavy trucks on highway design, maintenance, and operational performance. Designers of heavy trucks and of the highway infrastructure that is needed to support them are faced with changing requirements for both systems to operate effectively and safely. Because truck designs tend to evolve more rapidly than highways can be rebuilt or redesigned, inefficiencies can result. This report of the TRB describes heavy-truck design factors and operating characteristics; and their influence on highway planning, design, and performance. The key truck operating characteristics, such as weights and sizes, mechanical properties, turning requirements, accelerating and braking, crash avoidance, pavement and bridge loadings, and the effects on traffic flow are discussed. To more clearly illustrate the subject, matrices of truck and roadway characteristics that are associated with each of these elements are presented.
21	Fitzpatrick, K., D. Middleton, D. Jasek	Countermeasures for Truck Accidents on Urban Freeways: A Review of Experiences	1992	Yes				√		√						Because of the rise in truck volume, the interaction of these large vehicles with other traffic, and the publicity given to major truck accidents, public awareness of the consequences of truck accidents and incidents are heightened. A literature review, telephone interviews, and visits to selected sites provided information on several truck accident countermeasures implemented on high-volume urban freeways. A Federal Highway Administration (FHWA) survey found that 15 states have restricted trucks to certain lanes to improve highway operations. The New Jersey Turnpike and I-5 north of Los Angeles have sections on which trucks are restricted to a separated facility. Ramp treatments include reconstruction to remove outside curbs, installation of tall barriers, evaluation of the appropriateness of posted ramp speeds, and active and passive warning signs. Truck diversions or bans exist in Minneapolis-St. Paul, south of Cincinnati, San Diego, Los Angeles, and Atlanta. Allowing trucks to park in a park-and-ride lot during nighttime hours and increasing enforcement to restrict the length of stay in inappropriate locations (e.g., mainlane shoulders or along entrance and exit ramps) are measures used to reduce shoulder parking. Maryland, Virginia, and California have urban truck inspection stations; and Chicago, Tampa, and Seattle have elements of their incident management program directed toward trucks.

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22	Hanscom, F. R.	Operational Effectiveness of Truck Lane Restrictions	1990	Yes				√		√						The operational effectiveness of restricting trucks from designated lanes on multilane roadways is addressed. Three locations with no truck restrictions were treated with signing restricting trucks to certain lanes. The applied field study was of a before-and-after design (with matched control sites). Truck lane restrictions were implemented at two three-lane sites and one two-lane location. Favorable truck compliance effects were evident at all three locations. Before-and-after comparisons indicated significant truck lane use shifts; however, violation rates were higher (i.e., 10.2 percent) at the two-lane site in comparison with the three-lane sites (i.e., 0.9 percent and 5.7 percent). Higher violation rates at the two-lane site resulted from increased truck densities caused by restricting trucks to a single lane. An emphasis was placed on determining traffic flow effects to nontrucks in the traffic stream. Beneficial effects on three-lane roadways were realized in terms of reduced congestion and fewer trucks impeding vehicles (at both sites) and shorter following queue lengths (at one site). This finding supports the conclusion that traffic congestion at three-lane sites was reduced as the result of the restriction. An adverse effect, observed at the two-lane restriction, was reduced speeds of impeded vehicles following trucks. However, a slight benefit was found in that fewer trucks impeded following vehicles. All-vehicle speed comparisons were examined to determine whether increased differential speeds were likely to occur between the restricted and adjacent lanes. No speed changes were observed to indicate an adverse effect of the truck lane restriction.
23	McCasland, W. R.	Truck Operations and Regulations on Urban Freeways	19840800	Yes				√		√						This study examines six general classes of truck regulations in terms of their impacts on urban freeway safety and traffic operations. The truck restrictions and regulatory practices examined were: 1) lane restrictions; 2) time-of-day restrictions; 3) speed restrictions; 4) route restrictions; 5) driver licensing and certification programs; and 6) increased enforcement of existing regulations. Of the six classes of regulations examined, only two appear capable of truck usage of producing any substantial improvement in the safety and operational aspects of truck usage of urban freeways in Texas. Reduced speed limits, either for all vehicles or trucks only, appear to merit consideration on a trial basis. In terms of long-term actions, the areas of driver licensing/training and incident management techniques should be emphasized.
24	St. John, A. D.	Safety Considerations for Truck Climbing Lanes on Rural Highways	19910000	Yes				√	√							Truck arrester beds, or escape ramps, located within Arizona were used for prototype testing. Tractor semi-trailer combinations with GVWs of approximately 35,000 lbs (15,876 kg) and entrance velocities of 45 and 64 mph were driven into these ramps. The testing was used to help evaluate the effects of ramp material, ramp preparation, and maintenance on ramp performance. Instrumentation utilizing radar and a data acquisition computer were developed to record truck velocities from entrance until run out in the ramps. The instrumentation was designed to be used during testing and for remote sensing of entries at the completion of the research. The study team enlisted the help of the only heavy-duty towing company in the vicinity of the two I17 escape ramps.

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25	Tom, G. K. J.	A Case Study of Truck Merging Operations at Selected Freeway On-Ramp Locations In California	19970300	Yes				√	√							This report provides an evaluation of truck merging operations for selected freeway on-ramp locations where there are significant truck volumes. Data regarding vehicle merge locations, speeds, traffic volumes, and accidents are included in this report. There is an auxiliary lane approximately 2,152-foot (655.9-meter) long at one of the rural locations (Stanislaus County, Route 5, Ingram Creek Road Interchange, Postmile 23.0, northbound on-ramp). The auxiliary lane was adequate for merging and was used by most vehicles. The fatal and injury accident rate for the merge area at this location was higher than the expected accident rate. This difference was not statistically significant. The fatal and injury accident rate for the merge area at the other rural location (San Bernardino County, Route 15, Lenwood Road Interchange, Postmile 68.8, northbound on-ramp) was higher than the expected accident rate. This difference was statistically significant. It should be noted that an auxiliary lane is currently being proposed at this location. Vehicle merge data were not summarized for this location. At the two suburban locations (San Bernardino County, Route 10, Postmile 13.2, Cherry Avenue Interchange, westbound and eastbound on-ramps), most of the merging by cars and by truck combinations occurred within intervals of only about 200 feet to 350 feet (61.0 meters to 106.7 meters). The fatal and injury accident rates for the merge areas at these locations were less than the expected accident rates. The annual average daily traffic and travel for the two rural locations were less than those for the suburban locations. Each of the four freeway on-ramp locations evaluated in this report has its unique set of characteristics in terms of traffic volumes and geometric design, which might influence truck merging operations. Therefore, the information contained in this report would be helpful for planning and designing freeway on-ramp merge areas with similar characteristics.
26	Wilkins, W. M.	Truck-Only Lanes Can Help to Reduce Traffic Congestion	20041000	Yes				√								Truck-only lanes can be an effective method of reducing traffic congestion, improving mobility, and increasing traffic safety. With commercial truck travel expected to increase by 49 percent by 2020, urban traffic congestion will worsen and traffic safety will be further impacted, especially as research finds that traffic accidents involving large trucks cause one out of eight traffic fatalities. This article cites a few examples of how some states are studying methods of expanding or building truck-only lanes in heavily-trafficked areas as a means of reducing gridlock.
27	Rawling, F. G.	If We Build It, Will They Come?	20040300	Yes									√	√		The paper examines a proposed truck-exclusive facility with an intelligent transportation system (ITS) component designed to provide for intermodal truck chaining in the metropolitan Chicago area. This concept is part of a national cooperative vehicle-highway automation system (CVHAS) initiative that is seeking to identify a viable rest location. Before deciding on Chicago for the test site, following questions need to be answered: if freight business continues to grow at the anticipated rate, where will it all be put? Is freight transportation a business the state, regional, and local political bodies want to see prosper and grow, and if so, what needs to be done to make it happen? The proposed choice of Chicago as the site was partially based on a 1981 study that determined there was a favorable condition for a compact system of truckways to connect several intermodal ramps. In addition, the motivation for the choice of Chicago was because the planners think it is the logical place.

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28	Cothron, A. S.	Enforcement Issues on Managed Lanes	20030100	Yes		√								√		This report provides an overview of enforcement issues for operating freeways with managed lanes. The term “managed lanes” encompasses a variety of facility types, including HOV lanes, HOT lanes, single-occupancy vehicle (SOV) express lanes, special-use lanes, and truck lanes. The role of enforcement is explored through identifying the available enforcement strategies and elements of enforcement area design. The state of the practice for managed lane enforcement at various locations around the country gives insight of items to consider when developing an effective enforcement program. Lastly, this report acknowledges managed lane enforcement is becoming ever more dependent on technological advancements in presenting innovations in the area of automated enforcement technology, specifically, automated vehicle identification (AVI), license plate recognition (LPR), and electronic toll collection (ETC).
29	Samuel, P.	How to “Build Our Way Out of Congestion.” Innovative approaches to expanding urban highway capacity	19990100	Yes		√	√			√				√		The author of this report argues that traffic congestion can be relieved by innovative highway design and construction. One solution is to provide separate lanes for cars and for trucks. Cars need much smaller dimensions; hence, cars-only lanes can be done as double decks, either above the surface or in tunnels beneath high-value real estate. Paris, Melbourne, and Sydney are developing new urban expressways using some of these new concepts. To pay for new advanced expressways, the author suggests toll roads that charge automatically. Electronic tolling costs far less than labor-intensive toll booths. Demand-responsive market pricing has been found highly effective in keeping toll lanes from becoming congested in two Southern California projects.
30	Shladover, Steven E.	Improving Freight Movement by Using Automated Trucks on Dedicated Truck Lanes: A Chicago Case Study	20060000	Yes		√					√			√		This article frames the general heavy-vehicle traffic situation as negative – albeit with a positive potential solution in dedicated truck lanes and vehicle automation. The author describes a case example in Chicago where certain aspects of these technologies have been applied, finding the most beneficial solution in truck platooning and other capacity expanding methods. Such methods are specifically allowable in truck-only lanes due to the relative ease of coordination for a restricted space as opposed to the dynamics of standard roadway. The cost of implementing such a system, as explained through the Chicago study, would be beneficial, according to the author, due to the alternative of simply expanding standard roadway capacity ($263 million for standard roadway as opposed to $40 million for truck automation equipment).

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31	Staudinger, Max	Electronic Vehicle Identification Using Active Infrared Light Transmission	20040000	Yes										√		In-vehicle Electronic Vehicle Identification (EVI) technology has several applications for vehicle location, data exchange, HOT, etc. Infrared light is an active medium allowing roadside checking, which permits in-vehicle devices to start the communication sequence of events to send active data. It is, therefore, possible to establish car-to-car and vehicle-to-roadside communication links. Implementing EVI is the new-age choice for ITS in an effort to protect against crime; improve safety; implement activities related to terrorism protection; and initiate potential applications, including HOT. Communication with vehicles can be noninterrogatory (i.e., extract public data that does not violate privacy concerns). Communication is also possible using the common approach of a "Challenge-Response" protocol that is noninterrogatory, where the in-vehicle device checks the permission (via a digital signature) of the interrogator to access stored data. The administrative and legislative considerations still to be accomplished are to determine the ownership of in-vehicle electronic data; determine what data can be transmitted and received; the best way to retrofit and factory install tamperproof integration devices; and how to enforce data use and privacy rights, and to define technological requirements for operating distances and medium properties. Due to the easy application and versatility of infrared light communications, several ITS systems are installed worldwide. This presentation discusses the current implementation scenarios for EVI Using Active Infrared Light Transmission, and introduces the infrared ITS application in the German Truck Tolling System for enforcement in 1 million trucks in Germany. Criticisms of infrared have been overcome with innovations that make possible the benefits and simplicity of infrared communication in outdoor applications; developing the technology to extract infrared data from virtually any background noise, thereby eliminating the problem of direct sunlight previously associated with infrared. The second outstanding innovation is zero power intelligent standby circuitry.
32	Boyer, Kenneth D.	Stuck in the Slow Lane: Traffic Composition and the Measurement of Trucking Productivity	20070000	Yes		√						√	√			Several recent studies have found large productivity gains in the trucking industry over the period covered by this study, with implications for the economic effects of public investment or the adoption of technological innovation. But a careful analysis in which traffic composition effects are removed shows that trucking productivity instead follows the predictions of the Baumol hypothesis: that productivity growth in labor-intensive services industries will tend to lag that of the economy. Physical productivity growth in the trucking industry in fact has been only a little more than one percent per year, and is attributable primarily to factors such as increases in the dimension of trucks and increased speed limits on American roads. There have undoubtedly been quality improvements in the outputs of the trucking sector that can be attributed to technological change in the industry, as in other industries in the service sector; but such improvements are fully consistent with the expectation that physical productivity improvements in the service sector have been modest.

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33	Holguin-Veras, J.	Economic and Financial Feasibility of Truck Toll Lanes	20030000	Yes		√			√		√	√	√			The economic and financial feasibility of heavy-truck toll lanes was analyzed. This research expanded the line of inquiry of previous researchers by analyzing toll lanes for exclusive use by heavy trucks (i.e., large size and capacity). Implementation of such a toll system was studied relative to productivity changes, toll-lane fees, users travel time and vehicle operating cost savings, and impact on infrastructure costs. The economic benefits were estimated using the Highway Design and Maintenance Standards Model developed by the World Bank. The analyses, complemented with sensitivity analyses of key variables, indicate that heavy-truck lanes are economically and financially viable.
34	Poole Jr., Robert W.	Toll Truckways: A Win-Win Approach to Increasing Highway Capacity	20051100	Yes		√	√					√	√			This article outlines the concept of using toll truckways to increase highway capacity. The author describes an approach that would add new heavy-duty, truck-only lanes along existing Interstates and urban freeways. For safety reasons, they would be separated from general-purpose lanes by concrete barriers, and access and egress would be via flyover lanes. It would also be feasible to allow longer, heavier trucks (called longer combination vehicles (LCVs)) to operate on this separate system of lanes. Some of the benefits of this system include increased truck productivity, reduces emissions, and support for just-in-time deliveries (with reduced traffic problems, schedules would be easier to achieve). The truckways could also support fast and reliable short-haul trips, bypassing freeway congestion. The author then discusses the cost aspects, hypothesizing that, in order to gain these advantages, it would be worth it to a trucking company to pay tolls to use the truckways. The author concludes by considering the public policy challenges of this proposition, including the general ban on using tolls on any portion of the Interstate system that was not grandfathered in when the system was designed, the lack of support from the American Trucking Association and the railroads' trade association, and the realization on the part of state DOTs that if they use their remaining right of way for toll truckways, they will be prevented from adding general purpose lanes.
35	Forkenbrock, David J.	Benefits, Costs, and Financing of Truck-Only Highway Lanes	20050000	Yes							√	√	√		√	This paper explores the conditions under which investment in truck-only lanes on rural interstate highways could be considered and what sorts of benefits may accrue to both occupants of passenger vehicles and to operators of heavy trucks. The authors examine the available evidence regarding the nature and magnitude of these benefits to gain insight into the willingness of highway users to pay for these lanes. Findings indicate that the willingness to pay for truck-only lanes on the part of occupants of passenger vehicles appear to be quite limited and that support for these lanes by trucking firms is likely to depend upon their being allowed to operate LCVs on them. Since these lanes would be too expensive to be funded through traditional sources, trucking firms could be assessed tolls to travel in truck-only lanes, with these tolls representing some fraction of the increased productivity gained through being allowed to operate LCVs. For each potential truck-only lane project, it would be necessary to conduct a detailed feasibility analysis that takes into account current traffic characteristics, the potential for productivity gains, possible toll levels, connectivity of LCV facilities, and cost of adding the lanes.

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36	Janson, et al.	Economic Feasibility of Exclusive Vehicle Facilities	1991	Yes								√	√			A microcomputer program called "exclusive vehicle facilities" (EVFS) that determines the economic feasibility of separating light vehicles from heavy vehicles on a given section of controlled-access highway by designating existing lanes and constructing new lanes to be used exclusively by light or heavy vehicles is described. On the basis of user inputs to a spreadsheet user interface, EVFS calculates the net present value, benefit-cost ratio, and other performance measures of the alternative exclusive vehicle facility specified. The three possible lane use policies allowed within EVFS are mixed-, light-, and heavy-vehicle lanes. EVFS accounts for the following potential benefits or cost savings both for person and for freight travel: 1) travel time savings; 2) vehicle operating cost savings; 3) accident cost savings (fatalities, injuries, and property damage), because of less severe accidents by separating light and heavy vehicles; and 4) queuing delay savings because of fewer accidents causing blockages. EVFS also accounts for the following project costs: 1) initial construction costs; 2) initial right-of-way acquisition and demolition costs; and 3) periodic pavement resurfacing costs, which may be less frequent and less costly for light-vehicle lanes. EVFS is designed to evaluate any of the following five cases: 1) do nothing; 2) designate existing lanes for mixed, light, and heavy vehicles; 3) add mixed-vehicle lanes (no special lane use restrictions); 4) add nonbarrier-separated lanes and designate new and existing lanes for mixed, light, and heavy vehicles; and 5) add barrier-separated lanes and designate new and existing lanes for mixed, light, and heavy vehicles. An example indicates that exclusive vehicle facilities are most warranted for congested urban highways with significant percentages of single-unit and combination trucks in the traffic stream.
37	Jasek, D., M. Shafer, D. Picha, and T. Urbanik II	Evaluation of the Feasibility, Legal, and Design Issues of Dedicated Truck Lanes in Texas (Task 1, Literature Review and Survey of State Practices, Final Report)	1997	Yes								√	√			
38	Kassoff, Hal	Flexible Managed Lanes: An Alternative to Exclusivity	20070700	Yes								√	√			This article advocates the implementation of HOT roads as a forward-looking solution to congested highways. While HOV lanes initially presented a good alternative to expanding lanes, it is argued that their lack of use even in relatively unrestrictive circumstances means that their value in easing traffic congestion for SOVs is nil. However, as HOT lanes put a premium on the flexible managed lane during peak hours for all vehicles, their use can be controlled by market factors. This use has allowed the preservation of the HOV ideology, which services car pools, buses, and vans, while maintaining the lane's utility for easing congestion. The author recommends expanding this concept in the form of express toll lanes rather than another proposal put forward that calls for the development of a national network of dedicated truck lanes.

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39	Multiple	Finance, Economics, and Economic Development 2006	20060000	Yes								√	√			This Transportation Research Record contains 20 papers on the subject of finance, economics, and economic development. Specific topics discussed include California's transportation finance reform proposal; financing local roads; transportation infrastructure concessions in Chile; targeting transportation funding to economic development in low-income communities; highway-induced development; the combined traffic impacts of the time-of-day pricing program and E-ZPass usage on the New Jersey turnpike; the impacts of the Port Authority of New York and New Jersey time-of-day pricing initiative on car and truck traffic; the feasibility of a truck-only toll lane network in Atlanta, Georgia; an analytical tool for evaluating the adaptation of an HOV lane to an HOT lane; a value pricing education and outreach model in Minnesota; lessons in public support for congestion pricing from Edinburgh, Scotland; guidelines for the conversion of an HOV lane to an HOT lane; value pricing in the Dallas-Fort Worth region; a stated-preference survey of SOV demand for HOV lanes; the Malaysian toll road public-private partnership program; the econometric estimation of motor fuel sales with incomplete data; the cost-benefit analysis of a high-speed train system in Spain; an economic impact assessment of the large-scale infrastructure project in the Lyon-Turin corridor; the benefits and financial feasibility of a multimodal investment and pricing strategy; and the behavioral responses to road pricing in the Netherlands.
40	Poole Jr., Robert W.	The Case for Truck-Only Toll Lanes	20070400	Yes								√	√			Although the expected future growth in truck traffic will require increased highway capacity, inadequate funding makes this expansion difficult. This paper discusses the possibility of using toll finances to develop truck-only toll (TOT) lanes on existing limited-access roadways that are key trucking routes. Urban TOT lanes would provide congestion relief and better access to and from key ports and airports. Long-distance TOT lanes also would permit longer combination vehicles that are not allowed on most interstate highways. Trucking firms and shippers might be willing to pay tolls in return for the increased speed, reliability, and payload offered by TOT lanes. Tolls also may do a better job than increased diesel fuel taxes of targeting investment to new capacity for goods movement. Prospects for TOT lanes look bright since they are beginning to gain support in some states and among Federal government agencies.
41	Poole Jr., Robert W.	Truck toll lanes, not higher fuel taxes	20061016	Yes								√	√			
42	Schulz, John D.	Trucks Only	20020624	Yes								√	√			Subtitle: Toll 'Truckways' Touted As Safe Way to Reduce Shippers' Costs by $40 Billion.

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43	Cate, M. A., and Urbanik II, Thomas	Another View of Truck Lane Restrictions	2004	Yes		√							√			As truck volumes on U.S. highways continue to increase, both elected officials and members of the general public often look to the use of lane restrictions for large trucks as a means to increase operating efficiency and highway safety. In the past, research has offered little evidence that either safety or efficiency is positively affected by widespread use of this practice. Another view of truck lane-use restrictions on high-speed, limited-access facilities is offered. To determine the effects of lane-use restrictions, scenarios that varied traffic characteristics, such as volume, grade, percentage of trucks, and the presence of entrance and exit ramps, were developed with the VISSIM model. In each scenario, traffic along the model freeway segment was monitored to determine the effect of the lane-use restrictions by comparing values of various traffic measures from a model run first without and then again with truck-lane restrictions. As in past research efforts, the implementation of truck-lane restrictions in a variety of scenarios is shown to have little effect on a number of traditional measures, including average speed, speed differential between cars and large trucks, and level of service. However, further examination of data resulting from the simulation process shows that significant gains in the area of safety and driver comfort may be realized through the reduction of lane-changing maneuvers by all vehicle types, lending support to past driver surveys indicating strong support for this practice among drivers of passenger vehicles.
44	Grenzeback	Expanding Metropolitan Highways: Implications for Air Quality and Energy Use; Appendix C: Impact of Changes in Highway Capacity on Truck Travel	1995	Yes		√							√			The impact of changes in highway capacity on truck travel in metropolitan areas is discussed in this appendix. At issue is whether highway capacity improvements induce truck travel and, conversely, whether restricting highway capacity dampens truck travel. The answers are needed to inform the debate about the impact of changes in highway capacity on congestion, air pollution, and energy consumption.
45	Vidunas, et al.	Exclusive Lanes for Trucks and Cars on Interstate Highways	1997	Yes		√			√				√			Increases in heavy-truck traffic on the nation's highways in recent years have raised concerns about safety and capacity, particularly on the Interstate system. In response, a number of strategies for dealing with the effect of truck traffic on safety and capacity have been developed. One promising strategy is to provide separate lanes for trucks and cars on freeways or Interstates. However, since separate lane strategies have not been widely used, little is known about their economic and operational effects. An FHWA computer model, referred to as EVFS, was evaluated. The model determines the economic feasibility of separating trucks and other vehicles on freeway segments. Practices and experiences with exclusive facilities nationwide were examined. EVFS can analyze many alternatives for a variety of conditions. It is inexpensive and easy to use. However, EVFS does not differentiate between the lanes to which exclusions are applied (inside, middle, and outside); and physical barriers are not treated explicitly. To demonstrate the application of the program, 10 lane separation strategies were evaluated for a 50.7-km (31.5-mi) segment of the I-81 in Virginia. The results of the I-81 analysis indicate that user savings can be achieved if one or more lanes are designated for the exclusive use of trucks or cars.

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46	American Association of State Highway and Transportation Officials (AASHTO)	Transportation Invest In Our Future	20070000	Yes									√			America's transportation network of highways, transit, rail, and ports is poised on the threshold of an unprecedented period of innovation. Investing in our future will change the lives of our children and grandchildren – for the better. Envision a future with more transportation choices and efficiency than ever before. The stranglehold of congestion will be loosened by driving shorter distances, riding transit, and better utilizing our highways. Strategic investment in new lanes, new corridors, and new capacity for all modes will remove bottlenecks and connect America and the world. Today's tragic toll of 43,000 people dying on our highways will be a distant memory as we continue to reduce fatalities by more than 1,000 each year. Freight will move so fluidly that on-time arrival is taken for granted. America will continue to lead the world in the efficient flow of goods from factory to store shelf and front door. Rail and truck corridors will interconnect, allowing guaranteed delivery with predefined arrival times scheduled at shipment. New materials, construction techniques, and designs will enable us to maintain, repair, and replace the network faster, cheaper, and with longer lasting life spans. Working together, Federal, state, and local governments, businesses and the general public will ensure that America's transportation network will be a sustainable system, the envy of the world. This brochure discusses transportation challenges to meet, solutions for the 21st century, and how to invest to achieve the vision of a 21st century transportation system.
47	Bearth, Daniel P.	Trucking Executives Express Dismay Over Plan to Add Truck Toll Lanes	20020318	Yes									√			
48	Collier, T.	Developing A Managed Lanes Position Paper For A Policy-Maker Audience	20020200	Yes									√			The managed lane concept is currently being considered on major freeway projects in Texas cities. While the HOV concept is familiar in most urban areas, motorists are less familiar with managed lanes. The term "managed lanes" encompasses a variety of facility types, including HOV lanes, HOT lanes, SOV express lanes, special use lanes, and truck lanes. The premise of the managed lanes concept is to increase freeway efficiency and provide free-flow operations for certain freeway users by packaging various operational and design strategies. The strategies deployed offer the flexibility to be adjusted to match changing corridor and regional goals. This report documents the development of a position paper. The position paper incorporates research findings from Task 8 of the Texas DOT Research Project 0-4160, "Operating Freeways with Managed Lanes." The research findings are published in Report 4160-7, "Marketing the Managed Lane Concept." The appendix of this report contains a position statement on managed lanes suitable for use by policy-makers considering decisions related to freeway planning. The paper provides policy-makers with a statewide perspective on managed lanes. The paper identifies the benefits of managed lanes, how the lanes may be operated, where successful projects have been implemented, and what Texas DOT has planned for Texas.

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49	Collier, T.	Developing A Managed Lanes Position Paper for a Media Audience	20020200	Yes									√			The managed lane concept is currently being considered on major freeway projects in Texas cities. While the HOV concept is familiar in most urban areas, motorists are less familiar with managed lanes. The term “managed lanes” encompasses a variety of facility types, including HOV lanes, HOT lanes, SOV express lanes, special use lanes, and truck lanes. The premise of the managed lanes concept is to increase freeway efficiency and provide free flow operations for certain freeway users by packaging various operational and design strategies. Most of these actions offer the flexibility to be adjusted to match changing corridor and regional goals. This report documents the development of a position paper. The position paper incorporates research findings from Task 8 of the Texas DOT research project 0-4160, “Operating Freeways with Managed Lanes.” The research findings are published in Report 4160-7, “Marketing the Managed Lane Concept.” The appendix of this report contains a position statement on managed lanes suitable for use by the media in conveying the concept of managed lanes to the public. The paper provides the media with a statewide perspective on managed lanes. The paper identifies the benefits of managed lanes, how the lanes may be operated, where successful projects have been implemented, and what Texas DOT has planned for Texas.
50	Collier, T.	Marketing the Managed Lanes Concept	20020400	Yes									√			The managed lane concept is currently being considered on major freeway projects in Texas cities. While the HOV concept is familiar in most urban areas, motorists are less familiar with managed lanes. The term “managed lanes” encompasses a variety of facility types, including HOV lanes, HOT lanes, SOV express lanes, special use lanes, and truck lanes. The premise of the managed lanes concept is to increase freeway efficiency and provide free-flow operations for certain freeway users by packaging various operational and design strategies. Most of these actions offer the flexibility to be adjusted to match changing corridor and regional goals. The projects reviewed in this report focus attention on the newer concept of pricing separate travel lanes, including HOT lanes and toll lanes, since previous research has addressed marketing and gaining public support for HOV lanes, SOV lanes, and truck lanes. The goal in reviewing these kinds of projects is to gain an understanding of public perception and public interaction when a new and complex concept for managing travel demand is introduced.
51	Fischer, Andrea	Georgia road agency considers Atlanta-area truck-toll lanes	20050815	Yes									√			
52	Fischer, Andrea	Proposed truck-only toll lanes illegal, Georgia trucking officials contend	20070827	Yes									√			
53	Gillam, Artelia C.	Georgia DOT gets four truck-only toll lane plans	20061113	Yes									√			
54	Gillam, Artelia C.	Truck-only toll road sought in Atlanta	20060522	Yes									√			
55	Gillam, Artelia C.	VDOT recommends scrapping plan for truck-only toll lanes on I-81	20061002	Yes									√			
56	Grata	Truckers’ group backs higher fuel tax, not tolls	Mar-08	Yes									√			

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57	Holland, Grant	Son of AB680 Awaits California Assembly's Stamp	20050400	Yes									√			In 1989, California passed AB 680, legislation that granted franchises for the 91 express lanes, which spawned a whole new subindustry (HOT/managed lanes), and the SR 125 toll road near San Diego. AB 680 created a transportation PPV industry. This article reports on a new piece of California legislation, AB 850, which would authorize the use of PPVs to help address California's transportation needs. AB 850 is part of a three bill package designed to speed the completion of roadways within the State; the other two facets are AB 1266 authorizing the use of project sequencing, and SP 705 that expands design-build project delivery. As introduced, AB 850 authorizes Caltrans to solicit proposals from, and enter into franchise agreements for, transportation projects. Qualifying projects include HOV lanes, where HOVs are permitted free passage, truck-only lanes, mixed-flow toll and free lanes, and non-HOV or managed lanes. The author describes the details of AB 850, considering specific projects that may fall under the new legislation. However, the author does not make a conclusion or prediction as to the success of this new legislation, should it pass the California assembly.
58	Kockelman, Kara M.	Public Perceptions of Pricing Existing Roads and Other Transportation Policies: Texas Perspective	20060000	Yes									√			Public perceptions are key to the future of many transportation policy proposals. In this work, statewide surveys, followed by a series of focus groups, illuminate public opinion and many of the issues at play in Texas. Statistical models of respondent opinions highlight the influence of demographic, location, and other variables. And focus group interactions explore the underlying reasons for these opinions. The statewide surveys revealed considerable agreement (over 70 percent) among respondents on just two issues: 1) charging heavy vehicles a higher toll is a good toll road feature, and 2) dedicated truck lanes should be added to highways. Results suggest reasonable support for conversion of nontolled roads to tolled roads if benefits can be demonstrated, and that frequent toll road users are more likely to support such conversions – while Austin residents and long-distance commuters tend to be less supportive. A multinomial logit model of stated responses to congestion pricing indicates that older persons are likely to reduce their travel during peak periods, members of larger households are more likely to change travel routes, and full-time workers are more likely to stick with their current travel patterns. Exploded logit models of policy rankings indicate that older, more educated persons, as well as long-distance commuters, females, and residents of nonmetro areas are more supportive of pricing new and existing roads than others. Such model specifications also offer insight into the most acceptable sources of revenues – their uses. The focus group discussions revealed a great variety of misunderstanding. Highly informative messages were received favorably. And "ordinary" people appear to make the most effective spokespersons. These results of all these analyses should prove useful in crafting toll-related policies, as well as public information campaigns.
59	McNally, Sean	Virginia Advisory Panel's I-81 Plan would put tolls on all vehicles	20040223	Yes									√			Subtitle: Proposal Calls for Separate Truck and Car Lanes.
60	McNally, Sean	New Jersey proposes turnpike expansion	20041206	Yes									√			Subtitle: $1.3 billion plan would extend truck lanes 20 miles south.
61	McNally, Sean	Hill backs truck-only lanes; Capka warns of high costs	20070716	Yes									√			

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62	McNally, Sean	Foundation releases route list for proposed truck tollways	20040301	Yes									√			
63	McNally, Sean	Highway funding looks at tolls, truck-only lanes	20050221	Yes									√			
64	McNally, Sean	Supporters of highway tolls oppose truck-only lanes	20040315	Yes									√			
65	Miller, Eric	Transportation groups endorse system of truck-only lanes to ease congestion	20070730	Yes									√			
66	Poole Jr., Robert W.	It is time for a goods-movement interstate system	20041100	Yes									√		√	In this article, the author argues the rationale for a change in surface transportation, notably for the development of a goods-movement interstate system. The author notes that there is an overwhelming predominance of trucking (90 percent of all goods moving by truck) in the goods-movement system, due primarily to the development of the Interstate highway system. However, that system, as it is presently structured, cannot meet growing needs of the transportation world. The author discusses urban congestion, fuel-tax revenue sources, and Congressional support and legislation, and then proposes the use of toll truck lanes as a new approach. The author describes the use of LCVs and how to gain trucking industry support for toll truck lanes. This support can be gained not only by allowing use of LCVs on toll truckways, but also by enticing existing street-legal 18-wheelers to use the toll truckways by offering time savings, increased safety, and lower stress. The author concludes by calling for beginning stages of legislation that would support this type of approach.
67	Poole Jr., Robert W.	Advocate backs truck-only toll lanes, but execs want plan to address needs	20061127	Yes									√			
68	Schulz, John D.	At A Rails Against Tolls	20020318	Yes									√			Subtitle: Trucking Group Calls Plan for Truck-Only Toll Lanes 'Unsafe and Financially Unsound'.
69	Short, Jeffrey Bradford	Survey of Motor Carrier Opinions on Potential Optional Truck-Only Toll Lanes on Atlanta Interstate Highways	20070000	Yes									√			In 2005, Georgia's State Road and Tollway Authority (SRTA) released a feasibility study of optional TOT lanes on Interstate highways within the Atlanta metropolitan region. The study examined a series of TOT lane alternatives aimed at congestion mitigation in response to existing conditions and forecasts of increased commercial and passenger vehicle demand. As a follow-up to the study, the American Transportation Research Institute (ATRI) was commissioned by SRTA to determine willingness to pay for use of optional TOT lanes in Atlanta. A total of 71 Georgia-based trucking firms, ranging from small carriers (1 to 10 power units) to large carriers (over 200 power units) responded to the survey. The results of the data collection and analysis associated with this effort are outlined in this paper as they relate specifically to the SRTA TOT study, and to national highway congestion and funding shortage issues. Research results indicate that Georgia carriers are willing to use optional TOT lanes when no costs exists, and that a pricing mechanism could successfully keep TOT lanes at free-flow levels. Results also indicate strong pressure from shippers regarding delivery times, thus leading Georgia carriers to conduct business during hours of peak highway demand. Such information suggests that increased capacity is critical to reducing congestion, while attempts to change the times at which trucks operate by pricing trucks during peak periods may not address the issue.

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70	Wislocki, John	California truckers ponder truck-only lane proposal	20020311	Yes									√			
71	Wislocki, John	Industry urges caution on tolled truck-only lanes	20030120	Yes									√			
72	Young, Don	Rep. Young says he supports truck-only toll road proposal	20020610	Yes									√			
73	Burke, Neil A.	Dedicated Truck Facilities as Solution to Capacity and Safety Issues on Rural Interstate Highway Corridors	20070000	Yes		√					√	√				This paper identifies the safety and operational benefits of constructing dedicated truck facilities on a rural Interstate corridor. The Interstate highway segment in the case study is a 164-mi section of I-80 from the Iowa–Illinois border to Altoona, Iowa (an eastern suburb of Des Moines, Iowa). Although many studies have considered constructing an additional lane on freeways and designating it for trucks only, this paper considers the construction of a separate four-lane, limited-access facility for trucks. The I-80 corridor was analyzed with the Highway Economic Requirements Software – state edition (HERS-ST) to measure the performance before and after trucks were removed from the general purpose lanes. Several benefit-to-cost ratios were calculated outside of HERS-ST to determine the economic feasibility (but not the financial feasibility) of constructing dedicated truck lanes. Since there are no similar truck-only facilities in the United States, it is unknown what proportion of motor carriers would choose to use a truck-only facility rather than the mixed-traffic lanes (general purpose lanes), and future policy may or may not require trucks to use parallel truck-only facilities. Therefore, a sensitivity analysis was conducted within the benefit-to-cost analysis to determine the benefits of diverting 100 percent, 75 percent, 50 percent, and 25 percent of trucks to a dedicated truck facility. At all levels of diversion, the benefits exceed the costs. Although the analysis shows that a truck-only facility is desirable, the policy framework to make such a facility physically and financially feasible does not exist in Federal or Iowa policy.
74	De Palma, Andre	An Economic Analysis of Segregating Cars and Trucks	20070000	Yes		√					√	√				Truck-only lanes and tollways have been promoted as ways to combat congestion, enhance safety, and reduce pavement damage. This paper conducts a partial economic analysis of truck lanes by considering whether there are advantages in separating light and heavy vehicles. Several factors are identified as important for determining the benefits of vehicle separation: the relative volumes of light and heavy vehicles, the congestion delay and safety hazards that each type of vehicle imposes, values of travel time for light and heavy vehicles, and lane capacity indivisibilities. An efficient allocation of vehicles to lanes can be supported using differentiated tolls, but generally not with lane access restrictions.
75	De Palma, Andre	The Economics of Truck Toll Lanes	2006	Yes		√					√	√				Truck-only lanes and truck tollways have been studied and promoted in the U.S. as a potential tool for combating road congestion, enhancing safety, and reducing pavement damage. The goal of this paper is to conduct a preliminary and partial economic analysis of truck lanes by considering whether there are advantages in separating light and heavy vehicles, and if so, how this can be implemented using tolls or lane access regulations. Several factors are identified as important: the relative volumes of light and heavy vehicles and the congestion costs they impose, lane indivisibilities, values of travel time for light and heavy vehicles, and the potential safety advantages (whether real or imagined) of separating vehicle types.

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76	FHWA	FHWA/TRB Managed and Priced Lanes Workshop: Summary of Workshop Results	20030000	Yes		√						√				Potential policy, program, and research initiatives to advance the planning, implementation, and operation of managed and priced lanes were the focus of this two-day workshop. The objectives of the workshop were: 1) to identify and prioritize potential research and technology transfer activities to advance the implementation of managed and priced lanes; and 2) to identify opportunities to champion and advance managed and priced lane research-related initiatives, particularly within the TRB. The structure of the workshop allowed participants to spend the first day focused on the broader concept of managed lanes, while the focus of the second day was narrowed to address priced lanes. This workshop serves as a first step by the FHWA and the TRB to receive focused feedback on managed lane issues. Further efforts to obtain feedback in the future can be expected as additional planning and coordination takes place.
77	Jones, Crystal	Perspective on Freight Congestion	20070700	Yes		√					√	√				This article describes the negative impact of traffic congestion on freight transportation, and discusses some steps that the Federal government is taking to improve freight movement. Congestion on the transportation network diminishes productivity and increases the overall cost of transportation services. One objective of the U.S. DOT is identifying and addressing emerging transportation needs. This includes research into freight movement, data and modeling to improve investment choices, and understanding of freight movement. This research should then be integrated into the transportation planning process. TOT lanes are being promoted as a strategy to both reduce congestion and to better align cost and benefits between freight system users and owners.
78	Obenberger, J.	Managed Lanes	20041100	Yes		√	√					√				This article describes the use of managed lanes, which manage and control traffic through a combination of access control, vehicle eligibility, and pricing strategies. Managed lanes can include HOT and HOV, respectively; reversible flow lanes; express lanes; and truck lanes. The author notes that managed lanes are proactively implemented and managed (in real time) in response to changing conditions. The author considers how the benefits of managed lanes can be assessed, how to improve the operation of freeway facilities, how to implement managed lanes, and lessons learned from the limited number of managed lanes currently in use. The author outlines institutional, organizational, and technical issues that need to be taken into consideration. The author encourages readers to identify managed lanes as a key strategy and integrate them into the appropriate agency and regional strategic and program plans. The author emphasizes the importance of installing sufficient traffic management, monitoring, and control devices to enable agencies to make real-time operational decisions; and have the capability to implement the necessary strategies to manage the roadway network. Sidebars report three case studies of managed lanes in California; another sidebar lists nine web site addresses for readers seeking additional information.

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79	Collier, T.	The Funding and Financing of Managed Lanes Projects	20020900	Yes							√	√					The managed lane concept is currently being considered on major freeway projects in Texas cities. While the HOV concept is familiar in most urban areas, motorists are less familiar with managed lanes. The term "managed lanes" encompasses a variety of facility types, including HOV lanes, HOT lanes, SOV express lanes, special use lanes, and truck lanes. The premise of the managed lanes concept is to increase freeway efficiency, and provide free-flow operations for certain freeway users by packaging various operational and design strategies. The strategies deployed offer the flexibility to be adjusted to match changing corridor and regional goals. This report documents research on the funding and financing of managed lanes projects. This report highlights the financial aspects of operating managed lanes projects. Additionally, it discusses innovative financing techniques and their applicability to various types of projects. The report describes various financing and funding strategies for given managed lane project scenarios. Successful implementation of a managed lanes project will require careful planning and a willing community. Managed lanes projects can be successfully implemented when the project is designed around the goals of the community or region. These goals will affect project financing, too. It is important to match the financing with the goals of the project.
80	Forkenbrock, David J.	Issues in the Financing of Truck-Only Lanes	20050900	Yes							√	√					Transportation planners have debated for decades the efficacy of separating traffic into lanes reserved for passenger vehicles and those reserved for trucks. This article discusses the feasibility of considering funding for such special-purpose lanes as truck-only lanes, and addresses the questions of "who pays" and "who benefits." Trucking advocates argue that the benefits of constructing truck-only lanes include traffic safety improvements, reduced conflicts, lower maintenance costs on general-traffic lanes, and improved comfort and convenience of those traveling in passenger vehicles. One study found that truck-only lanes would be cost-effective only when traffic volumes are relatively high, with a sizable presence of heavy trucks. Constructing truck-only lanes would be expensive: such construction alongside an existing rural interstate would cost around $2.5 million per lane-mile, plus additional land acquisition costs. Costs in densely developed urban areas would be higher. It has been proposed that financing would be done through tolls, but several issues have been raised about the appropriate level of tolls, which users should pay tolls, and the extent to which tolls will cover the full costs of the facilities. Two scenarios are explored regarding whether tolls should be paid only by large trucks or whether tolls should be paid by all vehicles. It has been proposed that costs should be paid by various vehicle classes. Four benefits to trucking firms may be: 1) trucking firms may be less exposed to the risk of car-truck crashes; 2) trucks could operate more efficiently with lower traffic volumes in the lanes; 3) the added capacity could alleviate congestion, reducing travel time and the uncertainties of arrival times; and 4) arguments for increased use of LCVs would be strengthened, because LCVs would not be operating in the same lanes as do passenger vehicles. Benefits to passenger vehicles are threefold: 1) improved safety, especially reducing collisions between large trucks and passenger cars; 2) the quality of the traveling experience would improve (e.g., small passenger vehicles would not be boxed in between trucks); and 3) truck-only lanes would improve speeds and traffic flow. The authors suggest a feasibility analysis that could be conducted that would suggest that truck operators would receive the majority of benefits from truck-only lanes; and thus, they should pay the majority of the costs.

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81	Jose Holguin-Veras, Ph.D., P.E.	On the Economic and Financial Feasibility of Toll Truckways	2003	Yes							√	√				The paper discusses the analyses conducted as part of a research project that studied the economic and financial feasibility of heavy-truck lanes. This research expanded the line of inquiry already explored by previous researchers by analyzing the case of tolled lanes for exclusive use of heavy trucks of increased size and capacity. The paper considered the productivity changes produced by the proposed system, tolls that could be levied, users' travel time and vehicle operating costs savings, and impact on infrastructure costs. The economic benefits were estimated using the Highway Design and Maintenance Standards Model developed by the World Bank. The analyses, complemented with sensitivity analyses on key variables, indicate that heavy truck lanes are both economically and financially a viable alternative.
82	Kawamura, K.	Perceived Benefits of Congestion Pricing for Trucks	20030000	Yes								√				Empirically derived value-of-time distributions are used to calculate the perceived benefits from the time saved by trucks in using toll lanes. The conditions on the SR 91 congestion pricing facility in California are used in a case study. Assuming that the value of time for trucks is lognormally distributed, the probabilistic truck mode share for the toll lanes was estimated separately for in-house and for-hire trucks. The mean values of time for toll-lane users and nonusers were estimated using Monte Carlo simulations. The benefits were calculated as the value of travel time savings that accrue for both toll-lane users and nonusers. The analyses found that the opening of the congestion pricing facility in 1995 has resulted in more than $2 million in annual savings for trucks. Trucks would realize an added $660,000 annually if the toll lanes were open to trucks. The disproportional share of the benefit goes to a few trucks with very high values of time, especially when the toll is expensive. Also, for-hire trucks receive, on average, greater benefit than in-house carriers because of higher values of time.
83	Ozbay, Kaan	Evaluation of Impacts of Time-of-Day Pricing Initiative on Car and Truck Traffic: Port Authority of New York and New Jersey	20060000	Yes								√				The traffic impacts of the time-of-day pricing program initiated by the Port Authority of New York and New Jersey (PANYNJ) on March 25, 2001, are analyzed. The analyses are based on the traffic data routinely collected at all toll lanes by PANYNJ. Since terrorist attacks at the World Trade Center disrupted the transportation network and made it impossible to isolate and analyze user reaction to the PANYNJ toll prices, only the period before the events of September 11, 2001, was considered. The research has confirmed a statistically significant shift toward prepeaks, in both mornings (5:00 a.m. to 6:00 a.m.) and afternoons (3:00 p.m. to 4:00 p.m.), in car traffic percentage share after the time-of-day pricing. Also, weekday truck traffic percentage share showed a statistically significant shift to morning prepeak (5:00 a.m. to 6:00 a.m.) and afternoon postpeak hours (7:00 p.m. to 8:00 p.m.). However, weekend car and truck traffic percentage shares did not have statistically significant changes during peak shoulder hours (11:00 a.m. to 2:00 p.m. and 8:00 p.m. to 9:00 p.m.). These findings indicated that PANYNJ time-of-day pricing initiative was successful in spreading weekday peak-period traffic to the hours just before or after the peak toll rates are in effect, mainly for passenger cars. As observed from descriptive analysis of commercial surveys, however, even though PANYNJ time-of-day pricing gives truckers an incentive to shift their travel periods, it is not the only factor affecting the truckers' travel pattern.

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84	Samuel, P.	Toll Truckways: A New Path Toward Safer and More Efficient Freight Transportation	20020600	Yes								√				This paper discusses an alternative method of approaching long-distance intercity trucking. The method presented is self-financing toll truckways. These toll truckways would be separated from the rest of traffic by concrete barriers, and would involve one or more traffic lanes in either direction for use solely by trucks. The paper proposes that, instead of rebuilding entire highways to cover the costs of heavier truck traffic loads and the pavement deterioration that they cause, only the specialized truck lanes be improved. This would ease the cost of permitting longer combination vehicles, which carry heavier loads, on the road. It would also decrease traffic conflicts between trucks and automobiles. It is recommended that the trucks pay tolls for these roads and not be charged Federal fuel taxes, state taxes, or other truck user taxes. The tolls would be collected electronically.
85	Smith, Andrew C.	Sand Blasting: Georgia Looks for Way to Funnel Traffic Faster	20070800	Yes								√				Value pricing of freeway lanes is being considered as a way to increase capacity of under-used roadways, raise revenues, and steer drivers away from roads during times of peak congestion. The Georgia DOT is planning a pricing plan for 15 miles of the I-75/I-575 corridor outside Atlanta. HOV lanes and truck-only lanes are two of the options being considered. Various scenarios are presented as part of a feasibility study GDOT commissioned. Among the possible configurations: HOT2+ and HOT3+ lanes, and even HOT4+, where vehicles with at least that number of riders travel for free. Another set of scenarios combines the HOT approach with voluntary truck only lanes (TOLs). A final set uses mandatory TOLs. Eleven lessons about managed lanes are also explained.
86	Weinstein, Asha	Transportation Financing Opportunities for the State of California	20061000	Yes								√				Available funding for transportation in California is expected to decline significantly over the next 15 years if the current transportation finance system remains unchanged. This report presents an analysis of a range of alternative sources of revenue, as well as different finance options. The research is based upon reviews of existing literature, interviews with key stakeholders, analyses of revenue trends, fuel tax rates and trends, statewide ballot measures, and two statewide phone surveys. The facility-based sources considered were toll roads and lanes, truck-only toll lanes, privatized rest areas, and public-private partnerships (PPPs). The taxes and fees evaluated were increasing fuel taxes by a fixed amount, indexing fuel taxes to inflation, mileage-based fees, vehicle registration fees, vehicle license fees, weight-mile taxes for trucks, a statewide sales tax, and state general fund revenues allocated either for current expenditures or to pay off general obligation bonds. Each of the revenue and finance options was evaluated according to five criteria: 1) revenue generation, 2) ease of implementation, 3) transportation system performance, 4) equity, and 5) political feasibility.

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87	Aultman-Hall, L.	Final Summary Report on Truck Route Access Evaluation	19990500	Yes		√										This report summarizes the evaluation of truck route access between the National Highway System (NHS) and 46 truck generating sites, including intermodal sites, throughout Kentucky (includes 81 routes and 800 miles of highway). Routes were evaluated quantitatively for nine highway features and assigned an overall route rating. Recommendations for routine maintenance and reconstruction were made. The level and quality of truck access to the NHS varies dramatically throughout the State. Some facilities are between 25 and 50 miles from the NHS. No significant difference in route ratings or other measures was found by geographic location. The different typography throughout the State contributed to differences in grade and curvature quality. Very few non-NHS truck routes have 12-foot lanes along their whole length. The intermodal facility routes, in general, were found to be of better quality than routes leading to truck-only sites. Trucks are not always using the routes they should. Ten of the routes were considered the "best" and required no improvements at this time. Improvements on other routes varied from routine maintenance to the need for complete reconstruction. Routes were prioritized by length and amount of truck traffic to recommend the most critical routes for improvement.
88	De Palma, Andre	What are the benefits from separating cars and trucks	18-Aug-06	Yes		√										
89	FHWA	Quick Response Freight Manual	1996	Yes		√										The objectives of this manual are: to provide background information on the freight transportation system and factors affecting freight demand to planners who may be relatively new to this area; to help planners locate available data and freight-related forecasts compiled by others, and to apply this information in developing forecasts for specific facilities; to provide simple techniques and transferable parameters that can be merged with passenger vehicle trip tables developed through the conventional four-step planning process; and to provide techniques and transferable parameters for site planning that can be used by planners in anticipating local commercial vehicle traffic caused by new facilities, such as regional warehouses, truck terminals, intermodal facilities, etc.
90	Fischer, M., and Myong Han	NCHRP Synthesis 298, Truck Trip Generation Data, A Synthesis of Highway Practice	2001	Yes		√										This synthesis report will be of interest to state DOTs and their staffs, as well as to the consultants that work with them in the areas of truck trip generation. Its objective is to identify available data and to provide a balanced assessment of the state of the practice in meeting the needs for and uses of these data by transportation engineers, travel demand modelers, and state and Federal transportation planners. The synthesis was accomplished through a review of recent literature and a survey of representatives from state transportation agencies. The data collected in the study are summarized and presented in appendices for use by practitioners. This report presents a summary of key issues that affect the collection and use of truck trip generation data. Conclusions and suggestions for future study are also provided.
91	Hoel, Lester A., and Jennifer L. Peek	A Simulation Analysis of Traffic Flow Elements for Restricted Truck Lanes on Interstate Highways in Virginia	Jan-99	Yes		√										
92	Janson, B. N., and A. Rathi	Feasibility of Exclusive Facilities for Cars and Trucks	1990	Yes		√										

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93	Kuhn, B.	State and Federal Legislative Issues for Managed Lanes	20030100	Yes		√	√									The managed lane concept is currently being considered on major freeway projects in Texas cities. The term "managed lanes" encompasses a variety of facility types, including HOV lanes, HOT lanes, SOV express lanes, special-use lanes, and truck lanes. The premise of the managed lanes concept is to increase freeway efficiency and provide free-flow operations for certain freeway users by packaging various operational and design strategies. The strategies deployed offer the flexibility to be adjusted to match changing corridor and regional goals. This report documents the research undertaken in Task 7 of this project. The objective of this task was to assess the Federal and state legislative needs necessary for Texas to successfully implement the various types of managed lane facilities across the State, and provide recommendations regarding necessary changes to Federal and state legislation.
94	Kuhn, B.	Interim Manual for Managed Lanes	20031000	Yes		√	√			√						Texas cities are currently considering the managed lane concept on major freeway projects. As a new concept of operating freeways in a flexible and possibly dynamic manner, it has a limited experience base, thereby, creating a knowledge vacuum in emerging key areas that are critical for effective implementation. Complicating the effort is the rapid progress of several freeway improvement projects in Texas in which managed lane operations are proposed. The operational experience both in Texas and nationally for managed lanes is minimal, particularly for extensive freeway reconstruction projects. The objectives of this research project are to investigate the complex and interrelated issues surrounding the safe and efficient operation of managed lanes using various operating strategies, and to develop a managed lanes manual to help the Texas DOT make informed planning, design, and operational decisions when considering these facilities for its jurisdiction. This document presents three years of research in the form of a draft manual for managed lanes. It includes three chapters in draft form, which include a guide to the manual, an introduction to managed lanes, and design. This document includes research in a usable format, providing a clear, concise, and step-wise approach to planning designing, operating, and enforcing a managed lanes facility. It also refers the user to other pertinent documents, which provide additional detailed information on various aspects of managed lanes.
95	List, et al.	Analysis of Dedicated Commercial Transportation Corridor in the New York Metropolitan Area	1995	Yes		√										

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96	Lord, Dominique	Does Separating Trucks from Other Traffic Improve Overall Safety?	20050000	Yes		√										Decision-makers have long speculated that building separate roads for trucks and passenger cars, or at least separating these into their own lanes, would accomplish two major objectives: 1) roadways would be made safer for passenger cars, and 2) roadways designed specifically for a select class of vehicles rather than for all vehicles might represent overall savings in construction costs. This paper addresses the first objective. Recent studies on the evaluation of safety effects of truck traffic levels on general freeway facilities have not provided a clear understanding of how they affect the number of crashes. In some cases, studies have been contradictory. In addition, no studies have specifically compared passenger car-only with mixed-traffic freeway facilities. The research on which this paper is based aimed to assess whether more homogeneous flows of traffic by vehicle type are safer than the current mixed-flow scenario. An exploratory analysis of crash data was conducted on selected freeway sections of the New Jersey Turnpike for 2002. These sections operate as a dual-dual freeway facility: divided inner and outer lanes. At these locations, the inner lanes have the special characteristic of being for passenger cars only (homogeneous traffic). The selected sections, therefore, offer a very good opportunity to compare the crash experience between passenger car-only and mixed-traffic rural freeway facilities. The results of the study show that outer lanes experience more crashes, both when raw numbers are used and when exposure is included in the analysis. It was shown that truck-related crashes contribute significantly to the total number of crashes on the outer lanes. In fact, trucks are overinvolved in crashes given the exposure on these sections. Although the outcome of this study suggests that separating truck traffic from passenger cars for freeway facilities improves safety, further work is needed to understand the contributing factors leading to truck-related crashes in the outer lanes.
97	Mannering, et al.	Truck Restriction Evaluation: The Puget Sound Experience	Aug-93	Yes		√										
98	Meyer, Michael D.	Feasibility of Truck-Only Toll Lane Network in Atlanta, Georgia	20060000	Yes		√										Many U.S. metropolitan areas are expecting significant growth in the amount of truck travel on their road networks. For those areas, such as Atlanta, Georgia, where the region experiences not only substantial truck movements internal to the region, but also large numbers of through truck trips, this growth presents a significant challenge. A proof-of-concept analysis was undertaken in Atlanta to examine the likely impacts of various TOT lane strategies for the regional freeway network. Three strategies are examined: 1) building new lanes along major truck corridors, 2) allowing trucks to use existing HOV lanes inside the central area, and 3) turning all proposed HOV lanes in the region into TOT lanes. The analysis of these strategies is presented, and the conclusion is that turning proposed HOV lanes into TOT lanes provides the greatest transportation benefit to the region.

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99	Middleton, et al.	Moving Analysis Program to Evaluate Geometric and Operational Feasibilities of Exclusive Truck Facilities	1987	Yes		√				√						Traffic growth in Texas has resulted in a study to investigate the feasibility of exclusive truck facilities (ETFs) in the median area of existing Interstate highways. A moving-analysis computer program was developed to identify candidate sections of a selected corridor for addition of truck lanes. A case study was conducted using the I-35 corridor between Dallas and San Antonio to demonstrate the program's usefulness. The program was designed to evaluate a selected length of Interstate highway by individual one-half-mile or other length segments, and to print the results in an easily interpreted format. The output allows the user to evaluate a given corridor by two basic criteria: volume-to-capacity (V/C) ratios and effective median widths. The program calculates V/C ratios with and without trucks using the techniques published in the Highway Capacity Manual.
100	Multiple	SR 60 Truck Lane Feasibility Study, Final Report	Feb-01	Yes		√										
101	Mussa, R.	Quantify the Effects of Raising the Minimum Speed on Rural Freeways and the Effects of Restricting the Truck-Lanes Only in the Daytime; Volume 2: Safety and Operational Evaluation of Truck Lane Restriction on Interstate 75	20040500	Yes		√										To reduce conflicts between trucks and smaller vehicles, most highway agencies including the Florida DOT have implemented various truck restriction strategies. The truck restriction methods employed in various states include restriction by speed, lane, time, or route. This study evaluated safety and operating characteristics of the Interstate 75 corridor in north Florida, where trucks are restricted throughout the day from using the inside lane (i.e., lane closest to the median) of the six-lane facility. The field data showed that approximately two-thirds of both passenger cars and trucks were traveling within the 10-mph pace that ranged from approximately 70 mph to 80 mph in the corridor that has a speed limit of 70 mph. The simulation results showed that there would be no gain in travel times or reduction in delays by rescinding the current policy of restricting trucks from the inside lane for a 24-hour period. In addition, the simulation results revealed that the number of lane changes would increase – predicting the likelihood of increased crashes in the corridor – if all lanes were opened to trucks. It is noteworthy that the review of crashes occurring in the corridor indicated that improper lane change was one of the major contributing causes for the crashes that occurred in this corridor. Based on these results, it was concluded that the current lane restriction policy has positive impacts on safety and operating characteristics in the corridor and should be left in place.
102	Mussa, R,	Quantify the Effects of Raising the Minimum Speed on Rural Freeways and the Effects of Restricting the Truck-Lanes Only in the Daytime; Volume 1: Evaluating the Relevance of 40 mph Posted Minimum Speed Limit on Rural Interstate Freeways in Florida	20040500	Yes		√										The relevance of posting the 40 mph minimum speed limit signs on rural Interstate freeways in Florida is analyzed by correlating safety and traffic operating characteristics. The operational data showed that only 0.14 percent of vehicles had speeds below 40 mph, while a four-year database of reported crashes indicated that about 9 percent of vehicles involved in crashes were estimated to be traveling with speeds below 40 mph. The modeling of crashes by Poisson regression showed that increase in the median speed significantly reduced the number of crashes, while increase in the variation between fast and slow moving traffic significantly increased the number of crashes. The preliminary recommendation that could be made based on the available data is for Florida to discard the practice of posting of minimum speed limit signs on rural Interstate freeways. This recommendation was partly influenced by the survey results, which showed that 25 states do not post minimum speed limit signs on highways.
103	Parker, John G,	Britain to Experiment With Truck-Only Lanes	19981019	Yes		√										

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104	Poole Jr., Robert W.	Corridors for Toll Truckways: Suggested Locations for Pilot Projects	20040000	Yes		√	√									This paper addresses possible locations for a pilot project that would add truck tollways on interstate highways. It also mentions the benefits of adding toll truckways to the highways. These barrier-separated truckways would increase highway capacity, save money on freight shipping (by using longer combination vehicles), help decrease traffic congestion, and address safety concerns of large trucks on highways. The pilot project is aimed at gaining Federal policy change to allow the interstate truck tollways.
105	Poole Jr., Robert W.	Miami Toll Truckway: Preliminary Feasibility Study	20071100	Yes		√										This study discusses an east-west truck-only truckway as a principal way to transport containers to and from the Port of Miami. It studies the feasibility of financing the truckway through tolls. Four different east-west routes were investigated and each of them seems to be feasible. Truck traffic was estimated on each of the routes, and revenues from tolls were forecast for 40 years. A long-term concession would be appropriate for the toll truckway; and it is estimated that the truckway would provide substantial benefits for freight transportation.
106	Poole Jr,, Robert W.	Reducing Congestion in Atlanta: A Bold New Approach to Increasing Mobility	20061100	Yes		√	√									This paper discusses the attempts to decrease traffic congestion and increase highway capacity and mobility in Atlanta, Georgia. Investments in public transit, land use changes, and carpooling have not paid off substantially enough to be able to reduce congestion in the Atlanta metropolitan area. The paper recommends a new approach – four projects that will increase highway capacity in targeted areas, add toll lanes to a freeway, introduce a truck tolling system, add a double-decker tunnel, and extend an east-west corridor.
107	Reich, S.	The Potential for Reserved Truck Lanes and Truckways in Florida		Yes		√	√			√						The purpose of this research was to evaluate the potential for reserved truck lanes and truckways in Florida in addition to determining how commercial vehicles have been managed within other states. The project specifically examines where exclusive truckways and truck lanes have been evaluated and constructed within the U.S. It summarizes and documents the costs and motivating factors in those cases where exclusive facilities have been constructed in the U.S. The study then evaluates the potential for reserved truck lanes and truckways on the Florida State Highway System by employing a geographic information system (GIS) screening tool and field review of the highways that emerge as having a high potential for use of this strategy. The methodology is presented in detail, and the results of the analysis for each corridor that was identified for the potential for exclusive truck lanes are discussed along with an identification of opportunities for consideration. The research also documents and maps abandoned railroad rights of way, and relates them to highway corridors where additional exclusive truck facilities may be warranted. The report includes a brief discussion on the current uses of differential speed limits for trucks and automobiles.
108	Trowbridge, et al.	The Potential for Freight Productivity Improvements Along Urban Corridors	Dec-96	Yes		√										

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109	Wong, Philbert	Southern California Goods Movement Challenge, Opportunity, and Solution	20070000	Yes		√										This paper documents the SCAG's strategy for addressing the enormous growth in goods movement that Southern California is experiencing while also mitigating its negative impacts. The proposed strategy entails an investment of $36.2 billion, comprised of $20.2 billion in highway investments, including dedicated truck lanes, $6 billion in rail investments, including track infrastructure and grade separations, and $10 billion in environmental mitigation. These investments will help ensure that Southern California continues to benefit from its goods movement industry by creating well paying jobs that are a viable replacement for lost manufacturing jobs in the region. It is possible to finance this strategy through a combination of a container fee imposed on loaded, imported containers, and a toll for use of the dedicated truck lane system. It is believed that private-sector shippers and truckers would be willing to pay container fees and tolls because the infrastructure investments would yield significant benefits to them in the form of time savings and increased shipping reliability. A series of steps are needed to advance this strategy. This would include peer review within both the public and private sectors of the analysis of the costs and benefits of this program, the establishment of federal infrastructure financing related to international trade, and leadership from elected officials and those in the private sector. Furthermore, additional coordination will be needed with environmental agencies, as well as the possible creation of a Southern California institution to execute infrastructure construction.
110	Berard, R.	Truck Widths and Paths	19980100	Yes						√						Knowledge of the widths of heavy good vehicles and determination of the paths they follow constitute vital information for the operator of a highway or motorway network. These data are used in planning the widths of road and toll station lanes, and have a definite impact on journey comfort and safety. The data presented come from measurements made in a number of countries of the European Community (France, Germany, and Belgium).
111	Button	Synthesis of Pavement Issues Related to High-Speed Corridors	Sep-04	Yes						√						The objective of this research project was to produce a synthesis of available information to support specific areas related to pavements for the safe, economical development of the Trans Texas Corridor (TTC). This synthesis is divided into nine sections, each of which deals with a specific topic or topics. These specific areas include: 1) pavement design for heavy vehicles, 2) pavement design for light vehicles, 3) skid resistance issues on high-speed corridors, 4) issues related to traffic characterization, 5) smart pavements for high-speed corridors, 6) pavement material response to dynamic loads and performance prediction, 7) safety issues related to splash and spray, and 8) ride quality for high-speed corridors.

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112	Fitzpatrick, K.	Managed Lane Ramp and Roadway Design Issues	Sep 2002; Resubmitted: Jan 2003	Yes						√						Texas is exploring the use of managed lanes in congested urban corridors. This report discusses the findings from an evaluation of managed lane ramp design issues. Most of the recent literature regarding ramp design has focused on ramp design speed and truck performance. To have an appreciation for current department of transportation practices, a search of each state's design manual was conducted via the Internet. Of the 23 states that had all or part of their design manuals online, 12 had some material available concerning the design of ramps. The potential managed lane system in Texas could contain elements of systems that are currently in use in other communities. As part of this research project, members of the research team visited the New Jersey Turnpike. Simulation was used to obtain an appreciation of the effects on corridor operations when several pairs of ramps are modeled. Speed was the primary measure of effectiveness used to evaluate the effects of different ramp spacings, volume levels, and weaving percentages. The research found that a direct connect ramp between a generator and the managed lane facility should be considered when 400 vehicles per hour are anticipated to access the managed lanes. If a more conservative approach to preserving freeway performance is desired, then a direct connect ramp should be considered at 275 vehicles per hour (which reflect the value when the lowest speeds on the simulated corridor for the scenarios examined were at 45 mph or less).
113	Hannah, James	At least nine states eye proposals for truck-only highway lanes	20070806	Yes												
114	Harwood, Douglas W., et al.	Distribution of Roadway Geometric Design Features Critical to Accommodation of Large Trucks	1999	Yes						√						The ability of the roadway system to accommodate large trucks is constrained by the geometric design of key features, including horizontal curves, interchange ramps, interchange ramp terminals, at-grade intersections, and steep grades. The distribution of the dimensions of roadway elements that is critical to accommodation of larger trucks on the highway is shown, including horizontal curves and grades on mainline roadways, horizontal curves on interchange ramps, and curb return radii for at-grade ramp terminals and intersections. Frequency of mainline and ramp curves with very sharp radii and of very steep mainline grades was found to be very limited. For example, only about 5 percent of interchange ramps have horizontal curves with radii of 30 meters (100 feet) or less, and approximately 20 percent of rural ramps and 30 percent of the urban ramps have radii of 75 meters (250 feet) or less. Curb return radii less than or equal to 12 meters (40 feet) on which trucks would frequently encroach are more frequent. Curb returns with sharp radii are more prevalent in urban than in rural areas, and are more prevalent at intersections than at ramp terminals.
115	Hoel and Heather Lyn Wishart	Analysis and Evaluation of Truck Traffic Restrictions and Separation Methods on Interstate Highways	Jun-96	Yes			√			√						
116	Hoel, et al.	Exclusive Lanes for Trucks and Passenger Vehicles on Interstate Highways: An Economic Evaluation	1997	Yes			√			√						
117	ITE	Geometric Design and Operational Considerations for Trucks	Feb-92	Yes						√						

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118	Janson	Effects of Geometric Characteristics of Interchanges on Trucks	1997	Yes						√						
119	Janson, Bruce, and Jake Kononov	Effects of Geometric Characteristics of Interchanges on Truck Safety	Jan-99	Yes						√						
120	Jasek, et al.	Guidelines for Truck Lane Restrictions in Texas	Aug-97	Yes			√			√						
121	Lan, C-J	Truck Speed Profile Models for Critical Length of Grade	20030700	Yes						√						The climbing lane is an effective means by which to increase roadway capacity, improve safety, and provide smooth traffic operation on mountainous and rolling terrains where significant trucking prevails. Current critical length design guides for the climbing lane in the AASHTO Green Book is based on truck speed profile charts derived by the design standard of the weight-to-power ratio equal to 120 kg/kW (200 lb/hp). For locations where a significant mix of larger and heavier trucks with more axial loads exists, the AASHTO suggests one apply a more representative weight-to-power ratio, but gives no specific computational procedure other than a cautionary statement. This study proposes a well-defined approach and formulation to obtain truck speed profiles, based on the nominal dynamic, kinematic, and operating characteristics of trucks on grades. The design controls that regulate the resultant speed profiles include not only the weight-to-power ratio and the grade used in the current AASHTO manual, but also the design engine power of trucks (or the corresponding design load). The formulations, design charts, and tables derived from the design standards consistent with prevailing truck manufacturing specification allow designers to deduce the appropriate critical length for the climbing lane when significant deviation is found between the prevalent truck weight-to-power ratio and the current design standard. For practical design purposes, a tractable approximation model of reasonable accuracy that is suitable for manual calculation is also proposed, thus providing a feasible alternative to the look-up design chart currently employed by the AASHTO.
122	Martin, Peter T.	Developing Forecasting Model for Managed Lanes Using Data from Utah's High-Occupancy-Vehicle Lanes	20060000	Yes					√							A managed lane optimizes the available roadway capacity through various operations and designs. It restricts its users based on eligibility, pricing, and access. Therefore, managed lanes include all traditional HOV lanes; HOT lanes; value-priced lanes; reversible lanes; bypass lanes; and special use lanes (such as express, bus-only, or truck-only lanes). Periodic performance evaluations of managed lanes help determine whether they are serving their intended purpose. The paper presents a forecasting model that enables evaluation through a broad-based forecasting model of managed lanes, which is based on the data from three Salt Lake Valley HOV lane studies. The MOEs considered are vehicle volume, person throughput, Average Vehicle Occupancy (AVO), travel time savings in minutes, travel time savings in percentage, speed, and violation rate. Smoothing methods and trend projection in forecasting are applied to each MOE. The selection of the best technique for each MOE is based on the least Mean Squared Error (MSE) generated. A key finding from the modeling is that it is easier to make predictions about violation rate, speed, and AVO than it is to make predictions about vehicle volume and person throughput. The forecasting model has generic applicability. It can be applied to both existing and planned managed lane projects, and is valuable in projecting future managed lanes performance. The paper provides a methodology for trend analysis that supports further model development.

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123	Mason, et al.	Geometric Design of Exclusive Truck Facilities	1985	Yes						√						Past truck research is studied to determine the applicability of the AASHTO geometric design policies to exclusive truck facilities. The policies addressed include those with respect to vehicle characteristics, sight distance, horizontal alignment, vertical alignment, and cross-section elements. Each existing AASHTO design policy is described, the applicability to exclusive truck facilities is discussed, and alternative design criteria are recommended where past research warrants possible change.
124	Middleton	Truck Accommodation Design Guidance: Policy-Makers Workshop	Oct-03	Yes						√						The number of trucks on many highways in Texas and across the nation has increased to the point that special or unique roadway design treatments may be warranted. Increases in truck traffic have resulted from increases in time-sensitive freight (e.g., just-in-time deliveries), the North American Free Trade Agreement (NAFTA), and until recently a robust economy. As particular corridors have become increasingly dominated by truck traffic, or in locations where truck traffic might reasonably be segregated, questions have arisen regarding accommodations and treatments that may be appropriate for those corridors to address issues caused by truck traffic. This research investigated the sensitivity of current Texas design practice to the unique operating characteristics of large commercial vehicles and determined threshold conditions under which design should reflect these larger vehicles. Findings of this study indicate that serious consideration needs to be given trucks when the average annual daily truck traffic (AADTT) reaches 5,000 trucks per day during the design period. When the design AADTT reaches 25,000 trucks per day, there may be justification for considering separated truck roadways with a minimum of two lanes in each direction. This research recommends that the Texas DOT consider changes in the following design parameters in its Texas DOT Roadway Design Manual (and/or other appropriate documents): stopping sight distance, intersection and channelization, lane width, shoulder width and composition, sideslopes and drainage features, traffic barrier, passive signs, and acceleration lanes.
125	Middleton, D.	Truck Accommodation Design Guidance: Designer Workshop	October 2003	Yes						√						The number of trucks on many highways in Texas and across the nation has increased to the point that special or unique roadway design treatments may be warranted. Increases in truck traffic have resulted from increases in time-sensitive freight (e.g., just-in-time deliveries), the NAFTA), and until recently a robust economy. As particular corridors have become increasingly dominated by truck traffic, or in locations where truck traffic might reasonably be segregated, questions have arisen regarding accommodations and treatments that may be appropriate for hose corridors to address issues caused by truck traffic. This research investigated the sensitivity of current Texas design practice to the unique operating characteristics of large commercial vehicles and determined threshold conditions under which design should reflect these larger vehicles. Findings indicate that serious consideration needs to be given trucks when the AADTT reaches 5,000 trucks per day during the design period. When the design AADTT reaches 25,000 trucks per day, there may be justification for considering separated truck roadways with a minimum of two lanes in each direction. This research recommends that the Texas DOT consider changes in the following design parameters in its Roadway Design Manual (and/or other appropriate documents): stopping sight distance, intersection and channelization, lane width, shoulder width and composition, sideslopes and drainage features, traffic barrier, passive signs, and acceleration lanes.

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126	Orski, K.	Toll Truckways: Toward a Model 21st Century Freight Highway System	20020900	Yes											√	High capacity tractor-trailers, the so called LCVs, are able to carry several times the payload of ordinary trucks, and thus offer significant productivity gains and large savings in shipping costs. Trucking interests have long urged liberalization of the current Federal standards prohibiting such trucks in most states under a 1991 Federal freeze limiting truck weight to 80,000 lbs. Safety advocates and many state DOTs oppose any such relaxation on the basis that allowing bigger rigs in mixed traffic on today's highways would pose an increased risk of accidents and lead to accelerated pavement damage. This article discusses findings of a recent study by the Reason Foundation that offers a potential solution to these issues: construction of separate toll truckways in selected interstate highway corridors to accommodate LCVs and offer the option of safer and faster travel to ordinary trucks. The study suggests that truckers would be more than willing to pay truckway tolls because separate lanes would save them time and money. While many obstacles to building truckways remain, the idea is sound and deserves serious governmental consideration.
127	Schulz, John D,	Life in the Truck Lane	20040308	Yes											√	Subtitle: Truck-Only Lanes Pushed in Highway Bill As Funding Alternative, LCV Option.
128	Zarrillo, M. L.	Toll Network Capacity Calculator: Operations Management And Assessment Tool for Toll Network Operators	20020000	Yes					√							A performance assessment tool was developed to assist managers and operators of highway networks containing toll collection facilities. The toll network capacity calculator (TNCC) quantifies a toll facility's ability to process traffic. The calculator can also help engineers who are designing toll facilities to serve highway systems adequately. TNCC determines the maximum amount of traffic that a collection facility can handle. In addition, TNCC may be used for disruption management during lane closings, incidents, or maintenance checks. Furthermore, TNCC may be employed as a planning tool and a performance assessment tool by predicting the impact of surging traffic volumes during special events. The performance of a toll facility was determined from plaza characteristics, such as lane number, lane type, and processing rates. The results of the calculations met constraints set by the characteristics of the arriving traffic. For example, variables such as the percentage of arrivals that were ETC patrons and the percentage of arrivals that were semi-trailer trucks requiring non-ETC services influenced the plazas' performance outcoms. Overflow of ETC users from the dedicated ETC lanes into the mixed lanes was also a factor. Performance was independent of hourly arrival volumes. Videotapes and transaction data at plazas provided necessary input to TNCC in the evaluation of 32 plazas on the toll network of highways in Orange County, Florida.
129		Effects of Lane Restrictions for Trucks	Oct-86	No												
130		I-75 Preferential Heavy Vehicle Lanes Evaluation Project	1979	No												
131		New Freeways Reserved to Trucks, An Italian Project (in progress)	1985	No												
132		Characteristics of Urban Freight Systems	1995	No												
133		Japanese Automated Freight Transportation System		No												
134		Large Truck Crash Facts 2000, 2002	2000, 2002	No												
135		The Future of Freight	Nov. 2, 2000	No												

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136		Tube Freight Transportation	Autumn 1994	No												
137		Los Angeles River and Tujunga Wash Channels Conceptual Engineering Analysis of Potential Transportation Uses	Feb-91	No												
138		The Second Vivekananda Bridge Tollway BOT Project	Jan-00	No												
139		Urban Congestion Affects Business Operations Costs	7/3/1998	No												
140		Urban Goods Movement and Its Relation to Planning	Oct. 1996	No												
141		Nothing Straight Forward About Paving Bike Paths	19980000	No												To appeal to the people who use them, bikeways and multipurpose trails cannot be constructed straight and level. They need to rise, fall, bend, and curve, which makes paving them more difficult. One contractor built more than 90 percent of the 60-mi (97-km) Little Miami Scenic Trail between Xenia and Milford, Ohio, and another 14 mi (23 km) of trails in Greene and Montgomery Counties. Sections of a 2.9-mi (4.7-km) trail along the Mad River were built atop a dike, and a 1,500-ft (457-m) section was built on an embankment where there had been river. Plans included carefully building the 12-ft (4-m) wide path on the levy so there would be no loss of storage capacity and sculpting a paved embankment at the river's edge. Only one truck at a time could travel down the narrow path, and ruts were quickly formed by the heavily loaded vehicles. This problem was countered by running a bulldozer behind every truck to blade the surface. Other trails constructed along abandoned railroad beds were not quite as demanding as paving along side a river, but they presented their own set of challenges. Old railroad ties that had been buried under ballast and shrubs had to be discovered and removed before work could begin. A scarifier attached to a grader combed the track bed for railroad spikes, which can easily puncture the tires on a grader or loader. Robbed of ballast by time and rain, the beds frequently required extensive earthwork work to meet the required grade. Working in the narrow rail corridors in an urban environment also required careful scheduling. A sidebar discusses how trail construction has gained momentum across the country.
142		Air Quality 2006	20060000	No												This Transportation Research Record contains 17 papers on the subject of air quality. Specific topics discussed are as follows: emission impacts of HOV lane operations; toll collection and electronic screening impact on heavy-duty vehicle emissions; emissions from extremely low-emitting vehicles; evaluating mobile source air toxic emissions; emissions from new and in-use transit buses; ultrafine particle number concentrations from hybrid urban transit buses; a traffic air quality simulation model; air quality measurements inside diesel truck cabs during idling; regional vehicle-mapping tables for MOBILE emissions model; variability of mobile source air toxic emissions factors with MOBILE6.2; emissions of dump trucks fueled with B20 biodiesel versus petroleum diesel; driver and road type effects on gas and particulate emissions; speed- and facility-specific emission estimates for on-road light-duty vehicles; road pollution alert system; energy and environmental impacts of roadway grades; and commuter exposure to fine particulates inside automobiles.

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143		Stena Danica – Largest Day Ferry	19820000	No												Stena Line's new-construction programme of six large ferries includes the day ferry Stena Danica (the first to be delivered) and her sister ship Stena Jutlandica, both ordered from Chantiers de France-Dunkerque, and four ferries with sleeping accommodation (which delivery, from the Gdynia shipyard, will be at least a year late). The day ferries will operate on the three-and-one-half-hour Gothenburg- Frederikshavn crossing, on which the Stena Line now has a monopoly, and their ship/shore access arrangements have been designed specifically for these two terminals, at each of which the turnround time will be only one hour. The article gives a detailed description of the Stena Danica, which principal particulars are: length, o.a. 152.2m; b.p. 135m; Breadth, moulded 28m; Depth, to No. 3 (lower vehicle) deck 8.2m, to No. 5 (upper vehicle) deck 13.6m; Draught, max. 6.3m; Deadweight, corresponding 3100 tonnes; Gross tonnage 16,000; Passengers 2,300 (Kattegat crossing), 2,000 (longer voyages); Vehicles 1,680 m truck-lane length, or 550 private cars; Propulsion Four CCM-Sulzer 12ZV40 Diesels, 6,400 kW each at 530 rpm, driving twin c.p. propellers at 146 rpm; two bow thrusters, each driven by a 660-kW motor; Speed 22 knots. The article includes general- arrangement drawings which show details of the deck layouts. The ship has two main vehicle-decks, each with eight truck lanes. Vehicle access is through bow and stern doors to the lower vehicle deck and (at fixed roadways at the terminals) through shell doors and ramps to the upper vehicle deck, in which hoistable decks can provide six 70-m lanes for cars. Spacious public rooms and galleys occupy the whole of the two decks above the vehicle decks. A high degree of redundancy has been provided in the main-engine ancillary equipment; service speed can be maintained with three of the four engines. Among the ship's many features are: twin semi-tunnel stern (adopted after a twin-skeg stern had initially been chosen); moderately-skewed c.p. propellers, with off-loaded blade tips; "barn door" opening 7 m wide at bow; two ramp-doors at stern, each with opening 9 m wide; two-compartment damage stability (made possible by the ship's wide beam); foredeck machinery under cover; 41 cabins for truck drivers; 450-seat bar-lounge, 475-seat restaurant, and 250-seat conference area; automatic conveyor and lift system for stores; duty-free shop believed to be the largest afloat; five 910-kWe Diesel-alternator sets.
144		Dust Control Program Sales Grading, Watering Costs	19740500	No												A program is described which was designed to stop dust on plant roads, and which has added savings in grading and watering heavily traveled gravel-surfaced truck ways. The basic ingredient of the program is Coherex (cold water emulsion of petroleum oils and resins), which is stored in an 8,000-gallon tank mounted 15 feet above ground next to a 12,000 gallon water tank. The water tank and agent tank are connected to one discharge pipe for loading the sprayer truck; and when the truck is loaded, the water and dust control agent are automatically mixed at a ratio of 1 agent to 10 water. At the start of the program, the 10,000 gal sprayer truck was loaded 8 to 10 times a day. After about three weeks, the dirt and gravel surface was relatively smooth and dust-free, so the driver cut down to only one pass over the area, spraying one load of the mixture at the start of the day. The dilution and quantity are varied according to ambient temperature, hours of sunshine, etc. The area sprayed covered about 1.5 miles of roadway, about three lanes wide, over rocky soil, and a parking area. A record was kept of the savings provided by the use of this technique in terms of truck time, labor, and the use and maintenance of graders all in comparison to the old method of using water to keep down dust. Added to these savings is a more manageable roadway system.

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145		Maatregelen Ter Beperking Van Het Energieverbruik In Het Verkeer En Vervoer		No												
146		Moving Violation Study	19680400	No												Traffic violation occurrence studies were conducted by direct observation of law violations from selected vantage points along a busy highway route. Violations were plentiful at each of 15 survey locations along U.S. Highway 101 in California. In multilane traffic, nonspeeding risk violations were more common than speeding violations only at heavy-volume locations. Nonspeeding risk violations did not constitute as high a percentage of volume at those sites as did speeding violations at the lighter volume sites. Following too closely was by far the predominant nonspeeding risk violation at all locations. Slow driver, left lane was observed next most frequently, with lane-changing violations almost as common as the latter in heavy volume, but decreasing conspicuously with volume decline. The total violation counts taken by multilane location for passenger vehicles were negatively, but very weakly related to the volume counts and to accidents. The percentage, nonspeeding risk violations/total violations was taken as a measure of the degree of multilane traffic flow restraint. Speeding violations comprised an extremely large portion of total violations only in locations of relatively low volume, unrestrained traffic. A range of about 3 percent to about 36 percent of trucks and vehicles with trailers committed speeding violations at multilane locations during the base period. Truck (and vehicle with trailer) base period speeding violations were sufficiently predictable from volume/capacity to afford a generally accurate picture for multilane locations.
147		Selection and Signing of Truck Routes in Urban Areas	19730400	No												The reports of subcommittees in the areas of commercial trucking, vehicle classification, route selection and terminal location, and signing have been used in the development of this report that is intended to provide criteria and information, which can be used as guidelines in establishing and signing truck routes. Recommendations are made on the practice to be employed in the selection and signing of truck routes in urban areas. Routes, which must be established through joint state and local government agreement, should be located only after traffic engineering studies on need and adequacy. Structural and geometric dimensions required to accommodate trucks, abutting developments, present traffic volumes, presence of railroad grade crossings, number of turns along the route, and cooperation with motor carrier groups are all considered. Advice is given on the development of a standard sign for the marking of established truck routes. The individual reports of the various subcommittees are appended.

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148		Toll Financing Is Gaining in Popularity	20050200	No												The growing interest in using tolling in highway financing was clearly evidenced at the 16th Annual Conference on Public-Private Ventures in Transportation. The innovative forms of financing the priced roads of the 21st century discussed included HOT lanes, express toll lane networks with bus rapid transit service, toll truckways, and electronic toll roads. Some of the financing arrangements proposed included public-private partnerships, long-term franchising similar to that used by private utility networks, and Texas-type regional mobility authorities that use a mix of public and private funding. Some of the reasons for the interest in tolling include: states and local governments have run out of other obvious sources of financing; variable tolls are seen as an effective tool of congestion management; there is increasing evidence that more and more motorists choose to use priced lanes when they are pressed for time; most transportation user groups have become vocal advocates of tolling; and, finally, tolling has received strong support from the present administration.
149		Atlanta Traffic Congestion Studied	19730200	No												The Georgia DOT has undertaken a major study to determine how much traffic can be diverted from Atlanta's downtown expressways to perimeter routes. Several proposals concerning different types of vehicles are under consideration in the study, including one that trucks and cars use different lanes. Another would establish a "qualification factor" that would require that all vehicles maintain the minimum speed of 40 mph. Still another would ban some categories of vehicles, such as mobile homes, cranes, and oversized trucks, from interstate routes inside the Interstate 285 perimeter route during rush hours. A transportation department spokesman says that there is general consensus within the committee that a minority of the truck traffic on Atlanta's interstates is causing a large portion of the problems. Proposed tollways for the Atlanta area that supposedly would alleviate some of the City's traffic congestion are being challenged in the courts, while the recently approved rapid transit system is several years from completion.
150		Highway Accident Report – Gateway Transportation Co., Inc., Tractor-Semi-trailer Penetration of Median Barrier and Collision With Automobile, I-70, St. Louis, Missouri, September 25, 1977	19790322	No												At 8:07 p.m. on Sunday, September 25, 1977, an empty tractor-semi-trailer was traveling eastbound on I-70 in downtown St. Louis, Missouri, when the truck driver lost control of his vehicle on wet concrete pavement. The tractor struck, broke, and overrode a concrete median barrier, vaulted into the westbound lanes, and collided with a westbound automobile. All three occupants in the automobile died; the truck driver was injured slightly. The National Transportation Safety Board determines that the probable cause of this accident was the loss of tractor-semi-trailer control during evasive maneuvers made by the truck driver in response to improper lane changes by an eastbound automobile driver. Contributing to the severity of the accident were the barrier impact speed and attack angle of the tractor-semi-trailer, which may have only slightly exceeded the design limits of the functional "New Jersey" concrete barrier.

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151	Archilla, R.	Traffic Characteristics on Two-Lane Highway Downgrades	19940000	No												This paper presents the findings of a study of traffic flow on low downgrades on the primary highway system in Western Canada. Downgrade data was collected on three long, steep downgrades using time lapse video camera. The findings indicated that, while truck speeds on level terrain are only slightly slower than passenger cars on downgrades, the presence of trucks noticeably affects speed-flow relationships. Both the Hyperlang and Schuhl headway distribution produced excellent fits to the headway data. The data yielded over 6,000 platoons. The Geometric, Borel-Tanner, and one parameter Miller distributions provided a good representation of traffic flow on downgrades only under some conditions; however, the two-parameter Miller distribution produced very good fits in all cases of plato size distributions.
152	Archilla, R.	Traffic Characteristics on Two-Lane Downgrades	19960300	No												Downgrade operations are not specifically addressed in the 1985 Highway Capacity Manual procedures for two-lane highways. However, traffic operations on long steep downgrades on two-lane highways are becoming increasingly important due to increasing volumes and the higher percent of slow moving vehicles, such as recreational vehicles and heavy trucks in the traffic stream. Compounding the slow moving vehicle platooning problem is the fact that most downgrades on the primary highway system in Western Canada are long no-passing zones. It is noted that most upgrades on the primary highway system have climbing lanes, and passing lanes are being built on level tangent sections, which have extended no-passing zones. This paper presents the findings of a study of traffic flow on long downgrades on the primary highway system in Western Canada. Downgrade data was collected on three long, steep downgrades using a time lapse video camera. The findings indicated that, while truck speeds on level terrain are only slightly slower than passenger cars, on downgrades the presence of trucks noticeably affects speed-flow relationships. Both the Hyperlang and Schuhl headway distributions produced excellent fits to the headway data. The data yielded over 6,000 platoons. The Geometric, Borel-Tanner, and one-parameter Miller distributions provided a good representation of traffic flow on downgrades only under some conditions; however the two-parameter Miller distribution produced very good fits in all cases of platoon size distributions.
153	Ballard, A J	Current State of Truck Escape-Ramp Technology	19830000	No												Drivers who lose control of their heavy vehicles on long, steep downgrades have an alternative to riding out the hill when a truck escape ramp is on the grade. There are six basic types of escape ramps in the United States. Only recently has there been an appreciable increase in the advancement of truck escape-ramp technology. Many of these advancements were developed by state transportation agencies, and are documented individually in the various states' reports. The purpose of this paper is to provide a pool of information on the characteristics of the many truck escape ramps that are found in the numerous literature sources throughout the United States. (Author)

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154	Barnett, J. C., and R. F. Benekohal	Accident Reduction Effects of Using Weigh-In-Motion and Automatic Vehicle Identification for Mainline Bypass Around Truck Weight Stations	1999	No												Using weigh-in-motion (WIM) and AVI technologies may permit trucks with appropriate credentials to bypass the weigh station on the mainline traffic stream. This would reduce the number of disruptions to the mainline traffic stream, and reduce the chances that an accident might occur. Characteristics of accidents on road segments around weigh stations [influence zones (IZs)] are examined and compared with those for accidents on similar basic freeway sections [control zones (CZs)]. There were significantly more accidents around weigh stations than on similar basic freeway sections, particularly during operating hours. Similarly, there were significantly more accidents involving trucks in the IZs than in the CZs. A comparison of the number of IZ and CZ accidents during typical operating hours, excluding animal-related accidents, indicated that the CZs had 38-percent fewer accidents than the IZs. This would result over 10 years in 146 fewer accidents during typical operating hours around the 20 Interstate weigh stations when animal accidents are not included. When animal accidents were included, the reduction was 30 percent. This would reduce the total number of accidents during typical operating hours around the 20 Interstate weigh stations over 10 years by 129. Thus, a maximum reduction of 129 to 146 accidents could be achieved if the IZs were made identical to the CZs. These figures represent the upper limit of accident reductions. A model is developed to predict potential accident reductions around weigh stations at varying levels of WIM and AVI usage. The resulting model is an S-shaped curve, which should approximate the potential accident reductions as a function of percent WIM-AVI usage.

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155	Bergh, T	2+1-Roads With and Without Cable Barriers: Speed Performance	20000600	No												The objective of this paper is to present the Swedish National Road Administration (SNRA) development program to upgrade traffic safety on existing 13-mile cross-section roads using low cost measures and early findings on speed performance. Traffic safety findings have been reported in depth elsewhere. The main traffic safety proposal in the development program is conversion to 2+1 with a separating cable barrier and roadside improvements within existing right of way. In 1998, the director general of SNRA decided to proceed with a full-scale program with six sections. The empirical findings presented here are based on 1.5 years of experience from the first section to be opened, the E4 semi-motorway Gavle-Axmartavlan with an Annual Average Daily Traffic of 7,000 veh/d; 2+1 partly with cable barrier partly only with road markings. The solution chosen on the first section gives one-lane sections with a total paved width of 5.6 m, but only 4.6 at existing bridges and side guardrails. This has been heavily criticized as giving an unacceptable level of service for a national highway due to low overtaking opportunities and queues at vehicle breakdowns and maintenance operations. Early speed performance findings so far are as follows: the average car spot speed at speed limit 90 km/h has been 101 km/h; car spot speeds are in the range 93 to 100 km/h at the beginning of a one-lane section at traffic flows around 1,200 to 1,350 veh/h; 5 percent of the hourly speeds are below 90 km/h at speed limit 90 km/h; the 1 percent percentile speed at 90 km/h is 75 km/h at both the beginning of a one-lane and at the end of the two-lane location close to a transition zone; car spot speeds on overtaking lanes, 300 to 350 veh/d, are very high in the range 110 to 120 km/h, far above the official speed limit of 90 km/h (before April 1999); average passenger car spot speeds on two-lane sections are 4 km/h higher in September 1998 on the cable barrier section compared with September 1997 with wide lanes, and on two-lane sections with road marking the spot speeds are slightly higher than for the cable barrier section; passenger car speeds on one-lane sections on the cable barrier part are more or less unchanged though speeds at side steel barriers have decreased some km/h, and speeds on the road marking part seem to be approximately 2 km/h higher in one-lane sections; side cable barriers 1 m from the pavement do not affect speeds; there is approximately one median barrier repair per week requiring on average a 2-hour overtaking lane closure; two illegal transports, one with an over-width truck and one with an over-height truck, have been stuck resulting in long queues; and some five accidents and incidents have blocked one direction for numerous hours.
156	Breskin, Ira	Wiggle Room at Highway Bridges	20030000	No												This article relates how the Director of the New York State Thruway Authority coordinated the development of an electronic system that detects vehicles that are too tall. The system uses sensors to monitor the height of trucks traveling on the New York State Thruway. It projects a pair of infrared beams across the northbound section of the highway before the traffic reaches the toll plaza. If the beam is interrupted by a vehicle, an alarm is sounded and the system simultaneously closes the E-ZPass truck lanes, directing all trucks to a booth where the overheight truck is identified.

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157	Bryden, J. E.	Work Zone Traffic Accidents Involving Traffic Control Devices, Safety Features, and Construction Operations	19980000	No												There were 496 work zone traffic accidents on New York State DOT construction projects from 1994 through 1996. These accidents involved impacts with work zone traffic control devices and safety features; construction features, such as pavement bumps and joints; drainage features; excavations and materials; and construction vehicles, equipment, and workers. These items, which include all of the features introduced into the roadway environment by construction activity, represent one-third of all work zone accidents and 37 percent of those involving serious injury. Channelizing devices, arrow panels, signs, and other traffic control devices generally resulted in little harm when impacted. Impact attenuators, both fixed and truck mounted, also performed well. Although portable concrete barriers prevent vehicle intrusions, impacts with barriers are severe events. Barriers must be properly designed and limited to only those locations where they are needed to protect more serious hazards. Construction vehicles, equipment, and workers were involved in over 20 percent of all work zone accidents, resulting in serious injuries. Although intrusions by private vehicles into work spaces are a serious concern, construction vehicles, equipment, and workers in open travel lanes are also a serious concern. Good design of work zone traffic control plans, combined with adequate training and supervision of workers, is essential to control both concerns.
158	Deen, T. B.	Acceleration Lane Lengths for Heavy Commercial Vehicles	19570200	No												Data were collected on the acceleration rate actually being used by commercial vehicles on a high type roadway without the drivers being aware that they were being observed. A study was made at the Lincoln Tunnel Interchange on the New Jersey Turnpike. Only loaded vehicles were included in the sample. Semi-trailer trucks with single rear axles and semi-trailer trucks tandem rear axles had nearly identical acceleration characteristics. All of the data are concerned with vehicle accelerations on a level or nearly level grade. Single unit trucks were found to accelerate at a higher rate than other heavy commercial vehicles at speeds below 29 miles per hour. Buses accelerate at a greater rate above 29 miles per hour. Semi-trailer trucks accelerate at the lowest rate of the commercial vehicles studied. Acceleration lanes designed under current length standards are adequate for single unit trucks for all highway design speeds of 50 miles per hour or less, and are adequate for semi-trailer trucks for all highway design speeds of 30 miles per hour or less. Design of acceleration lanes based on the acceleration characteristics of the assumed SU or C-50 design vehicles as determined from the society of automotive engineers truck ability prediction procedure do not appear justified, nor are they required to accommodate most heavy commercial vehicles.

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159	Duffy, D. M.	Runaway Truck Ramp Testing Program	19980000	No												This document presents a summary of Washington State Transportation Center's (TRAC) examination of privately collected roadway performance data in the Puget Sound Region. The review examined the accuracy and reliability of those data for use by Washington State DOT on roadways in the Puget Sound metropolitan region that are not covered by existing freeway surveillance systems. This project is the first step in the analysis of the potential use of privately collected datasets for arterial performance monitoring for both monitoring of signal control systems and freight (truck movement) analysis. These test results apply only to the Seattle metropolitan region, and only to spring 2007. The project team's conclusions from the tests are that the private sector data are currently overly conservative estimates of roadway speed and performance. At this time, it is not recommended that the data be used for arterial performance monitoring. It is recommended that Washington State DOT and other roadway agencies be open to additional testing of these data sources as improvements are made.
160	Eck, R. W.	State Practice and Experience in the Use and Location of Truck Escape Facilities	19790000	No												One phase of a study undertaken to develop warrants for the use and location of truck escape ramps is described. A questionnaire submitted by mail to state highway agencies sought information on 1) the type and number of escape facilities constructed, 2) variables considered in determining the need for escape ramps, 3) factors that affect ramp location, and 4) operational experience with escape ramps. The study results indicated that, although most ramps are located on four-lane divided and two-lane highways, they can also be found on three-lane routes, in medians, and at the end of freeway off-ramps. Only two states indicated that a rational technique made use of accident rates. Other important factors in determining the need for escape ramps included length and percentage of grade, percentage of trucks, and conditions at the bottom of grades. Topography was cited as the primary factor in ramp location. Examples of satisfactory and unsatisfactory ramp location are described. (Author)
161	Elefteriadou, et al.	Development of Passenger Car Equivalents for Freeways, Two-Lane Highways and Arterials	1997	No												Passenger car equivalents (PCEs) have been used extensively in the "Highway Capacity Manual" to establish the impact of trucks, buses, and recreational vehicles on traffic operations. PCEs are currently being used for studying freeways, multilane highways, and two-lane highways. A heavy-vehicle factor is directly given for the impact of heavy vehicles at signalized intersections (and indirectly along arterials). These PCE values are typically based on a limited number of simulations and on older simulation models. In addition, the impact of variables such as traffic flow, truck percentage, truck type (i.e., length and weight/horsepower ratio), grade, and length of grade on PCEs has not been evaluated in depth for all facility types. The methodology for developing PCEs for different truck types for the full range of traffic conditions on freeways, two-lane highways, and arterials is described. Given the scope of this research and the variability of traffic conditions to be examined, simulation was selected as the most appropriate tool. The resulting PCE values for freeways, two-lane highways, and arterials indicated that some variables, such as percentage of trucks, do not always have the expected effect on PCEs; whereas, other variables, such as vehicle type, are crucial in the calculations. Generally, major differences in PCEs occurred for the longer and steeper grades. There was great variability in PCE values as a function of the weight/horsepower ratio, as well as of vehicle length.

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162	Firestine, M.	Operating Larger Trucks on Roads With Restrictive Geometry: Summary Report	19890900	No												Changes in the 1982 Surface Transportation Assistance Act (STAA) allowing wider and longer trucks on the National Network have raised questions about highway safety. The FHWA sponsored a study by Goodell-Grivas, Incorporated, that investigated the performance of trucks of various lengths and widths on roads with restrictive geometry. The report summarized here highlights the main findings of that study for transportation officials and practicing engineers. Field studies at both urban and rural sites indicated that truck drivers compensate for the reduced operating capabilities of larger trucks. Despite driver skill, however, trucks on urban roads encroached into other lanes on streets with widths less than 12 feet. Intersections with less than 60-foot corner radii caused some problems for most truck types, especially those wider than 102 inches. Prohibiting large trucks from turning onto narrow urban streets, employing turn movement templates in roadway design, adjusting signal and/or left-turn lane lengths, and manufacturing 48-foot semi-trailers with axles forward only may minimize these and other problems. On rural roads, lanes wider than 12 or 13 feet allowed oncoming vehicles to move further right to avoid trucks, and shoulders wider than 4 feet allowed oncoming vehicles a greater margin of safety. At sharp curves (7 to 15 degrees), opposing vehicles slowed down significantly and made other undesirable changes to pass large trucks. Consideration should be given to reducing the sharpness of curves greater than 7 degrees and to allowing large trucks only on two-lane rural roads with lanes at least 12-foot wide and shoulders greater than 4 feet. This summary report was based on the following study: "The Operation of Larger Trucks on Roads with Restrictive Geometry Volume I: Final Report: FHWA/RD-86/157."
163	Green, W. H.	Turnpike Interchange Provides Critical Link to Valley	19990100	No												The Route 146/Massachusetts Turnpike Interchange, the first major interchange project undertaken by the MTA in over 30 years, will provide direct access between Worcester (a major commercial and industrial city in central Massachusetts and second largest city in New England), the rapidly developing Blackstone Valley, and the Massachusetts Turnpike. Construction, which was begun in 1995, is expected to be completed by mid-1999. The corridor project involved upgrading the existing two-lane, unlimited access roadway segment to a four-lane, limited access highway. A major component is construction of the turnpike's new interchange, consisting of new ramps; four bridges; four retaining walls; a 500-car park-and-ride facility; a new toll plaza; water and sewer connections; new acceleration, deceleration, and truck-climbing lanes; and wetland-mitigation areas.
164	Guss, B.	Bringing Run-Aways Home	19740800	No												After attempts at signing and reduced speeds, the Utah Highway Department elected to try escape lanes to stop runaway trucks in Parleys Canyon. The effectiveness of pea gravel is discussed, as are design features. Statistics indicate that the lane is well used, and that the accident rate on the road has decreased. Some improvements have been made following suggestions from towing companies. The only remaining problems are automobile failure to yield right of way to trucks trying to reach the lane, and people parking in the entrance to the escape route.

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165	Hallenbeck, Mark E.	Review of Private-Sector Data for Roadway Monitoring	20070500	No												It is self-evident that the future traffic on a given highway depends upon many local conditions, and that to determine a factor, based on motor vehicle registration, for forecasting future traffic which would be of general appreciation is impracticable. It is recommended that the determination of the future traffic on a given highway should be based only upon a comprehensive highway transport survey. Since such various factors influence the utilization of motor vehicles, it is thought useless to endeavor, at the present time, to forecast the saturation point of motor vehicles in any community, except in congested urban districts. On local roads (i.e., 500 to 1,000 vehicles per day) a minimum width of 18 feet of traveled way is needed to provide for two lanes of traffic. Between edges of ditches a total width of 30 feet is necessary to provide for parking of vehicles outside of the traveled way. On such a road, drainage structures should preferably be not less than 30 feet clear width. On roads between congested manufacturing or industrial areas, where there will be a large volume of slow-moving vehicles, the traveled way should be designed for at least four lanes of traffic. Present highway capacity can be increased by relieving local congestion, but immediate steps should be taken toward the establishment of present property lines and the acquisition of needed right of way for future traffic development. On highways with four or more traffic lanes, a minimum speed limit should be determined and enforced by law. Available highway funds are so limited that many miles of surface capable of carrying traffic every day in the year are more needed than a few miles of high class pavement. Details of the purposes, costs, and organization of highway transport surveys are given in the complete report. Data obtained from highway transport surveys are given in the complete report. Data obtained from highway transport surveys indicate the necessity for classification of highways on the basis of motor truck capacity and gross loads and subsequent design and construction on the basis of this classification. The following topics are being studied by the committee: safety of operation of vehicles on a three-lane road; adequate widths of right of way for future traffic developments.
166	Hamlin, G. E.	Report of Committee on Highway Traffic Analysis	19250000	No												It is self-evident that the future traffic on a given highway depends upon many local conditions, and that to determine a factor, based on motor vehicle registration, for forecasting future traffic that would be of general appreciation is impracticable.

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167	Hart, Jeryl (Jere) D.	Simplified Advanced Truck Detection and Green Extension in Lubbock, Texas	20070000	No												Signalized intersections installed at locations where one or more approaches are high-speed present a unique challenge to traffic engineers. At these rural to semi-urban locations, heavy-truck traffic typically represents a significant percentage of total daily traffic. Collisions, while perhaps fewer in number, are usually much more severe. One hallmark of high-speed approaches is a wide "dilemma zone," which forces drivers into a quick decision. This problem is even more severe when a heavy truck is caught in the dilemma zone. The City of Lubbock has designed a solution to this safety problem using devices, which are already in common use within the traffic engineering community. In March 2006, the City completed the installation of a traffic signal at an arterial where it crosses a semi-urban expressway. At this location, large vehicle traffic is heavier than at most signalized intersections. Utilizing only a standard 2070 traffic signal controller running Econolite's Oasis operating system and two Autoscope MVP Solo Pro traffic cameras, the dilemma zone has been virtually eliminated for incoming vehicles, especially heavy-truck traffic. Using the MVP camera's classification processing capability, large vehicles are filtered from passenger vehicles, while at the same time, their speed is calculated. This information is relayed to the 2070 controller, which runs the data through an algorithm. When a user-definable set of conditions is met, the controller applies a short hold on the green indication for incoming traffic in such a way that truck drivers are no longer put to a split-second decision as to whether to brake or continue through the intersection.
168	Hayden, R. L.	Mt. Vernon Canyon Runaway Truck Escape Ramp	19821200	No												A gravel arrester bed type Runaway Truck Escape Ramp was built on a 5.2-percent downgrade along I-70 in Mt. Vernon Canyon, Colorado. The ramp was completed in July 1979, and to date it has stopped 53 runaway or potentially runaway trucks. Only two trucks sustained damage and there were no injuries or fatalities in the escape ramp. During the same period at this location, there were 18 accidents involving runaway trucks that did not use the escape ramp, resulting in 7 fatalities and 24 injuries. A closed-circuit TV surveillance system was included as part of the project, and 23 trucks were recorded on video tape as they used the escape ramp. Analysis of the tape indicated the rolling resistance to a truck in the gravel decreased as the speed increased. Further research is needed to verify and expand this finding for design purposes. Research is also needed to develop the methodology to predict the maximum probable entry speed of a runaway truck. Research is currently underway to predict the deterioration or contamination rate of the aggregate materials used in arrester beds. (FHWA)

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169	Heine, M.	Caltrans Gives Ventura Rehab 'VIP' Treatment	19890900	No												The article describes how a fast-pace construction schedule, a mapped-out traffic management plan, and night work helped speed production on Caltrans' Ventura improvement project (VIP). VIP consists of three separate overlapping projects: the first will increase traffic lanes and rehabilitate existing pavement; the second will resurface 9 miles of pavement; and the third will add a fifth lane in each direction, widen the freeway, construct soundwall, repair and resurface pavement, widen bridges, and reconstruct ramps. Almost all work is performed at night. Other traffic management methods are also employed: free 24-hour tow truck service patrol; temporary signals; Los Angeles DOT officers stationed at intersections to keep traffic moving; automated traffic surveillance and control system; motorist advisory radio; changeable message signs; and a toll-free hotline for motorist information. A public relations agency was engaged to publicize the construction. The incentive/disincentive clause used by Caltrans is noted. "Gawk screens" are used for work performed during the day. Other construction highlights are also noted.
170	Katz, Abryan J.	Field and Modeling Framework and Case Study of Truck Weigh Station Operations	20020000	No												WIM systems improve the capacity of weigh station operations significantly by screening trucks while traveling at high speeds and only requiring trucks within a threshold of a maximum permissible gross of axle weight to be weighed on more accurate static scales. Consequently, the operation of a weigh station is highly dependent on the accuracy of the screening WIM system. This report develops a procedure for relating axle accuracy to gross vehicle accuracy and develops a field and modeling framework for evaluating weigh station operations. The WIM scale operation at the Stephens City weigh station in Virginia is examined to demonstrate how the field and modeling framework can be applied to evaluate the operation of a weigh station. Specifically, the field evaluation evaluated the accuracy of the WIM technology in addition to the operations of the weigh station in terms of service time, system time, and delay incurred at the static scales. During the field evaluation of the Stephens City WIM load cell system, the WIM technology was found to estimate truck weights to within 6 and 7 percent of the static weights 95 percent of the time. The modeling framework provides a methodology that can be used to determine the effects of the truck demand, the WIM accuracy the system threshold, and the WIM calibration on system performance. The number of vehicles sent to the static scale and bypass lanes, as well as the amount of delay experienced, were analyzed for various system characteristics. The proposed framework can be utilized to estimate vehicle delay at a weigh station.

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171	Khandelwal, Rahul	A Safety Evaluation of Photo-Red Enforcement Programs in Virginia	20050800	No												A photo-red enforcement system entails the use of cameras that photograph vehicles entering an intersection after the signal has turned red; citations are then mailed to the vehicle's registered owner. The purpose of the research was to identify the safety impacts of photo-red enforcement programs in Virginia. An empirical Bayes approach was used to examine the impact of the program on crashes while controlling for mainline traffic volume, yellow interval, truck percentage, number of lanes, and speed limit. The use of the cameras was correlated with decreased red light running crashes (25 to 34 percent), increased rear-end crashes (45 to 65 percent), increased total crashes (5 to 13 percent), decreased injury crashes attributable to red light running (23 to 34 percent), and increased total injury crashes (4 to 20 percent). Analysis of variance (ANOVA) and generalized linear models (GLMs) were used to control for confounding factors (such as average daily traffic, the yellow interval, and intersection geometry) and to pinpoint locations where use of photo-red enforcement can have a positive safety effect. ANOVA was used as an innovative screening tool to delineate the factors (including second order interaction terms) that potentially affect the crash frequency, and GLMs were used to quantify how these factors affect the crash frequency. The analysis illustrates the utility of selecting the largest and most heterogeneous group of sites possible subject to the constraints: 1) the geometric characteristics can be explicitly modeled, and 2) the sites are homogenous in all other aspects not included in the model. Such sites can only be identified by detailed manual examination. The results suggest that photo red enforcement may have a positive impact on safety at intersections where the yellow interval is excessively higher than that recommended by ITE standards. The crash results presented herein suggest that Virginia's program will realize a net safety gain if the severity of the eliminated red light running crashes is substantially greater than the severity of the induced rear end crashes. A detailed study of injury severity, therefore, is needed to determine if the cameras have a net safety benefit.
172	Kuennen, T.	Truck Motorway Would Use Full-Depth Asphalt	19880100	No												An exclusive truck motorway (ETM) concept is now being promoted in Florida. It will use full-depth asphalt (7 1/8-in asphaltic concrete) for its 350-plus-mile, Jacksonville-to-Fort Lauderdale length. It will have heavy trucks using their own limited access highway at speeds up to 70 mph, thus easing congestion on Florida's over crowded roads. The ETM is envisoned as a minimal access four-lane facility; two lanes with shoulders in each direction separated by a paved median and barrier wall. The pavement will be designed structurally to accommodate heavy-truck traffic, and the geometrics will promote smooth, safe, uniform operation of truck combinations at high speeds. Initial construction cost of the ETM is anticipated to be through a bonding program. Part of the construction costs could be offset with current and future Federal aid state highway funds. A portion of the cost would be funded through toll revenue. Other details of this proposal are briefly discussed.
173	Lamkin, J. T., and W. R. McCasland	Feasibility of an Exclusive Truck Facility for Beaumont-Houston Corridor, Research Report 393-3F	1986	No												

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174	Lee, Eul-Bum	Innovative Approach to Rapid Rehabilitation of Concrete Pavement on Urban Highway	20050000	No												This case study presents an innovative fast-track reconstruction approach applied to a heavily trafficked LLPRS project on Interstate-15 (I-15) in southern California. A 4.5-km stretch of badly damaged concrete truck lanes, two in each direction, was rebuilt in only two 210-hour (about nine days) one-roadbed continuous closures, using counterflow traffic and around-the-clock operations as accelerated construction, an undertaking estimated to take 12 months using traditional nighttime closures. This post-construction case study validated preconstruction estimates of productivity and traffic delay, which closely matched performance data measured during construction. The I-15 Devore project provided a unique opportunity to validate, fine-tune, and enhance highway analysis tools for future LLPRS projects. The use of CA4PRS schedule analysis and other traffic models presented in this study facilitates teambuilding amongst engineers involved in the design, construction, and traffic phases to mutually arrive at an optimal solution.
175	Levinson, H. S.	Innovations in Urban Goods Movement	19770000	No												This paper looks at innovations in urban goods movement in the context of economic and political reality. It overviews dimensions of the urban goods movement problem as it relates to urban growth and economy; identifies impacted groups; and analyzes real and pseudo-solutions. The paper suggests better street traffic management; auto-free zones rather than truck-free zones; and selective construction of truckways and truck streets. It calls for consolidated shipping and receiving areas in office buildings; increased cargo containerization; and strategic development of transportation facilitation centers.
176	Lindsey, Sue	Virginia to study using rails to cut I-81 congestion	20061023	No												Subtitle: State says it will not consider truck-only lanes, but tolling remains an option.
177	Mahmassani, H. S.	Application and Testing of the Diagonalization Algorithm for the Evaluation of Truck-Related Highway Improvements	19870000	No												Highway and transportation officials are increasingly concerned about accommodating rising truck traffic and the associated size and weight trends. A network traffic assignment procedure is an essential component of the methodological support for the identification, evaluation, and selection of truck-related physical and operational improvements in a highway system. A general mechanism is presented for the network representation of improvements consisting not only of physical capacity expansion, but also corresponding operational strategies in the form of (existing or new) lane-access restrictions to either vehicle class; this mechanism allows the consideration, as a special case, of exclusive truck lanes or facilities contemplated by several agencies. The special requirements of the traffic assignment procedure in this context, including the need to explicitly consider the asymmetric interaction between cars and trucks, give rise to potentially serious methodological difficulties that must be addressed for specific types of applications. The applicability of the diagonalization algorithm to such problems is investigated by using numerical experiments on three test networks under varying conditions. The three test networks include an abstracted condensed representation as well as a full-scale version of the Texas highway network, thus providing a realistic case application. The main aspects of the algorithm's performance addressed in these experiments are its convergence characteristics, as well as the effectiveness of some computational streamlining strategies. Although convergence is not guaranteed a priori, it was actually achieved in all test cases. Furthermore, it is shown that shortcut strategies can considerably reduce the algorithm's computational requirements.

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178	Marshall, Alex	The Mega-City Maker	20050800	No												Almost one-half century after the creation of the Interstate highway system, new mega cities or megalopolises have grown up around key Interstates, turning existing cities and towns into huge regional organisms. This article on mega-cities reviews the development of these giant metropolitan areas, including the features that define and create a mega region. The author explores how the interstates create places differently than did their 19th century counterpart, the railroads. The author then discusses the possibilities of services, such as high-speed train lines, direct train-to-airport linkages, and specialized truckways, in the densely-populated mega regions. The article concludes with a brief description of the work of the Regional Plan Association in New York City, a group that is exploring the option of these types of services in their campaign, "America 2050: A National Strategy for Global Competitiveness."
179	Metcalf, D. G.	Analysis of Arizona Arrestor Bed Performance; Special Report	19921200	No												The Arizona DOT designs arrestor beds using an equation that predicts stopping distance based on entry velocity, assumed rolling resistance (R), and the slope of the bed. There are several arrestor bed features not accounted for in the design equation that are specified based on experience: 1) bed depth, 2) length of transition from initial depth to final depth, and 3) aggregate specification. The arrestor bed design equation has been cited as overly conservative in research done by the Pennsylvania Transportation Institute (PTI). Additionally, Arizona DOT is interested in the effect of different types of equipment that can be used to level and scarify the bed after an entry. To evaluate Arizona arrestor bed performance, Arizona DOT performed 102 full scale truck entries distributed among four of Arizona's seven arrestor beds. Testing approximated a 2x2x3 factorial experiment. The length of each run was measured and recorded. The velocity during most of the runs was recorded every 1/20th of a second by a radar gun connected to a data recorder. The stopping distance and a backcalculated R value were used as response variables for ANOVA. The time vs. velocity plots were used to determine the character of the deceleration of each run. The analysis indicates that stopping distance increases approximately 70 percent when entry velocity is increased from 45 mph to 65 mph. Runs in the tracks left by a previous entry increased stopping distance by approximately 14 percent. An equipment type that is capable of scarifying the bed will decrease the stopping distance approximately 17 percent over equipment types that only level the bed. At the highest design entry speed, in beds of comparable aggregate and slope, an average R value of 0.41 was achieved in a bed that had an average depth of 39.2 in. over the average stopping distance, and an average R value of 0.34 was achieved in a bed that had an average depth of 12.8 in. over the average stopping distance.

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180	Miller, John S.	Safety Impacts of Photo-Red Enforcement at Suburban Signalized Intersections: An Empirical Bayes Approach	20060000	No												Data on the speed profiles of trucks on sustained upgrades can be combined with safety estimates to quantify the increased accident rates caused by slow-moving trucks and the changes in accident rate with distance up the grade. Truck performance and speed data were taken from recent field measurements and were evaluated using the truck performance equations presented in the NCHRP Report 185. The effect of speed differences on accident rate is based on the relationships developed by Solomon. The results show that there is a pronounced increase in accident rates of passenger cars and trucks in the traffic stream only when a sizeable portion of the truck population falls to speeds of 22.5 mph or less. The results indicate that, from a safety standpoint, there is little apparent need for truck climbing lanes on moderate upgrades (2 percent) or in the first portion of steeper upgrades. However, the results must be interpreted cautiously in light of limitations in the Solomon data that were found during the analysis. In particular, the Solomon data do not show how accident involvement rates change within the very important speed range from zero to 22.5 mph, and these data may represent sections with more intersection- and driveway-related accidents than would typically be found on a sustained grade. Further research is needed to quantify relationships between speed differences and accident involvement rates that are specifically applicable to sustained grades.
181	Miujen, L. G. M.	Measures to Restrict the Energy Consumption in the Transport Sector	19790600	No												The report discusses in detail some 350 specific measures to reduce energy consumption in the transportation sector. To provide an impression of the coverage, a number of these measures includes: relocation of enterprises to reduce transport requirements, increase in density in zoning; elimination or decrease of fiscal deductibility of travel expenses; introduction of a four-day work week; improvement of car and truck engines; restriction of energy-consuming options in cars; research and development of alternative vehicle engines; production of smaller cars; reduction of taxation for car pooling; creation of parking facilities and reservation of lanes for car pools; subsidization of public transport; improvement of quality of service of public transport; introduction of toll roads; taxes on peak-hour travel; speed limit; limit on highway construction; parking levies; parking limitation; introduction of gasoline coupons; limiting number of gasoline stations; and measures to restrict the energy consumption in the transport sector.

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182	Morris, Steven Michael	Impact of Using Designated Secure Rest Facilities on Single-Lane Truck Dispatching Productivity	20070000	No												This paper develops an approach for analyzing how restricting rest (sleep) locations for long-haul truckers may impact operational productivity, given hours-of-service regulations. Productivity in this paper is measured by the minimum number of unique drivers required to feasibly execute a set of load requests over a known planning horizon. When drivers may stop for rest at any location, they should be able to maximize utilization under regulated driving hours. When drivers may only stop for rest at certain discrete locations, drivers may suffer decreased utilization thus leading to productivity impacts on trucking firms. The framework and results should be especially useful in the analysis of truck transportation of security-sensitive commodities, such as food products and hazardous materials, where there may exist strong external pressure to ensure that drivers rest only in secure locations to reduce risks of tampering. The analysis in this paper considers the simplest case, where all loads to be transported move along a single lane. The paper presents an optimal tree search algorithm for determining the minimum number of drivers required to cover a set of loads given a set of allowed rest locations. Since the optimal approach is often computationally burdensome, the paper also presents and analyzes a set of simple heuristics for determining feasible load-to-driver assignments that can augment the search for the true minimum. Analysis on a sample data set demonstrates the approach, and indicates that for lanes of realistic length the productivity impact of restricting rest to a small number of discrete locations is likely to be small.
183	Moses, F.	Weigh-In-Motion Applied to Bridge Evaluation; Final Report	19850900	No												The WIM technology has been extended to the evaluation and rating of existing bridges. Software and hardware in the Ohio DOT bridge WIM system were modified for continuous operation to obtain truck axle and gross weight, and headways in two lanes plus bridge response data. Five sites in Northern Ohio were studied, including four state and one county bridge. The selected sites included a bridge with a posting limit and bridges where permits had been restricted or unusually high permits were allowed. The sites were all steel stringer bridges with only one bridge being of composite construction. The field results indicated a considerable number of overweight trucks. Bridge response, however, showed lower stresses than predicted by conventional methods due to the presence of additional composite action, higher section modulus, and smaller girder distributions and impact values than allowed by code. Three bridge sites were instrumented by Case personnel and two by Ohio DOT. The bridge evaluations performed by project personnel making use of the field measurements for girder distribution and impact showed much higher rating values than predicted by conventional rating (e.g., BARS) methods. The WIM system was used to more effectively rate bridges by providing more realistic data for the rating process. Reliability methods were also presented that showed that safety levels for the sites studies were high for the truck traffic now being carried. Only strength capacity was studied, however, and due to the increased number of permits being issued further evaluations based on fatigue life should be performed.

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184	Newman, L.	Effect of Grades on Service Volume	19641210	No												The purpose of this research was to develop a level of service chart relating service volume to number of trucks and steepness and length of grades for rural freeways with two lanes in one direction. Truck speed distributions observed by time-lapse photography methods on various grades in California were used to calculate relative number and duration of passing maneuvers. The premise in developing the level-of-service chart is that traffic is affected by grades in three ways: 1) length of grade, 2) steepness of grade/speed of trucks, and 3) frequency of trucks. Evidence is given that quality of flow for cars passing a truck or series of trucks will not be seriously affected if the car flow rate does not exceed 1,200 to 1,500 vph; and all trucks or slow vehicles stay in the right-lane only. However, all trucks do not stay in the right lane. A truck will pass another slower truck as soon as he catches up, regardless of automobile volume levels. The number of truck-passing-truck maneuvers for a given average truck speed varies directly with: 1) the length of grade and 2) the square of the number of trucks. The number and duration of passing maneuvers are related to the speed distribution of the trucks. From the field observations, a family of curves was drawn showing automobile and truck volume for a constant level of service as the length and steepness of grade are varied. The effect on operation by providing a climbing lane can be ascertained.
185	Nowak, A. S.	Load Model for Bridge Design Code	19940200	No												The paper deals with the development of load model for the Ontario Highway Bridge Design Code. Three components of dead load are considered: weight of factory-made elements, weight of cast-in-place concrete, and bituminous surface. The live load model is based on the truck survey data. The maximum live load moments and shears are calculated for one-lane and two-lane bridges. For spans up to about 40 m, one truck per lane governs; for longer spans, two trucks following behind the other provide the largest live load effect. For two lanes, two fully correlated trucks govern. The results of calculations indicate that dynamic load depends not only on the span, but also on road surface roughness and vehicle dynamics. Load combination, including dead load, live load, dynamic load, wind, and earthquake, is modeled using Turkstra's rule. The developed load models can be used in the calculation of load and resistance factors for the design and evaluation code.
186	Pigman, J. G.	Evaluation of Truck Escape Ramps	19850100	No												Out-of-control vehicles on steep grades have the potential for and frequently do result in severe accidents. There are two truck escape ramps in Kentucky, and both were constructed as a result of severe accidents and the potential for additional accidents. One escape ramp is on the Hyden Spur (KY 118) in Leslie County. Because of geometric conditions of the highway and topographic constraints, an arrester-type escape ramp was designed with pea gravel as the arrester material. The beginning of the ramp is a 386-foot paved section on an 8-percent downgrade; followed by a gravel bed 520 foot long on a 4-percent downgrade. This ramp was opened for use in 1980, and it has been used four times in emergency situations. The other escape ramp is on KY 11 leading into Beattyville in Lee County and is a combination gravity and arrester design. The ramp includes a 400-foot paved approach, followed by a 700-foot arrester bed over a 1.5-percent downgrade, and then a 210-foot arrester bed over a 14-percent upgrade. There has been only one reported emergency usage of this ramp since it opened in 1980. Overall, the escape ramps have proven to be operating properly and appear to be performing as they were designed. Of the five cases where the ramps were used by out-of- control vehicles, no one has been injured and there has been very little damage to the vehicles involved.

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187	Potts, C. F.	Now Is the Time to Create A New Vision: The Importance of the National Highway System	20020500	No													The importance of the national highway system extends beyond the efficient transportation of goods and services to the very quality of life enjoyed in the U.S. today, according to a speech made by National Asphalt Pavement Association's Second Vice Chairman Charles F. Potts. Among the visions for the future would be specialized portions of the highway system for heavier freight and self-financed truck-only lanes; and increased funding for research and development to improve the safety, durability, cost-effectiveness, and environmental soundness of the highway system.
188	Samuel, P.	The Future of Tolling in U.S.	20020100	No													Electronic toll express (ETX) lanes have become increasingly popular on U.S. highways. All new toll roads are being built with these ETX lanes. This article summarizes some projects that are incorporating ETX lanes, including the first full U.S. toll road to plan all electronic tolling. No provision will be made for cash payment on the Westpark Toll Road in Houston, Texas. In another project, the Dallas North Tollway in Texas, a truck crash severely damaged a toll plaza. The former configuration of unmanned toll booths retrofitted with electronic tolling was not rebuilt. Instead, the highway authority immediately converted to four ETX lanes. To further encourage ETX lanes, legislation is needed to support camera enforcement to identify toll evaders.
189	Schulz, John D.	Go It Alone	19990000	No													Subtitle: Truck-Only Lanes Winning Support As Congestion, Freight Demand Soars.
190	Scrase	Driving Freight Forward	May/June 1998	No													
191	Shladover, S. E.	Opportunities in Truck Automation	20010000	No													Most of the attention devoted to trucks within the world of ITS has been focused on very near-term considerations of using electronics to facilitate border clearances, administrative processes, toll collection, and fleet management. In addition, there have been some applications of Advanced Vehicle Control and Safety System (AVCSS) technologies to trucks for safety warnings (forward collision, road departure) and adaptive cruise control. However, there is a potential for trucking operations to gain substantially more dramatic benefits from use of vehicle automation technology to provide fully automated driving capabilities. The benefits of truck automation can be considered in three primary clusters: 1) benefits of separate truck lanes, 2) benefits in terms of vehicle operating economics (including fuel and emissions savings), and 3) benefits associated with the truck drivers. The nature of the specific benefits and their monetary values can differ significantly from country to country based on differences in driving conditions, freight movement logistics, and truck designs, so quantitative findings that apply in one country are not necessarily directly transferable to another.
192	Stokes, R. W., and S. Albert	Preliminary Assessment of the Feasibility of an Exclusive Truck Facility for Beaumont-Houston Corridor	19860900	No													This report examines, in general terms, the feasibility of several truck facility options in the Beaumont-Houston corridor. Specific attention is given to the feasibility of exclusive truck facilities on or adjacent to I-10E and U.S. 90.
193	Stokes, Robert W., and William McCasland	Truck Operations and Regulations on Urban Freeways in Texas	Feb-86	No													

Ref. No.	Reference Name	Publication Title	Publication Date/Time Period	Useful Source for NCHRP 03-73?	Applicability to NCHRP 03-73: Existing Truck Lane Project	Feasibility/ Planning/ Analytical/Modeling Study	Types of Facilities	Performance Measures	Data Inputs and Tools for Evaluation of Performance Measures	Physical Criteria/Design Considerations	Costs	User Fee/Tolling Considerations	Planning Process Issues	ITS Applications	LCV Applications	Abstract
194	Stokoe II, K. H.	Super-Accelerated Testing of Flexible Pavement With Stationary Dynamic Deflectometer	20000000	No												The Texas DOT, in partnership with the Center for Transportation Research, has implemented the Texas mobile load simulator (TxMLS) as a tool for accelerated testing of in-service pavements. Although the TxMLS has been used successfully to test in-service pavements in the Yoakum and Fort Worth Districts, the fact that only one TxMLS machine exists limits the number of accelerated pavement tests (APT) that can be performed. Therefore, Texas DOT is evaluating a modification of the rolling dynamic deflectometer (RDD) for use as a super-accelerated pavement tester. In this application, the truck-mounted dynamic loading system is operated in a stationary mode, with the loading rollers and rolling sensors of the RDD removed from operation. The servohydraulic actuator is used for application of harmonic loading to a wheel footprint on the pavement surface. Hundreds of thousands of load repetitions are applied in a matter of hours; hence, the designation as super-accelerated testing. This stationary dynamic deflectometer (SDD) is being studied as a possible tool for use in expanding Texas DOT's APT program. The SDD may allow Texas DOT to increase, in a cost-effective manner, the number of accelerated tests that can be performed. Preliminary tests have been performed with the TxMLS and SDD on two different pavement recycling strategies constructed on the northbound and southbound lanes of U.S. 281 in the Fort Worth District. That the same conclusion was reached about the relative performance of the test sections with both machines indicates the potential usefulness of the SDD.
195	Szagala, Piotr	Analysis of 2+1 Roadway Design Alternatives	20050000	No												One of the main problems encountered when analyzing 2+1 design is to determine the optimum length and frequency of additional lanes. The NCHRP recommends that passing lane lengths on 2+1 roadways should be consistent with optimal lengths for isolated passing lanes on two-lane highways. However, it is not reported that any special analysis was carried out in this aspect. Then, it was decided to analyze different layouts of 2+1 design using Twopas simulation model. The model was previously calibrated for traffic conditions on Polish roads. The analysis was done for an 8.4-km long section with fixed-length additional lanes located continuously in alternating directions. The analyzed alternative module lengths were: 600; 950; 1,300; and 2,000 m. Two measures of effectiveness were analyzed: percent time spent following (PTSF) and total vehicle-hours. Two-lane, two-way section with passing allowed throughout the whole length was assumed as the base-case. The parameters of the analysis were traffic volume and percent of trucks. As a result of the analysis, the relationships between traffic volume and PTSF and time savings were derived. The relationships show that for any module length from 950 to 2,000 m, there is no significant difference in the measures of effectiveness for the whole range of traffic volumes analyzed (from 250 to 1,500 veh/h/dir); whereas, for the 600 m module the calculated values are slightly worse. Thus, in practice any module length from the range of 1,000 to 2,000 m can be used, regardless of traffic volume. These results are different from the ones presented by the NCHRP.

Ref. No.	Reference Name	Publication Title	Publication Date/Time Period	Useful Source for NCHRP 03-73?	Applicability to NCHRP 03-73: Existing Truck Lane Project	Feasibility/ Planning/ Analytical/Modeling Study	Types of Facilities	Performance Measures	Data Inputs and Tools for Evaluation of Performance Measures	Physical Criteria/Design Considerations	Costs	User Fee/Tolling Considerations	Planning Process Issues	ITS Applications	LCV Applications	Abstract
196	Taylor, Steven T.	How It Is Helping Americans	19970000	No												This article gives an overview of how ITS applications are helping relieve traffic congestion in the U.S. It makes references to the ADVANCE project in Chicago express lanes on SR 91 in Southern California, automated toll lanes on MassPike in Boston, e-mail systems for truck drivers, computer-aided emergency dispatch systems, safety efforts in construction zones through the Minnesota Guidestar program, advanced parking information systems, AVL system in Portland, and the Traffic and Incident Management System (TIMS) in Philadelphia.
197	Thomas, C.	Policy Implications of Increasing Motorization for Nonmotorized Transportation in Developing Countries: Guangzhou, People's Republic Of China	19920000	No												Increasing motorization in developing countries may have positive or negative implications for urban mobility, mainly because of potential conflicts with the predominantly nonmotorized transportation in these countries. The potential for improved planning to avoid conflicts between these two increasingly important types of travel modes is considered. The most common difficulty in planning to reduce conflicts between motorized and nonmotorized transportation lies in the phenomenal growth in automobile ownership that has occurred in the last 10 or 20 years. Urban planning in Guangzhou (formerly Canton), China, located near Hong Kong is used as an example of planning to accommodate this phenomenon. Pooled accident data for 1989 and 1990 are used to illustrate the complex relationship between various types of collisions and traffic accident severity. Most traffic accidents in Guangzhou appear to reflect relative probabilities associated with purely random occurrences. Some types of accidents, including those involving two automobiles or two motorcycles, were more severe, as measured in terms of the ratio of personal injury to fatality accidents, than was expected, relatively speaking, on an a priori basis. This suggests that drivers of automobiles and motorcycles in Guangzhou are less well prepared for the worst types of accidents than are pedestrians or bicyclists, and that this lack of preparation is independent of any conflicts that may arise between motorized and nonmotorized traffic. The random component of accident severity nonetheless predominates overall, with the end result being that pedestrians and bicyclists are much more likely than those in automobiles or on motorcycles to be injured or killed when traffic conflicts leading to collisions between motorized and nonmotorized modes of travel do occur. Methods to reduce conflicts between motorized and nonmotorized modes of travel under increasing motorization may include education, experience, or the construction of physical barriers through grade separation. Because of the high cost of grade separation, however, it has been used only sparingly in most developing countries. There are some exclusive bicycle lanes in China, as well as some separated bicycle parking facilities, but not many. Other strategies of possible use in developing countries include the identification of truck-free areas or time periods and the creation of automobile-free zones in commercial or residential areas. In terms of controlling the rate of growth in automobile traffic and determining where such growth should occur, improved zoning regulations for automobile parking and the use of fees and licensing for road access may be used. In terms of safety, improved driving rules and better lane marking are important considerations. Travel demand management, in the form of comprehensive land use plan elements and zoning regulations that encourage employer action to promote alternative modes of travel, might be considered.

Ref. No.	Reference Name	Publication Title	Publication Date/Time Period	Useful Source for NCHRP 03-73?	Applicability to NCHRP 03-73											Abstract
					Existing Truck Lane Project	Feasibility/ Planning/ Analytical/Modeling Study	Types of Facilities	Performance Measures	Data Inputs and Tools for Evaluation of Performance Measures	Physical Criteria/Design Considerations	Costs	User Fee/Tolling Considerations	Planning Process Issues	ITS Applications	LCV Applications	
198	Wang, M. C.	Aggregate Testing for Construction of Arrester Beds	19890000	No												This paper presents methods of testing aggregate for use in arrester beds. Also presented are test results of five aggregates and the performance of the aggregates in the arrester beds. The test aggregates were obtained from five existing arrester beds throughout Pennsylvania. They were Pennsylvania State University (PSU) river pea gravel, PSU crushed aggregate, Pleasant Gap gravel, Green Tree gravel, and Freeport gravel. Tests performed in the laboratory included gradation, specific gravity, Los Angeles abrasion, and freeze-thaw. In addition, particle angularity, sphericity, and shearing resistance were determined. The field performance of the test aggregates, except Green Tree gravel, was evaluated in terms of mean average truck deceleration in the bed. The available data show that PSU crushed aggregate performs most poorly of the four. The other three perform nearly equally well, although Pleasant Gap gravel has a static internal friction angle considerably lower than PSU river pea gravel. These results indicate that aggregate performance depends not only on interparticle friction, but also on other properties such as particle angularity and sphericity. For long-term performance, particle durability is also an important factor. Thus, testing of aggregate for use in the arrester bed should involve determination of gradation, interparticle friction, angularity, sphericity, and durability.
199	Weckesser, P. M.	Turnpike Features Automatic Traffic Surveillance and Control	19770900	No												The author reports how changeable message signs route traffic for optimum safety and capacity utilization on the dual-dual (12-lane) section of the New Jersey Turnpike. By confining trucks to the right and center lanes of the three-lane traveled ways, a new level of control was affected that provided for more orderly flow of traffic and the accompanying improvement in safety.
200	Weckesser, Paul M., and Kenneth W. Dodge	Efficient Use of a Busy Roadway	Apr-76	No												An automatic traffic surveillance and control system are currently operational on the northern 36 miles of the New Jersey Turnpike. The completion of the system represents the final phase of a total traffic management philosophy begun more than 10 years ago with the preparation of the preliminary designs of a $700-million expansion of the northern portion of the turnpike from 6 lanes to 12. Thus far, the system has fulfilled its expectations in ensuring the most efficient use of the roadway it controls.

Ref. No.	Reference Name	Publication Title	Publication Date/Time Period	Useful Source for NCHRP 03-73?	Applicability to NCHRP 03-73: Existing Truck Lane Project	Feasibility/ Planning/ Analytical/Modeling Study	Types of Facilities	Performance Measures	Data Inputs and Tools for Evaluation of Performance Measures	Physical Criteria/Design Considerations	Costs	User Fee/Tolling Considerations	Planning Process Issues	ITS Applications	LCV Applications	Abstract
201	Yen, B. T.	Evaluation of the Luling Bridge Retrofit Details Under Service Loads; Final Report	19910800	No												Extensive strain measurements were carried out on three cross girder boxes used to connect the cable stays to the orthotropic deck-trapezoidal box steel structure. The measurements were obtained at CG3, CG4, and CG5 adjacent to the tower at Pier 2. The measurements were focused on details that had known cracks that had been retrofitted by installing holes in the trapezoidal box girder webs at the crack tip. The hole placement resulted in several residual uncracked web segments. These uncracked segments could be modeled for crack growth based on measured stress histories and compared with field observations of crack extension. The strain gages were installed in October 1986. The gages were protected and connected to junction boxes accessible from the bridge deck. Two types of stress measurements were acquired. On November 4, 1986, two test trucks with known weights of 80,140 lbs and 82,180 lbs were used to obtain the structural response as they traveled across the bridge either side-by-side in two lanes or in tandem in the traveling lane. Test runs were made in the southbound and northbound directions at a crawl speed of about 5 mph and at 60 mph. In addition, measurements were made under regular truck traffic for the four-day period from November 3 to November 6, 1986, using a magnetic tape recorder for continuous analog records. The frequency of trucks was low as only light traffic used the bridge. The measured maximum stress range at the details with cracks varied from 0.1 ksi to 0.74 ksi. These levels of stress range did not appear to exceed the crack growth threshold. Hence, no crack extension would develop from the truck traffic using the structure. During the measurements over 15-1/3 hours, a single large stress range excursion occurred at CG5. The maximum stress range was 16.3 ksi at one of the retrofit holes. It was hypothesized that this resulted from a wind gust and/or an unknown structural release. Because of the low live load response and single high stress event, no additional measurements were deemed desirable until the connecting roadways are completed and much higher traffic frequency develops.
202		Should Commercial Vehicle Traffic Be Restricted?	15-Oct-97	No												

Attachment B

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List of Literature Sources

Task 2: Planning Process Issues

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Attachment C

Data Tables

2.0 Planning Process Issues (Task 2)

2.1 Project Planning and Evaluation

Table 2.1 Initial Performance Measures

Performance Measure	Analysis Type / Source	Standard of Performance
Truck Volumes	Quantitative/ Statewide Travel Demand Model	> 30,000 trucks per day in 2035
Traffic Congestion	Quantitative/ Statewide Travel Demand Model	Daily 2035 Level of Service E & F
Major Truck Activity Centers / Routes	Qualitative	Do the Truck-Only Lanes serve key markets and routes?
Freight Bottlenecks	Qualitative	Would Truck-Only Lanes provide relief to major freight bottlenecks?
Planned and Programmed Improvements	Qualitative	Would Truck-Only Lanes investments complement planned and programmed improvements detailed in the State Transportation Improvement Program, Construction Work Program and Statewide Long Range Transportation Plan?

Source: Truck Only Lanes Needs Analysis and Engineering Assessment, Georgia Department of Transportation, April 2008

Table 2.2 Summary of Planning Initiative Consistency

Corridor (See Table 9 for Corridor Definitions)	Consistent with local, regional transportation plans	Consistent with local, regional land use plans	Consistent with local, regional development plans	Rating (2=Best) (0=Worst)
3A: I-75 South	Yes	Yes	Yes	2
3B: I-75 South	No	No	No	0
4A: I-75 North	Yes	No	No	1
4B: I-75 North	No	No	No	0
6B: I-85 South	No	No	No	0
7A: I-85 North	No	No	No	0
8: I-20 West	Yes	Yes	Yes	2
9: I-20 East	No	No	No	0
12A: I-285 North/East	Yes	No	Yes	2
12B: I-285 West/South	Yes	Yes	Yes	2

Source: Truck Only Lanes Needs Analysis and Engineering Assessment, Georgia Department of Transportation, April 2008

Table 2.3 Example of Truck Lane Strategies

OPTION*	CONSIDERATIONS: Accessibility/Mobility	Cost-Effectiveness	Environmental Issues	Safety	Operation	Regulatory Issues
A. "Mix trucks with carpools" 1. time-limited (off-peak only) [includes 70 new ramps]	-- no added capacity -- no exclusive lanes for trucks	-- need to build new lanes from I-710 to I-605 -- lanes may need to be rebuilt to accommodate trucks' weight --moderate infrastructure investment	-- little ROW** acquisition required	-- large speed differentials between trucks and autos -- blocked visibility -- weaving to access lane -- non-standard lanes	-- lane closure due to truck break down -- no passing opportunities -- additional ramp structures required -- enforcement issues	-- Carpool lane funding limits*** -- state law limits trucks to right lanes
2. access-limited (through-trucks only) [includes 12 new ramps]	-- no added capacity -- no exclusive lanes for trucks	-- need to build new lanes from I-710 to I-605 -- lanes may need to be rebuilt to accommodate trucks' weight --relatively low infrastructure investment	-- little ROW** acquisition required	-- large speed differentials between trucks and autos -- blocked visibility -- non-standard lanes	-- lane closure due to truck break down -- no passing opportunities -- additional ramp structures required at selected locations (710, 605, 57 & 15)	-- Carpool lane funding limits*** -- state law limits trucks to right lanes
3. Time- and access-limited [includes 12 new ramps]	-- no added capacity -- no exclusive lanes for trucks	-- need to build new lanes from I-710 to I-605 -- lanes may need to be rebuilt to accommodate trucks' weight --relatively low infrastructure investment	-- little ROW** acquisition required	-- large speed differentials between trucks and autos -- blocked visibility -- non-standard lanes	-- lane closure due to truck break down -- no passing opportunities -- additional ramp structures required at selected locations (710, 605, 57 & 15)	-- Carpool lane funding limits*** -- state law limits trucks to right lanes
B. "Add truck lanes at freeway grade" 1. Designate/separate 2 outside lanes [includes 70 new ramps]	-- no added capacity -- may reduce capacity	--no ROW** acquisition required --large separation costs	--no ROW** acquisition required	-- reduction in truck/auto mixing	-- additional ramp structures required at every on-off ramp -- 60-57 weave may be blocked	-- costs not recoverable through user fees****
2. Add two reversible lanes [includes 38 new ramps]	-- increased capacity	--some ROW** acquisition --moderate infrastructure investment	--some ROW** acquisition	-- potential for head-on collisions	-- new passing opportunities -- additional ramp structures required at selected locations -- peak directions not easily identified (volume of trucks balanced most hours)	
3. Add one lane each direction with passing lanes/zones [includes 38 new ramps]	-- increased capacity	--some ROW** acquisition --moderate infrastructure investment	--some ROW** acquisition	-- reduction in truck/auto mixing	-- new passing opportunities -- additional ramp structures required at selected locations	-- costs less likely to be recoverable through user fees
4. Add four lanes (two each direction on each side of freeway) [includes 38 new ramps]	-- increased capacity	-- large amount of ROW** acquisition required --large infrastructure investment	-- large amount of ROW** acquisition required	-- reduction in truck/auto mixing	-- new passing opportunities -- additional ramp structures required at selected locations	
C. "Add new lanes above freeway grade" 1. Add new auto-only lanes above freeway grade (dedicate lanes for trucks at freeway grade) [includes 38 new ramps]	-- increased capacity	-- largest infrastructure investment	-- possible noise issues --some ROW** acquisition	-- reduction in truck/auto mixing	-- additional ramp structures required at selected locations -- many options for allocating lanes among trucks, HOV, other vehicles	
2. Add new truck-only lanes above freeway grade [includes 38 new ramps]	-- increased capacity	-- largest infrastructure investment	-- truck noise --some ROW** acquisition	-- reduction in truck/auto mixing -- potential for more serious accidents	-- additional ramp structures required at selected locations -- ramp structures must not be too steep for trucks	

NOTES:
* All options assume (1) separate truck lanes are dedicated to trucks but trucks may use other lanes as well and (2) any construction results in standard dimensions for all lanes and shoulders.
** ROW = Right of Way
*** Federal funds used to build carpool lanes were dedicated only to serve carpools.
**** Fees to use existing lanes are not allowed under federal law.

Source: SR 60 Truck Lane Feasibility Study Final Report, Southern California Association of Governments, February 2001

Table 2.4 Example of Summary Ranking Evaluation by Objective

Goal	Corridor / Objective	3A: 1-75 South	3B: 1-75 South	4A: 1-75 North	4B: 1-75 North	6B: I-85 South	7A: I-85 North	8: I-20 West	9: I-20 East	12A: I-285 North/East	12B: I-285 West/South
A. Enhance Safety for all Transportation Systems	Improve Safety	2	1	2	1	1	1	2	1	2	2
	Promote Security	1	1	1	2	0	2	1	2	0	1
	Overall Goal Rating	**1.5**	**1.0**	**1.5**	**1.5**	**0.5**	**1.5**	**1.5**	**1.5**	**1.0**	**1.5**
B. Reduce Congestion and Improve Levels of Service & Improve Access and Mobility for all Citizens	General Travel Conditions	2	0	2	0	1	2	1	1	2	2
	Reduce Congestion	2	0	2	0	1	1	1	1	1	1
	Improve Access, Connectivity and Reliability	2	0	1	0	0	1	1	0	2	1
	Overall Goal Rating	**2.0**	**0.0**	**1.7**	**0.0**	**0.7**	**1.3**	**1.0**	**0.7**	**1.7**	**1.3**
C. Provide a Plan for Truck Lanes that are Fiscally Responsible, Economically Feasibility, and Equitable to all Parts of the State.	Capital Costs	1	2	0	2	2	0	1	1	0	1
	Transportation Benefits	2	0	2	0	1	1	1	1	1	0
	Cost Effectiveness	2	0	1	0	1	1	1	1	1	0
	Overall Goal Rating	**1.7**	**0.7**	**1.0**	**0.7**	**1.3**	**0.7**	**1.0**	**1.0**	**0.7**	**0.3**
D. Support Local, Regional, State, and National Economic Development Initiatives	Consistent with Plans	2	0	1	0	0	0	2	0	2	2
	Overall Goal Rating	**2.0**	**0.0**	**1.0**	**0.0**	**0.0**	**0.0**	**2.0**	**0.0**	**2.0**	**2.0**
E. Avoid, Minimize, and Mitigate Adverse Impacts to the Built, Natural, Social, and Cultural Environments	Social/Economic Effects	1	1	0	1	2	2	0	0	1	1
	Effects on Natural Environ.	2	2	0	2	1	1	1	1	1	1
	Effects on Land Use	1	1	2	1	1	1	1	0	0	0
	Overall Goal Rating	**1.3**	**1.3**	**0.7**	**1.3**	**1.3**	**1.3**	**0.7**	**0.3**	**0.7**	**0.7**
F. Miscellaneous	Constructability	1	2	1	1	1	1	1	1	0	0
	Temporary effects	1	2	0	2	2	1	1	1	0	0
	Overall Goal Rating	**1.0**	**2.0**	**0.5**	**1.5**	**1.5**	**1.0**	**1.0**	**1.0**	**0.0**	**0.0**
OVERALL CORRIDOR RATING		1.6	0.8	1.1	0.8	0.9	1.0	1.2	0.8	1.0	1.0
ADVANCE TO SYSTEM ANALYSIS		√		√			√	√		√	√

Source: Truck Only Lanes Needs Analysis and Engineering Assessment, Georgia Department of Transportation, April 2008

Table 2.5 Example of Detailed Evaluation Grading Matrix for Alternatives

● ◕ ◑ ◔ ○
Most Effective ← → Least Effective

Goal	Goal Description	Strategy A: No Build	Strategy B: TSM/TDM	Strategy C: HOV Lanes	Strategy D: Truck Lanes	Strategy E: Managed Lanes
		Existing Conditions plus Funded and Reasonably Anticipated Improvements	Transportation System Management and Demand Management Measures plus Strategy A (No Build)	One Full Corridor HOV Lane per Direction plus Strategy B (TSM/TDM)	Two Full Corridor Exclusive Truck Lanes per Direction plus Strategy B (TSM/TDM)	Two Reversible Managed Lanes (US-395 to I-210) plus One General Purpose Lane per Direction (Mojave River to US-395 & I-210 to SR-60) plus Strategy B (TSM/TDM)
Goal 1 Reduce Congestion	Weekday Peak Periods - General Purpose Lanes	◔	◔	◕	◕	◕
	Weekday Peak Periods - HOV, Truck, or Managed Lanes			●	●	●
	Weekend Peak Periods	○	○	◕	◑	●
Goal 2	Improve Goods Movement	○	○	◑	●	◑
Goal 3	Improve Transit Service	○	◔	◕	◔	◕
Goals 4&5	Improve Safety and Operations	○	◔	◑	◕	◑
Goal 6 Cost-Effective	Cost/Benefit (based on travel time savings)		◕	◕	○	◕
	Feasibility (based on ROW and Environmental Impact)	●	●	◑	○	◕
	Estimated Cost Range (in millions)	$0	$10 - $25	$497 - $719	$2045 - $3548	$573 - $830

Source: I-15 Comprehensive Corridor Study, SCAG, December 2005

Figure 2.1 Example of Criteria Measured

***1. ROUTE LENGTH in KM**	
2. ENVIRONMENTAL AND SOCIO-ENCONOMIC	
a. Population served by route	Number of residents in Counties
b. Number jobs added	Number of jobs
c. Value added	Dollars
d. Wages added	Dollars
* e. Jurisdictional waters	Area affected
* f. Wetlands	Area affected
* g. Endangered species	Number by County along I-35
* h. Air quality	Mobile5a emission factors
* i. Forest lands	Area affected
* j. Agricultural lands	Area affected
* k. Park lands	Number of parks
* l. Cemeteries	Number
* m. Historic Districts	Number on National Register
* n. Significant land uses	Number adjacent to I-35
* o. Business impacts	Linear feet adjacent to I-35
* p. Neighborhood impacts	Linear feet adjacent to I-35
* q. Impacts on Indian Nations	Linear feet adjacent to I-35
3. TRAFFIC SERVICE	
a. Corridor travel on facility	Vehicle kilometers of daily travel
b. Study Area travel	Vehicle kilometers of daily travel
c. Average travel per route km	Vehicle kilometers of daily travel
* d. Corridor time spent in travel	Vehicle hours of daily travel
* e. Study Area time spent in travel	Vehicle hours of daily travel
f. Vehicle Operating Cost Savings	Dollars per day
g. Travel Time Savings	Dollars per day
h. Accident Cost Reduction	Dollars per day
4. DEVELOPMENT COST	
* a. Construction cost (including mitigation)	1996 Dollars
* b. Right of Way cost	1996 Dollars
* c. Mitigation cost	1996 Dollars
* d. Total Cost	1996 Dollars
* e. Change in 1st year maintenance cost	1996 Dollars
5. FEASIBILITY	
a. Travel Discounted B/C	Ratio
b. Travel Net Present Value	1996 Dollars
c. Travel Internal Rate of Return	Percentage
d. States Discounted B/C	Ratio
e. States Net Present Value	1996 Dollars
f. States Internal Rate of Return	Percentage
g. Area Discounted B/C	Ratio
h. Area Net Present Value	1996 Dollars
i. Area Internal Rate of Return	Percentage

* NOTE: These measures are best minimized; others are best maximized.

Source: I-35 Trade Corridor Study – Recommended Corridor Investment Strategies, Texas Department of Transportation/I-35 Steering Committee, September 1999

Table 2.6 Example of Initial Screening Evaluation Matrix for Alternatives

● ◕ ◑ ◔ ○

Most Effective ← → *Least Effective*

		A: Future General-Purpose Capacity						B: Future HOV Capacity		C: Future Truck Capacity		D: Safety	E: Environment		F: Cost
		A1			A2			B1	B2	C1	C2	D1	E1	E2	F1
		AM Peak Hour (southbound)			PM Peak Hour (northbound)			AM	PM	AM	PM				
	Alternative	SR-60 to I-215	I-215 to US-395	US-395 to D St.	SR-60 to I-215	I-215 to US-395	US-395 to D St.	I-215 to US-395	I-215 to US-395	I-215 to US-395	I-215 to US-395	Truck/Auto Traffic Separation	Biological, Cultural, Geology and Hydrology	Noise	Cost/Fundability
1	No-Build	○	○	○	○	◑	◑					○	●	●	●
2	TSM/TDM	○	○	○	○	◑	◑					○	●	●	●
3	HOV Lane (SR-60 to D St) with Express Bus	◔	◑	◔	◔	◕	◕	◕	◑			◔	◕	◑	◕
4	Cajon Pass Dedicated Truck Lanes (Glen Helen to US-395)	◑	◔	◑	◑	◑	◕			●	●	◕	◑	◑	◔
5	Full Corridor Dedicated Truck Lanes (SR-60 to D St)	◔	◔	◔	◔	◑	◕			●	●	●	○	○	○
6	Single General-Purpose Lane (SR-60 to D St)	◑	◑	◑	◑	◕	◕					◔	◕	◕	◕
7	Express Lanes (SR-60 to D St)	◑	◕	◕	◑	◕	●					◕	◔	◔	○
8	Reversible Managed Lanes (SR-210 to US-395)	◑	◕	◑	◑	◕	◕					◑	◕	◑	◔
9	Commuter Rail Service (San Bernardino to Victorville)	○	○	○	○	◑	◑					○	◕	◑	◑

Source: I-15 Comprehensive Corridor Study, SCAG, December 2005

2.2 Congestion and Mobility / Operational Efficiency

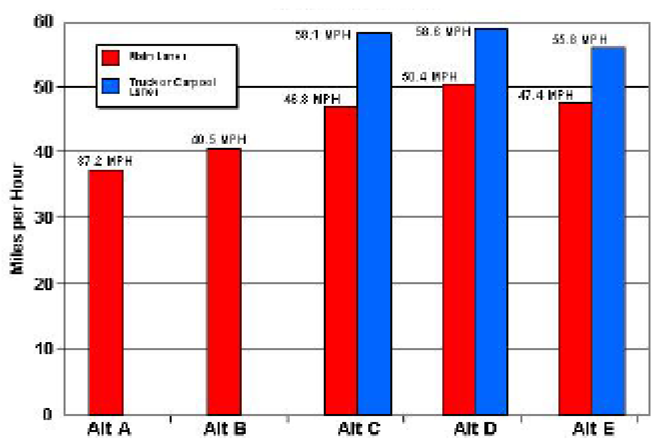
Table 2.7 Example of Projected Total Traffic Volume Growth Along I-81: 2004-2035

Location (from South to North)	Mileposts	2004 AADT Volume	2035 AADT Volume	2035 AADT Truck Percentage	Average Annual Growth Rate	Aggregate Growth
Route 140 to South Corporate Limit of Abingdon	16.4 and 17.0	42,100	74,400	30%	1.9%	77%
Route 11 to North Corporate Limit of Wytheville (I-77 overlap)	75.4	54,100	100,000	34%	2.0%	85%
Route 177 to Route 8 (near Radford)	110.8 and 113	42,900	77,800	35%	1.9%	81%
Route 581 to Route 115 (Roanoke)	145.3 and 146.1	58,800	114,100	26%	2.2%	94%
Route 11 to Route 11/614 (Buchanan)	164.5 and 167.8	35,600	63,000	45%	1.9%	80%
Route 606 to Augusta County Line (I-64 overlap)	207.5 and 207.3	42,900	77,700	42%	1.9%	81%
Route 11 to Route 659 (Harrisonburg)	245.3 and 245.4	49,400	91,000	33%	2.0%	84%
Route 50 to Route 7	315.8 and 316.0	58,500	109,000	26%	2.0%	86%
Average at Permanent Count Stations		**48,000**	**88,400**	**33%**	**2.0%**	**84%**

AADT – Average Annual Daily Traffic
1 2004 traffic volumes are based on 2003 AADT (see Table 2.3-1) grown by 3.3 percent to reflect annual growth and balanced in conjunction with 2004 ramp counts.

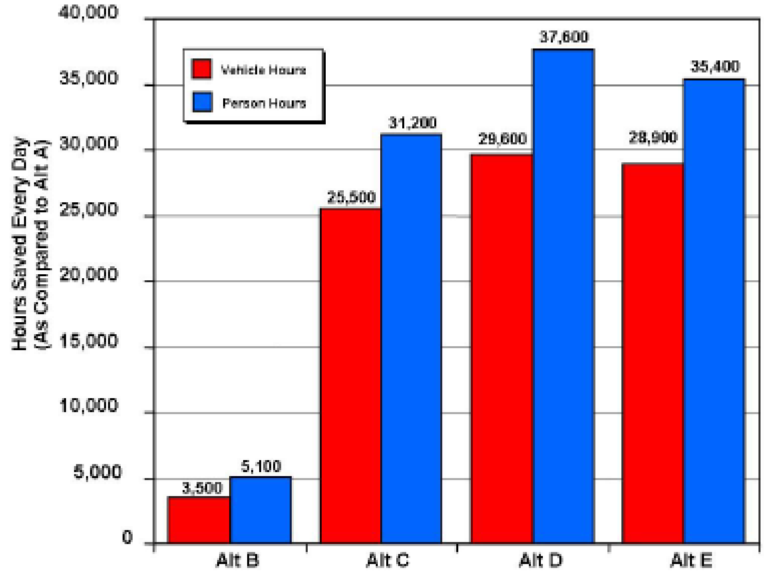
Source: I-81 Corridor Improvement Study, Tier 1 Draft Environmental Impact Statement, VDOT, 2005

Figure 2.2 Example of I-170 Average Travel Speeds – PM Peak Period



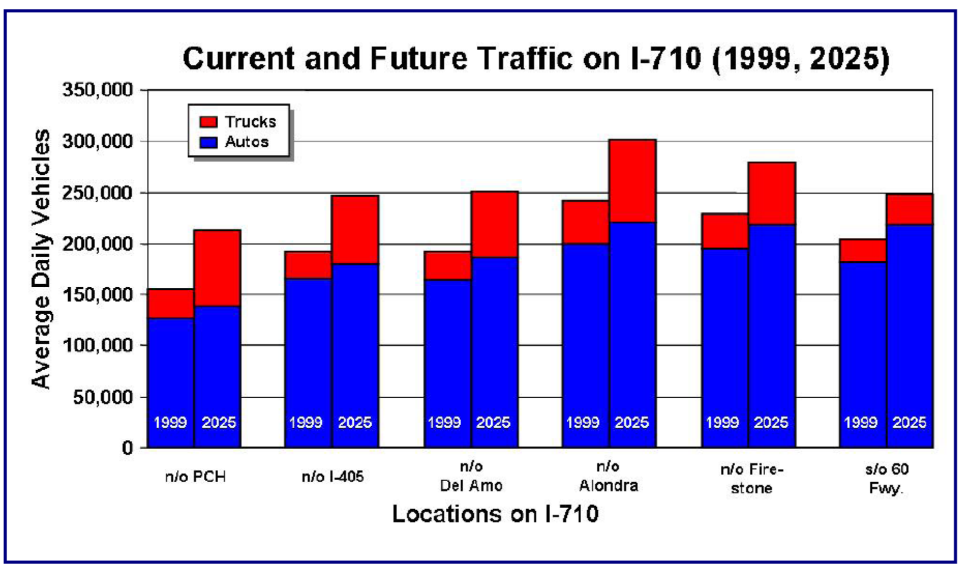
Source: I-710 Major Corridor Study Final Report, Los Angeles County MTA, March 2005

Figure 2.3 Example of Daily Reductions (Vehicle Hours, Person Hours Saved)



Source: I-710 Major Corridor Study Final Report, Los Angeles County MTA, March 2005

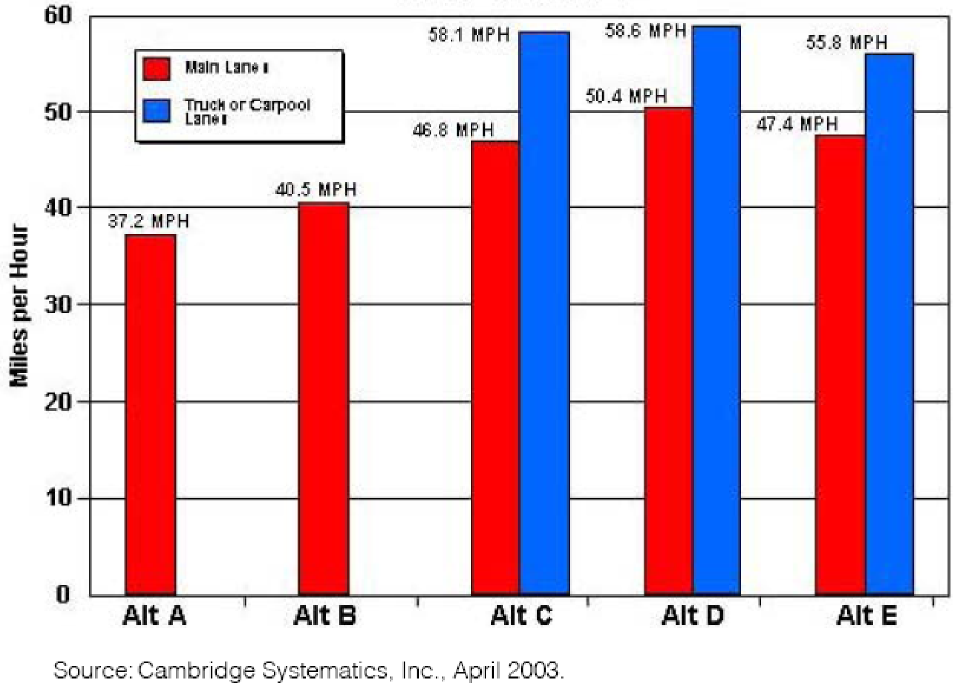
Figure 2.4 Example of Current and Future Traffic on I-710 (1995, 2025)



Source: Kaku & Associates, Inc., I-710 Major Corridor Study Existing & Future Conditions, September 2001.

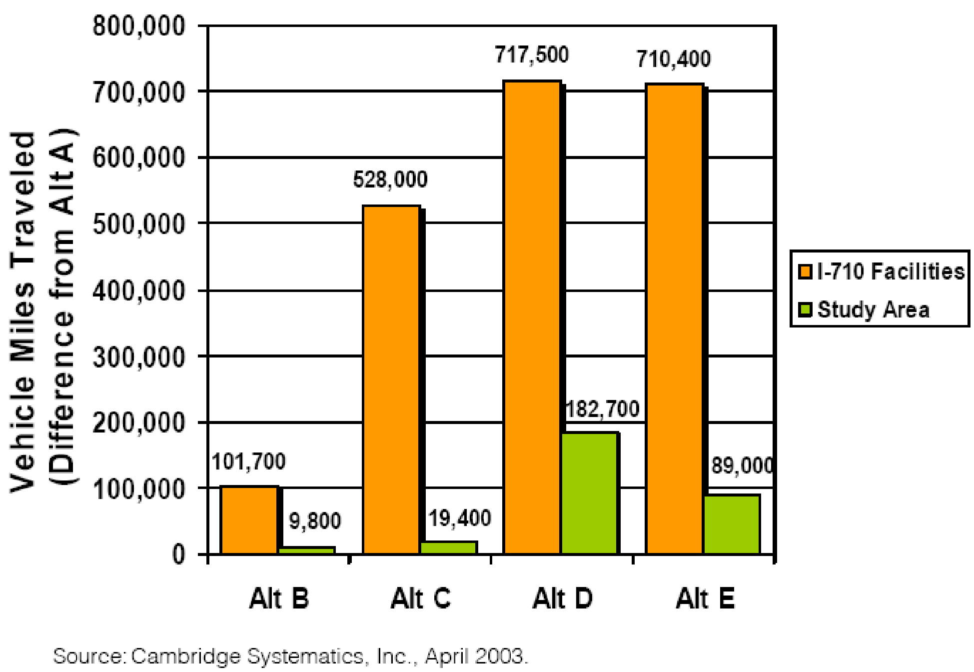
Source: I-710 Major Corridor Study Final Report, Los Angeles County MTA, March 2005

Figure 2.5 Example of Average Travel Speeds – NB, PM Peak, 2025



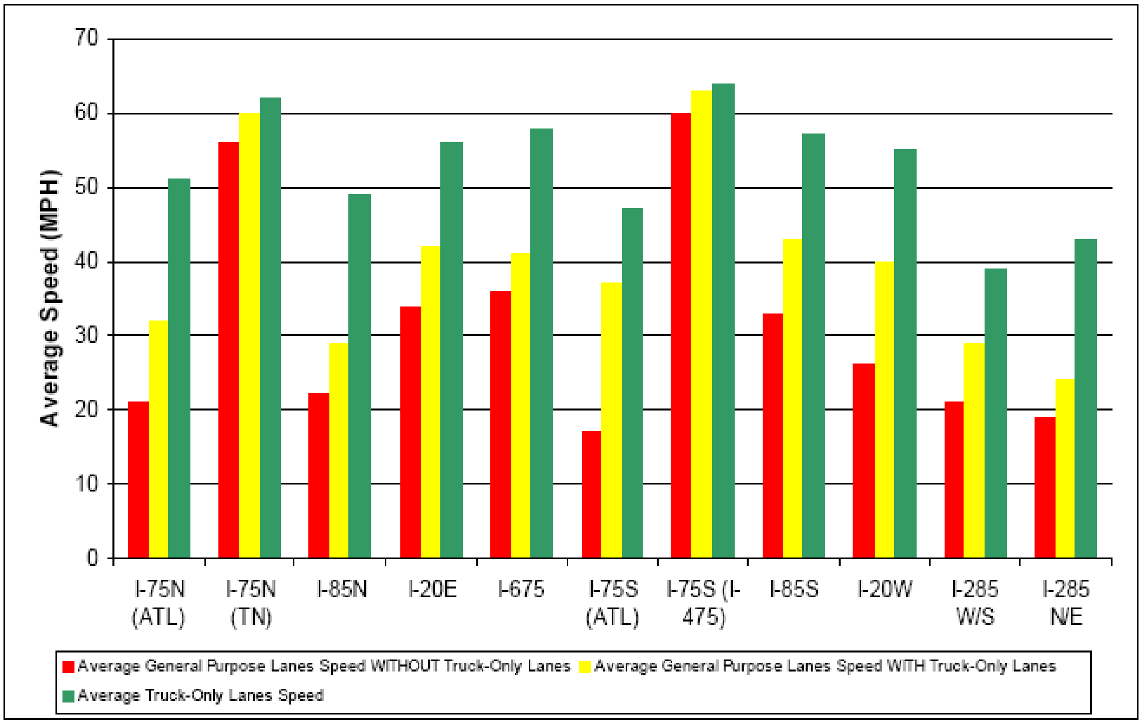
Source: I-710 Major Corridor Study Final Report, Los Angeles County MTA, March 2005

Figure 2.6 Example of Change in VMT



Source: I-710 Major Corridor Study Final Report, Los Angeles County MTA, March 2005

Figure 2.7 Example of Average 2035 PM Peak Period Travel Speed



Source: Truck Only Lanes Needs Analysis and Engineering Assessment, Georgia Department of Transportation, April 2008

Table 2.8 Example of Volume-to-Capacity Ratio and Corresponding Level of Service

Corridor (See Table 9 for Corridor Definitions)	Average PM Peak Period Speed			Average Daily Speed			Rating (2=Best) (0=Worst)
	WITHOUT TOL	WITH TOL		WITHOUT TOL	WITH TOL		
	GP	GP	TOL	GP	GP	TOL	
3A: I-75 South	1.05 (F)	0.84 (D)	0.69 (C)	0.68 (C)	0.52 (C)	0.45 (B)	2
3B: I-75 South	N/A	N/A	N/A	0.82 (D)	0.43 (B)	0.43 (B)	0
4A: I-75 North	1.03 (F)	0.83 (D)	0.58 (C)	0.67 (C)	0.50 (B)	0.40 (B)	2
4B: I-75 North	N/A	N/A	N/A	0.81 (D)	0.50 (B)	0.31 (B)	0
6B: I-85 South	0.87 (D)	0.69 (C)	0.39 (B)	0.56 (C)	0.41 (B)	0.25 (A)	1
7A: I-85 North	0.96 (E)	0.84 (D)	0.52 (C)	0.60 (C)	0.50 (B)	0.33 (B)	2
8: I-20 West	0.96 (E)	1.02 (F)	0.37 (B)	0.62 (C)	0.46 (B)	0.25 (A)	0
9: I-20 East	0.78 (D)	0.62 (C)	0.35 (B)	0.49 (B)	0.37 (B)	0.22 (A)	1
12A: I-285	1.04	0.98	0.61	0.63	0.57	0.36	1

Source: Truck Only Lanes Needs Analysis and Engineering Assessment, Georgia Department of Transportation, April 2008

Table 2.9 Example of Vehicle Miles Traveled (millions)

Corridor (See Table 9 for Corridor Definitions)	WITHOUT Truck Only Lanes				WITH Truck Only Lanes				Rating (2=Best) (0=Worst)
	Facility	4-mile Buffer	12-mile Buffer	Region	Facility	4-mile Buffer	12-mile Buffer	Region	
3A: I-75 South	5.42	20.99	59.03	231.59	6.69	21.67	59.08	231.61	0
3B: I-75 South	4.35	N/A	N/A	313.7	4.39	N/A	N/A	313.7	2
4A: I-75 North	7.02	25.06	70.65	231.59	8.59	25.85	70.80	231.49	0
4B: I-75 North	6.73	N/A	N/A	313.7	6.88	N/A	N/A	313.7	2
6B: I-85 South	4.28	13.26	45.49	231.59	4.86	13.66	45.66	232.23	1

Source: Truck Only Lanes Needs Analysis and Engineering Assessment, Georgia Department of Transportation, April 2008

Table 2.10 Example of Vehicle Hours Traveled (millions)

Corridor (See Table 9 for Corridor Definitions)	WITHOUT Truck Only Lanes				WITH Truck Only Lanes				Rating (2=Best) (0=Worst)
	Facility	4-mile Buffer	12-mile Buffer	Region	Facility	4-mile Buffer	12-mile Buffer	Region	
3A: I-75 South	0.26	0.98	2.64	10.25	0.15	0.83	2.46	10.06	2
3B: I-75 South	0.07	N/A	N/A	38.08	0.07	N/A	N/A	38.08	0
4A: I-75 North	0.26	1.10	3.28	10.25	0.20	0.98	3.10	10.04	2
4B: I-75 North	0.12	N/A	N/A	38.08	0.11	N/A	N/A	38.08	0
6B: I-85 South	0.11	0.49	1.85	10.25	0.10	0.46	1.83	10.28	0
7A: I-85 North	0.18	1.10	3.67	10.25	0.16	1.04	3.57	10.13	1
8: I-20 West	0.15	0.65	2.46	10.25	0.12	0360	2.84	10.17	0
9: I-20 East	0.08	0.56	2.58	10.25	0.07	0.55	2.55	10.20	1
12A: I-285 North/East	0.28	1.86	5.22	10.25	0.26	1.81	5.05	10.08	1
12B: I-285 West/South	0.14	1.07	3.91	10.25	0.15	1.05	3.80	10.14	1

Source: Truck Only Lanes Needs Analysis and Engineering Assessment, Georgia Department of Transportation, April 2008

Table 2.11 Example of Daily Hours of Delay (thousands)

Corridor (See Table 9 for Corridor Definitions)	WITHOUT Truck Only Lanes				WITH Truck Only Lanes				Rating (2=Best) (0=Worst)
	General Purpose Lanes		Truck Only Lanes	Total	General Purpose Lanes		Truck Only Lanes	Total	
	Auto	Trucks			Autos	Trucks			
3A: I-75 South	105.8	66.7	N/A	172.5	31.5	5.1	6.5	43.1	2
3B: I-75 South	2.7	2.2	N/A	4.9	0.8	0.3	0.1	1.2	0
4A: I-75 North	96.9	50.9	N/A	147.8	47.4	7.1	5.9	60.4	2
4B: I-75 North	8.9	4.1	N/A	13.0	3.8	0.7	0.1	4.6	0
6B: I-85 South	28.7	15.0	N/A	43.7	15.0	2.6	1.1	18.7	1
7A: I-85 North	63.7	30.0	N/A	93.7	42.9	8.6	3.0	54.5	1
8: I-20 West	46.0	29.8	N/A	75.8	19.8	3.7	1.9	25.4	2
9: I-20 East	19.7	9.2	N/A	28.9	11.2	1.8	0.6	13.6	0
12A: I-285 North/East	108.5	46.0	N/A	154.5	84.7	15.5	7.0	107.2	2
12B: I-285 West/South	36.9	37.3	N/A	74.2	35.2	10.1	9.3	54.6	1

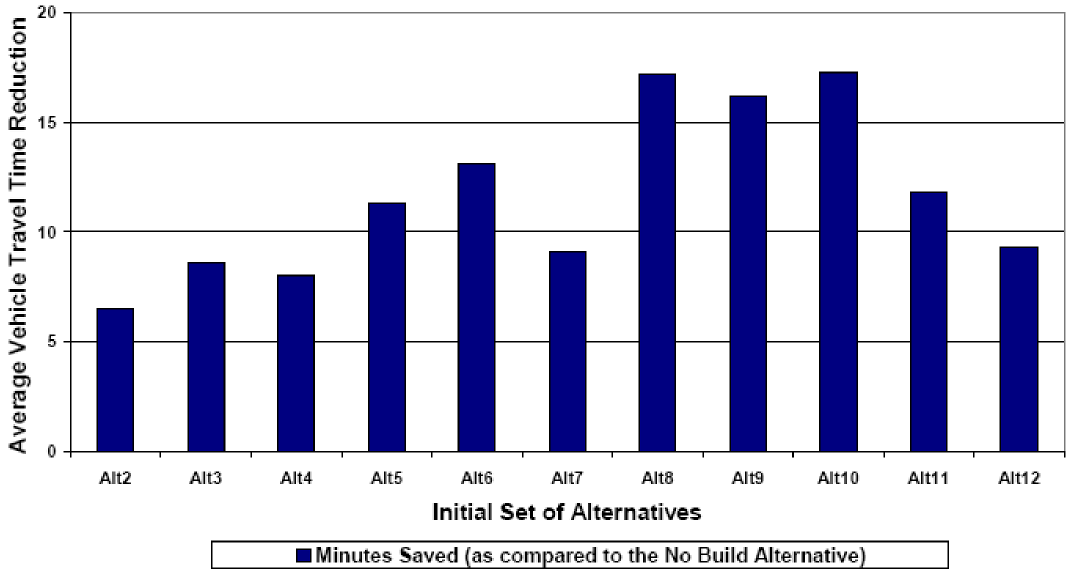
Source: Truck Only Lanes Needs Analysis and Engineering Assessment, Georgia Department of Transportation, April 2008

Table 2.12 Example of Summary Congestion Ranking

Corridor (See Table 9 for Corridor Definitions)	Speed Rating	Level of Service Rating	VMT Rating	VHT Rating	Delay Rating	OVERALL CONGESTION RANKING (2=Best) (0=Worst)
3A: I-75 South	2	2	0	2	2	2
3B: I-75 South	0	0	2	0	0	0
4A: I-75 North	2	2	0	2	2	2
4B: I-75 North	0	0	2	0	0	0
6B: I-85 South	1	1	1	0	1	1
7A: I-85 North	1	2	1	1	1	1
8: I-20 West	2	0	1	0	2	1
9: I-20 East	1	1	2	1	0	1
12A: I-285 North/East	1	1	0	1	2	1
12B: I-285 West/South	1	1	0	1	1	1

Source: Truck Only Lanes Needs Analysis and Engineering Assessment, Georgia Department of Transportation, April 2008

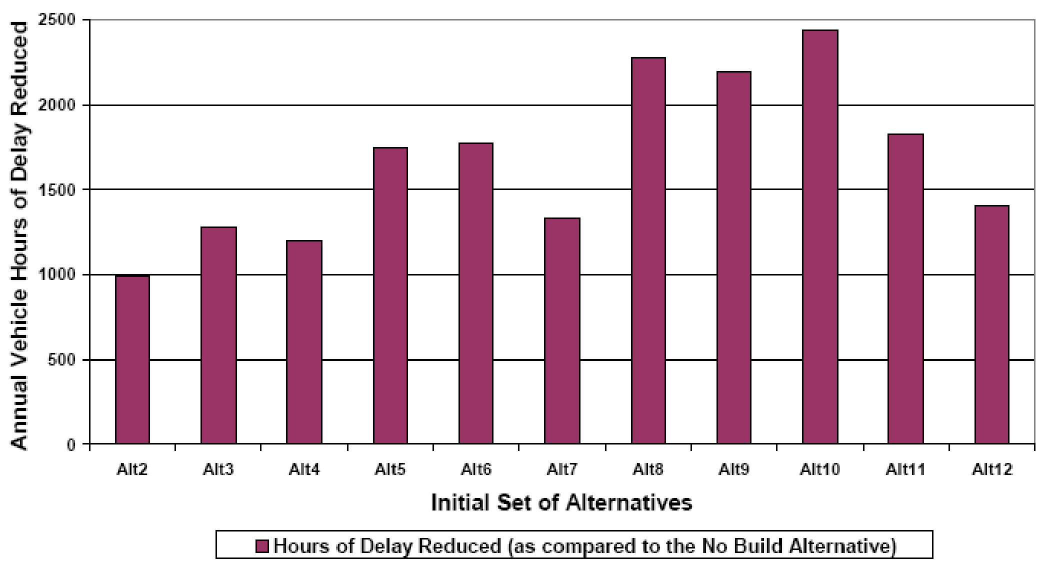
Figure 2.8 Example of Travel Time Savings (minutes)



Source: Kaku Associates, Inc. and Cambridge Systematics, Inc., Data Analysis Files, April 2002.

Source: I-710 Major Corridor Study Final Report, Los Angeles County MTA, March 2005

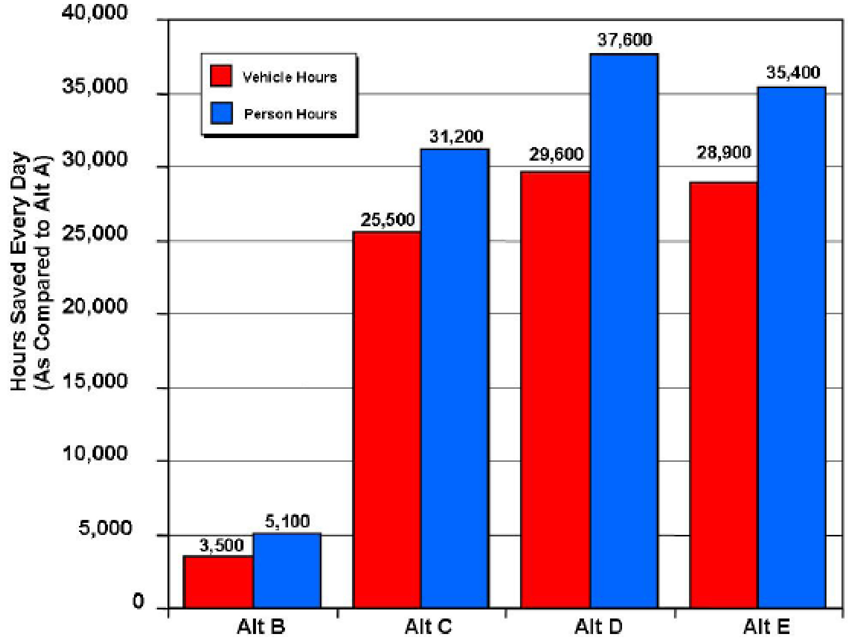
Figure 2.9 Example of Estimated Delay Reduction (thousands of hours)



Source: Kaku Associates, Inc. and Cambridge Systematics, Inc., Data Analysis Files, April 2002.

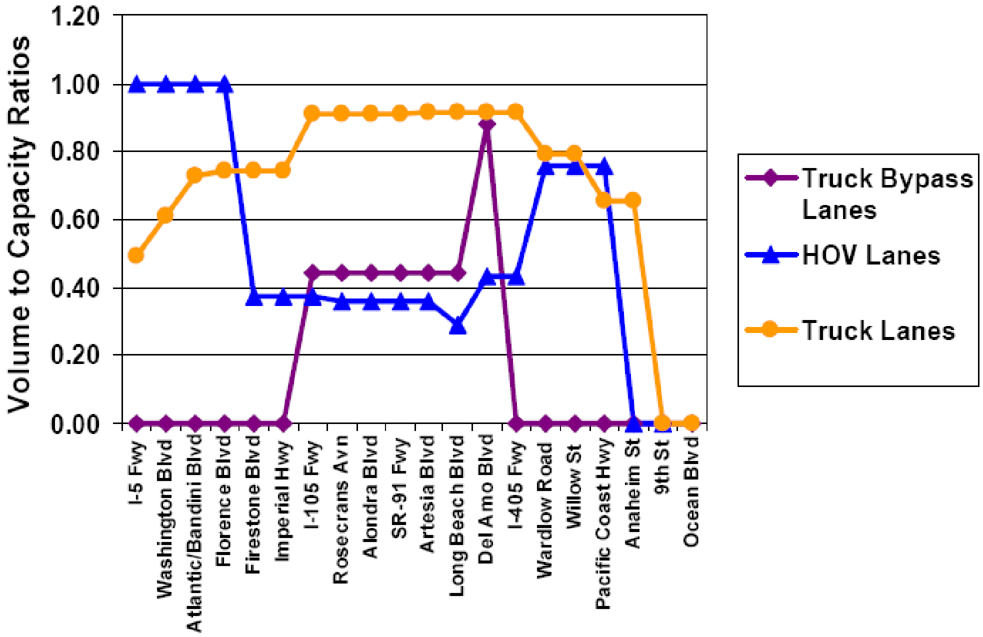
Source: I-710 Major Corridor Study Final Report, Los Angeles County MTA, March 2005

Figure 2.10 Example of Daily Reductions (Vehicle Hours, Person Hours Saved)



Source: I-710 Major Corridor Study Final Report, Los Angeles County MTA, March 2005

Figure 2.11 Example of projected V/C Ratios of I-710 Special Purpose Lanes – NB PM Peak, 2025



Source: Cambridge Systematics, Inc., April 2003.

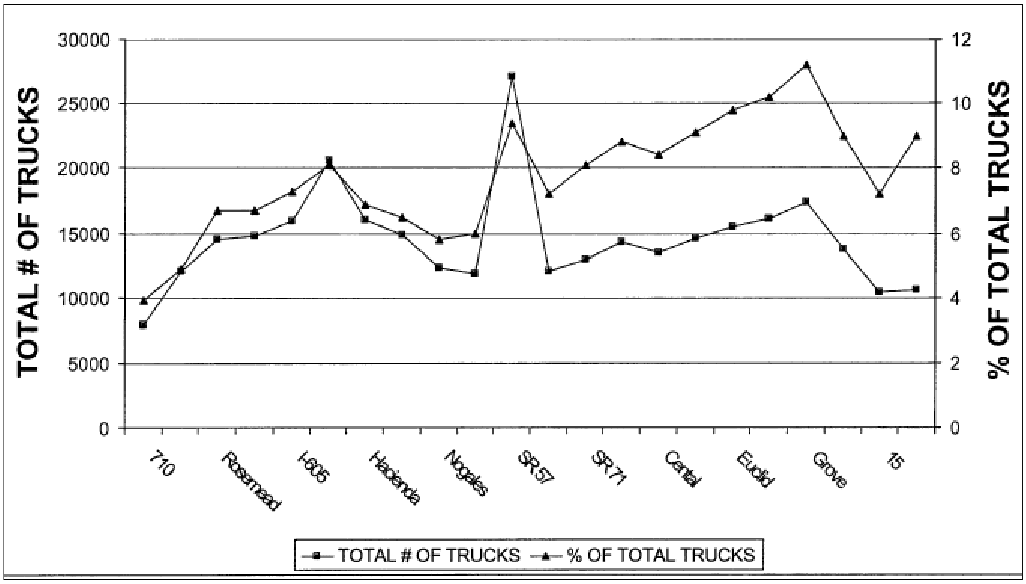
Source: I-710 Major Corridor Study Final Report, Los Angeles County MTA, March 2005

Table 2.13 Example of Average Corridor Levels of Service in 2035, Ranking

Segment	Facility	Start	End	2035 Average Level of Service *	Rating
1	I-75	GA/FL State Line	I-475 – South	C	0
2	I-75	I-475 - South	I-475 North	C	1
3	I-75	I-475 - North	I-285 – South	F	2
4	I-75	I-285 - North	GA/TN State Line	F	2
5	I-95	GA/FL State Line	GA/SC State Line	C	0
6	I-85	GA/AL State Line	I-285 – South	D	1
7	I-85	I-285 North	GA/SC State Line	E	2
8	I-20	GA/AL State Line	I-285 West	E	2
9	I-20	I-285 East	GA/SC State Line	D	1
10	I-59	GA/AL State Line	GA/TN State Line	E	2
11	I-575	I-75	End	D	1
12	I-285	I-75	I-75	F	2
13	I-985	I-85	End	E	2
14	I-185	End	I-85	D	1
15	I-16	I-75	I-95	B	0
16	I-516	I-16	End	C	0

Source: Truck Only Lanes Needs Analysis and Engineering Assessment, Georgia Department of Transportation, April 2008

Figure 2.12 Example of Profile of Truck Volumes on SR 60



Source: SR 60 Truck Lane Feasibility Study Final Report, Southern California Association of Governments, February 2001

Table 2.14 Example of Projected Truck Volume Growth Along I-81

I-81 Segment	Existing AADT Trucks	2035 AADT Trucks	Average Annual Growth Rate	Aggregate Growth
Route 140 to South Corporate Limit of Abingdon	9,180	22,310	2.8%	143%
Route 11 to North Corporate Limit of Wytheville (I-77 overlap)	13,450	33,970	2.9%	153%
Route 177 to Route 8 (near Radford)	11,240	27,120	2.8%	141%
Route 581 to Route 115 (Roanoke)	11,990	30,210	2.9%	152%
Route 11 to Route 11/614 (Buchanan)	11,970	28,130	2.7%	135%
Route 606 to Augusta County Line(I-64 overlap)	13,480	32,750	2.8%	143%
Route 11 to Route 659 (Harrisonburg)	12,870	30,330	2.7%	136%
Route 50 to Route 7	11,850	28,220	2.7%	138%

AADT – Average Annual Daily Traffic

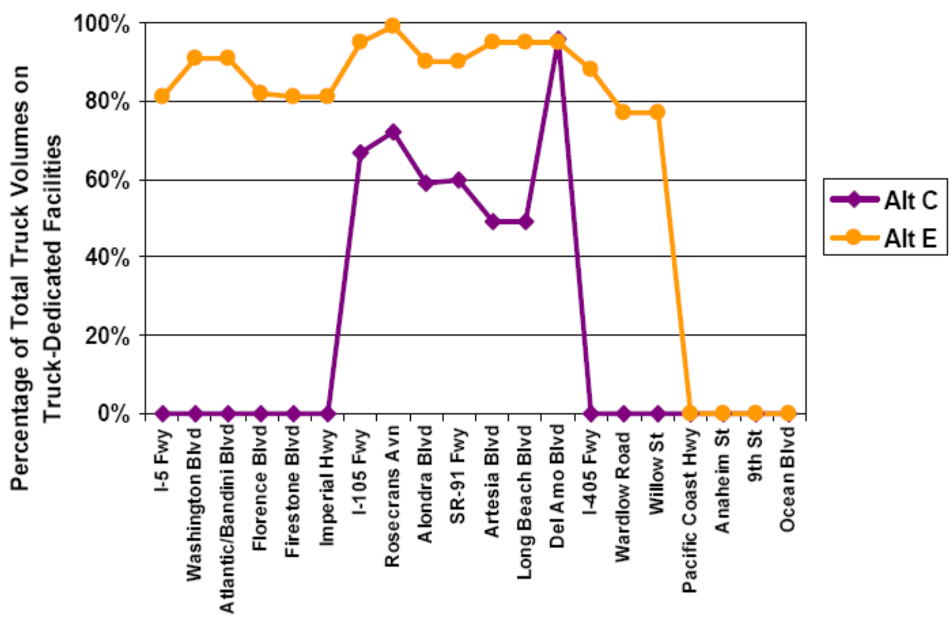
Source: I-81 Corridor Improvement Study, Tier 1 Draft Environmental Impact Statement, VDOT, 2005

Table 2.15 Example of Summary of I-81 Truck Volume and Growth Forecast

VDOT I-81 Count Station Identifiers I-81 Segment (South to North)	Existing Average Annual Daily Heavy Truck Volume	2035 Average Annual Daily Heavy Truck Volume	Average Annual Growth Rate
Route 140 to South City Line of Abingdon	9,180	22,310	2.8 %
Route 11 to North City Line of Wytheville	13,450	33,970	2.9 %
Route 177 to Route 8 (near Radford)	11,240	27,120	2.8 %
Route 581 to Route 115 (Roanoke)	11,990	30,210	2.9 %
Route 11 to Route 11-614 (Buchanan)	11,970	28,130	2.7 %
Route 606 to Augusta County Line	13,480	32,750	2.8 %
Route 11 to Route 659 (Harrisonburg)	12,870	30,330	2.7 %
Route 50 to South City Line of Winchester	11,850	28,220	2.7 %

Source: I-81 Corridor Improvement Study, Tier 1 Draft Environmental Impact Statement, VDOT, 2005

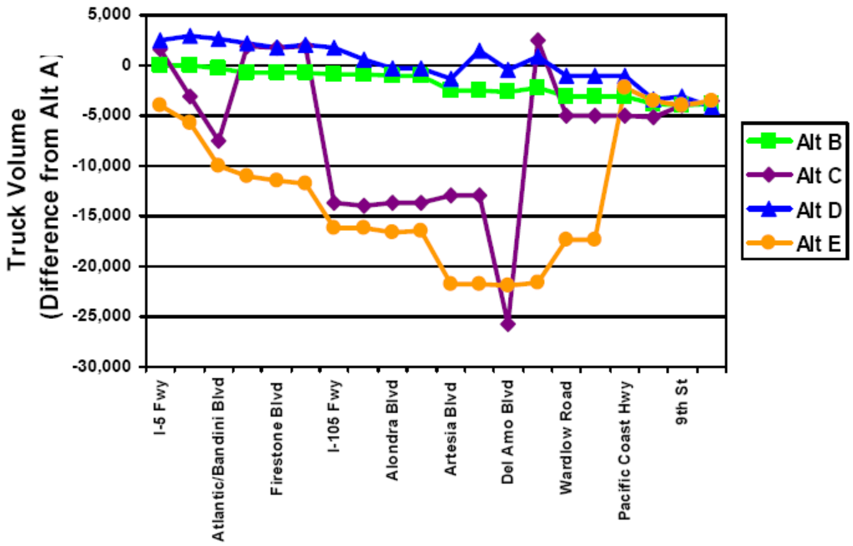
Figure 2.13 Example of Forecast Truck Utilization of Proposed I-710 Truck Lanes



Source: Cambridge Systematics, Inc., April 2003.

Source: I-710 Major Corridor Study Final Report, Los Angeles County MTA, March 2005

Figure 2.14 Example of Truck Diversion from the I-710 General Purpose Lanes – NB, PM Peak, 2005



Source: Cambridge Systematics, Inc., April 2003.

Source: I-710 Major Corridor Study Final Report, Los Angeles County MTA, March 2005

Table 2.16 Example of I-710 Average Heavy Duty Truck Volumes

Segments on I-710		Alt A Volumes	Alt B Volumes	B – A % Diff.	Alt C Volumes	C - A % Diff.	Alt D Volumes	D - A % Diff.	Alt E Volumes	E – A % Diff.
From	**To**									
SR-60	I-5	17,400	17,500	0.6%	20,300	16.7%	21,200	21.8%	25,200	44.8%
I-5	Washington	18,800	19,100	1.6%	24,200	28.7%	23,500	25.0%	29,800	58.5%
Washington	Atlantic/Bandini	28,600	28,300	-1.0%	33,300	16.4%	32,500	13.6%	39,900	39.5%
Atlantic/Bandini	Florence	38,400	37,200	-3.1%	42,600	10.9%	41,700	8.6%	48,700	26.8%
Florence	Firestone	39,700	38,400	-3.3%	43,400	9.3%	42,400	6.8%	48,900	23.2%
Firestone	Imperial	39,600	38,300	-3.3%	43,300	9.3%	42,500	7.3%	48,300	22.0%
Imperial	I-105	41,100	39,600	-3.6%	43,900	6.8%	43,500	5.8%	49,700	20.9%
I-105	Rosecrans	38,300	36,800	-3.9%	40,900	6.8%	39,200	2.3%	46,900	22.5%
Rosecrans	Alondra	57,700	55,500	-3.8%	60,200	4.3%	56,700	-1.7%	64,500	11.8%
Alondra	SR-91	57,000	54,900	-3.7%	59,600	4.6%	55,700	-2.3%	64,000	12.3%
SR-91	Artesia	56,800	53,100	-6.5%	60,900	7.2%	59,500	4.8%	61,100	7.6%
Artesia	Long Beach	57,800	54,100	-6.4%	62,100	7.4%	60,700	5.0%	62,600	8.3%
Long Beach	Del Amo	58,000	54,200	-6.6%	61,200	5.5%	59,200	2.1%	62,500	7.8%
Del Amo	I-405	60,300	56,800	-5.8%	66,000	9.5%	62,500	3.6%	65,800	9.1%
I-405	Wardlow	69,000	65,000	-5.8%	54,500	-21.0%	69,800	1.2%	68,500	-0.7%
Wardlow	Willow	71,900	67,700	-5.8%	57,600	-19.9%	73,100	1.7%	71,900	0.0%
Willow	Pacific Coast Hwy.	72,000	67,900	-5.7%	57,700	-19.9%	73,300	1.8%	72,000	0.0%
Pacific Coast Hwy.	Anaheim	68,200	63,400	-7.0%	54,400	-20.2%	65,200	-4.4%	66,300	-2.8%
Anaheim	9th	66,300	61,500	-7.2%	56,100	-15.4%	62,200	-6.2%	62,500	-5.7%
9th	Ocean	59,100	54,800	-7.3%	49,500	-16.2%	53,800	-9.0%	55,700	-5.8%

Source: Cambridge Systematics, Inc. and Kaku Associates, Inc., Electronic Data File, April 2003.

Notes: Average daily truck volumes are shown for each alternative for the Year 2025 for trucks using I-710 mainline travel lanes, including general purpose lanes, collector-distributor lanes, truck bypass lanes, and truckway lanes.

Percentage difference compares each alternative to the No Build Alternative (Alt. A).

Source: I-710 Major Corridor Study Final Report, Los Angeles County MTA, March 2005

Table 2.17 Example of Truck Traffic on I-35 as a Percent of Vehicle Travel

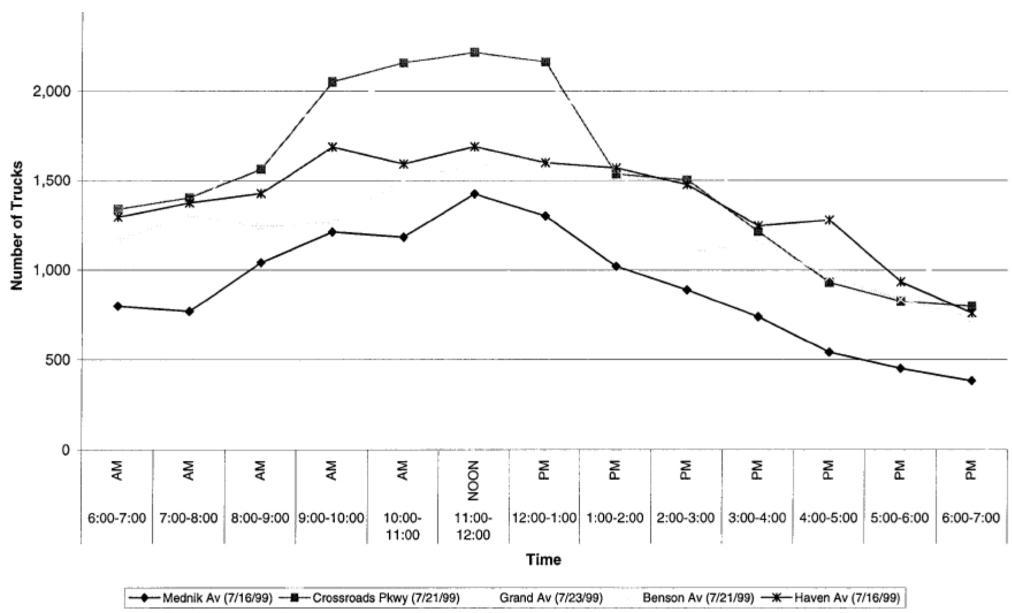
	Rural Areas			Urban Areas		
State	Single Units (1) (%)	Combination (2) (%)	Total(3)	Single Units (1) (%)	Combination (2) (%)	Total(3)
Iowa	3%	19%	22%	2%	12%	14%
Kansas	4%	18%	22%	4%	5%	9%
Minnesota	3%	18%	21%	3%	13%	16%
Missouri (4)	24%	0%	24%	9%	0%	9%
Oklahoma	2%	21%	23%	1%	7%	8%
Texas	5%	19%	23%	3%	9%	13%
Total	**5%**	**18%**	**23%**	**3%**	**8%**	**12%**

Source: FHWA HPMS Data for 1996

Notes:
(1) Single Unit trucks include buses, 2-axle, 3-axle and 4-axle single unit trucks.
(2) Combination trucks include single trailer and multi-trailer trucks.
(3) Total may not equal sum of Single Unit and Combination Truck percentages, due to rounding.
(4) All trucks shown in one category in HPMS data

Source: I-35 Trade Corridor Study – Recommended Corridor Investment Strategies, Texas Department of Transportation/I-35 Steering Committee, September 1999

Figure 2.15 Example of Annual Daily Truck Distribution



Source: SR 60 Truck Lane Feasibility Study Final Report, Southern California Association of Governments, February 2001

Table 2.18 Example of Year 2035 Average Corridor Truck Volumes, Ranking

Segment	Facility	Start	End	2035 Average Truck Volumes	Rating
1	I-75	GA/FL State Line	I-475 – South	46,074	2
2	I-75	I-475 - South	I-475 North	19,893	0
3	I-75	I-475 - North	I-285 – South	62,392	2
4	I-75	I-285 - North	GA/TN State Line	51,552	2
5	I-95	GA/FL State Line	GA/SC State Line	46,137	2
6	I-85	GA/AL State Line	I-285 – South	32,088	1
7	I-85	I-285 North	GA/SC State Line	45,242	2
8	I-20	GA/AL State Line	I-285 West	38,618	1
9	I-20	I-285 East	GA/SC State Line	32,931	1
10	I-59	GA/AL State Line	GA/TN State Line	49,028	2
11	I-575	I-75	End	7,006	0
12	I-285	I-75	I-75	17,490	2*
13	I-985	I-85	End	22,333	0
14	I-185	End	I-85	10,078	0
15	I-16	I-75	I-95	8,216	0
16	I-516	I-16	End	26,947	1

* The statewide model does not recognize the truck prohibition inside I-285 and underestimates demand.

Source: Truck Only Lanes Needs Analysis and Engineering Assessment, Georgia Department of Transportation, April 2008

Table 2.19 Example of Detailed Evaluation Summary Results, Traffic Congestion Relief

EVALUATION CRITERION	MEASURE	SEGMENT	EXISTING CONDITION	FUTURE ALTERNATIVE A No Build	B TSM/TDM	C HOV Lanes	D Truck Lanes	E Managed Lanes
CATEGORY 1: TRANSPORTATION SYSTEM PERFORMANCE ***SUB-CATEGORY 1C: TRAFFIC CONGESTION RELIEF***	**AM Peak Period Demand V/C Ratios** Southbound *(General Purpose Lanes)*	1	0.60	0.90	0.91	0.87	0.65	0.71
		2	0.59	0.70	0.70	0.64	0.45	0.55
		3	0.53	0.85	0.84	0.78	0.61	0.68
		4	0.79	1.26	1.25	1.13	1.01	0.94
		5	0.62	0.73	0.72	0.68	0.48	0.57
		6	0.80	0.89	0.88	0.84	0.70	0.73
		7	0.72	0.87	0.87	0.82	0.80	0.71
	AM Peak Period Demand V/C Ratios Southbound *(HOV, Truck, or Managed Lanes)*	1	na	na	na	0.14	0.41	not applicable
		2	na	na	na	0.20	0.41	not applicable
		3	na	na	na	0.24	0.49	0.34
		4	na	na	na	0.50	0.55	0.64
		5	na	na	na	0.24	0.59	0.37
		6	na	na	na	0.47	0.66	not applicable
		7	na	na	na	0.51	0.48	not applicable
	PM Peak Period Demand V/C Ratios Northbound *(General Purpose Lanes)*	1	0.39	0.79	0.79	0.69	0.62	0.60
		2	0.57	0.81	0.81	0.73	0.58	0.63
		3	0.41	0.92	0.91	0.80	0.75	0.69
		4	0.74	1.39	1.38	1.20	1.17	1.01
		5	0.61	0.78	0.78	0.68	0.56	0.55
		6	0.80	0.92	0.92	0.81	0.78	0.76
		7	0.86	1.12	1.12	1.09	1.09	0.91
	PM Peak Period Demand V/C Ratios Northbound *(HOV, Truck, or Managed Lanes)*	1	na	na	na	0.40	0.32	not applicable
		2	na	na	na	0.35	0.44	not applicable
		3	na	na	na	0.59	0.47	0.46
		4	na	na	na	0.78	0.53	0.81
		5	na	na	na	0.52	0.55	0.56
		6	na	na	na	0.66	0.50	not applicable
		7	na	na	na	0.66	0.44	not applicable

Segment 1 - Mojave River Crossing to Bear Valley Road
Segment 2 - Bear Valley Road to US-395
Segment 3 - US-395 to SR-138
Segment 4 - SR-138 to I-215
Segment 5 - I-215 to I-210
Segment 6 - I-210 to I-10
Segment 7 - I-10 to SR-60

Source: I-15 Comprehensive Corridor Study, SCAG, December 2005

Table 2.20 Example of Transportation Analysis Results – Operational Alternative Comparison

Separated Facilities																
	Operational Assumptions						Operational Results (Exclusive Car Lanes)		Operational Results (Exclusive Truck Lanes)		Operational Results (Non-Exclusive Truck Lanes)		Operational Results (General Purpose Lanes)			
	No Toll	Low Toll All	High Toll All	Low Toll Trucks	High Toll Trucks	With R3[5]	Deficient Miles[2]	Excess Miles[2]	Deficient Miles[2]	Excess Miles[2]	Deficient Miles[2]	Excess Miles[2]	Deficient Miles[2]	Excess Miles[2]	2005 Cost	2015 Cost
Separated Lane Concept 2[7]																
	✓						0	636	65	266	N/A	N/A	N/A	N/A	$12.5B	$18.3 B
		✓					0	645	53	279	N/A	N/A	N/A	N/A	$12.5B	$18.3 B
Add two exclusive truck lanes			✓				0	649	40	413	N/A	N/A	N/A	N/A	$12.5B	$18.3 B
In each direction plus two				✓			0	636	42	356	N/A	N/A	N/A	N/A	$12.5B	$18.3 B
exclusive car lanes in each					✓		0	636	36	393	N/A	N/A	N/A	N/A	$12.5B	$18.3 B
direction	✓					✓	0	636	42	359	N/A	N/A	N/A	N/A	$13.0B	$19.0 B
		✓				✓	0	645	21	386	N/A	N/A	N/A	N/A	$13.0B	$19.0 B
Results in 12- to 14-lane			✓			✓	0	649	0	459	N/A	N/A	N/A	N/A	$13.0B	$19.0 B
cross-section				✓		✓	0	636	10	433	N/A	N/A	N/A	N/A	$13.0B	$19.0 B
					✓	✓	0	636	0	451	N/A	N/A	N/A	N/A	$13.0B	$19.0 B
Separated Lane Concept 3[8]																
	✓						N/A	N/A	N/A	N/A	10	422	495	10	$9.3B	$13.6 B
Add two non-exclusive truck		✓					N/A	N/A	N/A	N/A	0	425	335	19	$9.3B	$13.6 B
lanes in each direction.			✓				N/A	N/A	N/A	N/A	0	494	266	69	$9.3B	$13.6 B
				✓			N/A	N/A	N/A	N/A	0	453	452	12	$9.3B	$13.6 B
Results in 8- to 10-lane					✓		N/A	N/A	N/A	N/A	0	478	440	12	$9.3B	$13.6 B
cross-section	✓					✓	N/A	N/A	N/A	N/A	0	460	452	12	$9.8B	$14.4 B
		✓				✓	N/A	N/A	N/A	N/A	0	468	335	22	$9.8B	$14.4 B
			✓			✓	N/A	N/A	N/A	N/A	0	494	240	74	$9.8B	$14.4 B
				✓		✓	N/A	N/A	N/A	N/A	0	529	424	12	$9.8B	$14.4 B
					✓	✓	N/A	N/A	N/A	N/A	0	556	413	13	$9.8B	$14.4 B

Table Notes:

Note: Operational Results represent325 miles in each direction or 650 total miles.

1 TSM = Transportation System Management projects. TSM includes safety, climbing lanes, ITS, Park & Ride lot projects TSM Enhancements included in all concepts carried forward.

2 Rail 1 includes minor level improvements to the Norfolk Southern Piedmont Line from Manassas to Front Royal, VA and north to the state line.

3 Rail 2 includes full level of improvements to the Norfolk Southern Piedmont Line within the Commonwealth of Virginia, including Rail 1.

4 New Rail Freight hauling technology with Intermodal centers at major intersections.

5 Rail 3 includes expansion of Rail 2 to include minor improvements to the Norfolk Southern Shenandoah line within Commonwealth of Virginia, and as the rail alternative tested against the highway operational assumptions because Rail 3 provides the best cost-benefit reduction along I-81.

6 Based on AASHTO Standards for Levels of Service: Rural-LOS B & Urban-LOS C

7 Exclusive truckway provides separate access/egress at all interchanges from a separated lane or separated lanes. Only trucks can travel in the separated lanes. Cars must travel in exclusive car lanes and use existing interchange configuration.

8 Non-Exclusive truckway allows trucks in separated lanes to cross into general purpose lanes to access existing interchanges. Only trucks can travel in the separated lanes. Cars can only travel in general purpose lanes. However, trucks can also use the general purpose lanes to access/egress existing interchanges. Up to 70 percent of trucks are expected to use the general purpose lanes. It is assumed that trucks do not travel in these lanes for long distances.

9 Exclusive car lanes provide separate access/egress at all interchanges from separated lanes. Only cars can travel in the separated lanes. Trucks must travel in exclusive truck lanes and use existing interchange configuration.

10 Exclusive car lanes provide separate access/egress at all interchanges from separated lanes. Only cars can travel in the separated lanes. Trucks must travel in the general purpose lanes. However, cars can choose to travel in either the exclusive or general purpose lanes for their entire trip. Twenty percent of cars are expected to use the general purpose lanes

Source: I-81 Corridor Improvement Study, Tier 1 Draft Environmental Impact Statement, VDOT, 2005

Table 2.21 Example of Mainline Freeway Operation Analysis, No-Build Scenario

Freeway Segment		Direction	Average Speed (mph)	Average Daily Traffic (vph)	Service Flow Rate (pcph)	Required No. of Lanes at LOS F(0)	Existing No. of Lanes
I.	I-710 to Vail	Eastbound	57.2	132,000	27,690	10	4~5
		Westbound	59.9	138,000	28,950	10	4~5
II.	Vail to Santa Anita	Eastbound	60.7	133,000	19,510	7	4~5
		Westbound	58.8	135,000	20,130	7	4~5
III.	Santa Anita to 7th	Eastbound	58.5	154,000	22,590	8	5
		Westbound	58.0	155,000	22,735	8	5
IV.	7th to Fullerton	Eastbound	59.6	135,000	20,130	7	4~5
		Westbound	58.0	134,000	29,930	10	4~5
V.	Fullerton to Grand	Eastbound	59.2	171,000	24,660	9	4~5
		Westbound	55.9	178,000	25,670	9	4~5
VI.	Grand to Reservoir	Eastbound	54.8	169,000	24,375	9	4
		Westbound	52.6	175,000	25,240	9	4
VII.	Reservoir to Euclid	Eastbound	54.1	137,000	26,125	9	4
		Westbound	54.1	141,000	26,125	9	4
VIII.	Euclid to I-15	Eastbound	57.5	140,000	27,255	9	4
		Westbound	56.6	154,000	29,540	10	4

Source: SR 60 Truck Lane Feasibility Study Final Report, Southern California Association of Governments, February 2001

Table 2.22 Example of Mainline Freeway Operation Analysis, Exclusive Truck Lanes Scenario

Freeway Segment		Direction	Average Speed (mph)	Average Daily Traffic (vph)	Service Flow Rate (pcph)	Required No. of Lanes at LOS F(0)	Existing No. of Lanes
I.	I-710 to Vail	Eastbound	57.4	125,000	25,335	9	4~5
		Westbound	59.7	130,000	26,810	9	4~5
II.	Vail to Santa Anita	Eastbound	59.2	125,300	17,765	6	4~5
		Westbound	58.6	126,500	17,935	6	4~5
III.	Santa Anita to 7th	Eastbound	59.2	144,400	20,120	7	5
		Westbound	59.4	144,000	20,065	7	5
IV.	7th to Fullerton	Eastbound	60.0	125,400	17,780	6	4~5
		Westbound	61.2	123,000	17,440	6	4~5
V.	Fullerton to Grand	Eastbound	61.5	161,300	21,685	8	4~5
		Westbound	58.1	166,700	22,820	8	4~5
VI.	Grand to Reservoir	Eastbound	56.3	157,400	21,545	7	4
		Westbound	54.3	163,300	22,355	8	4
VII.	Reservoir to Euclid	Eastbound	55.5	127,100	16,390	6	4
		Westbound	62.7	130,700	16,775	6	4
VIII.	Euclid to I-15	Eastbound	59.9	128,800	24,500	8	4
		Westbound	60.3	140,800	26,535	9	4

Source: SR 60 Truck Lane Feasibility Study Final Report, Southern California Association of Governments, February 2001

Table 2.23 Example of Truck Lane Operation Analysis, Exclusive Truck Lanes Scenario

Freeway Segment	Direction	Average Speed (mph)	No. of Lanes	Level of Service
I-710 to Atlantic	Eastbound	64.7	2	D
	Westbound	64.9	2	C
Atlantic to Paramount	Eastbound	65.5	2	C
	Westbound	65.0	2	C
Paramount to Rosemead	Eastbound	65.5	2	C
	Westbound	64.8	2	D
Rosemead to I-605	Eastbound	63.9	2	D
	Westbound	63.2	2	D
I-605 to Hacienda	Eastbound	64.2	2	D
	Westbound	61.8	2	E
Hacienda to Fullerton	Eastbound	64.5	2	D
	Westbound	62.1	2	E
Fullerton to Fairway	Eastbound	64.0	2	D
	Westbound	60.9	2	E
Fairway to SR-57(S)	Eastbound	64.7	2	D
	Westbound	63.7	2	D
SR-57(S) to SR-57(N)	Eastbound	59.8	2	E
	Westbound	65.0	2	C
SR-57(N) to Reservoir	Eastbound	64.5	2	D
	Westbound	63.8	2	D
Reservoir to Grove	Eastbound	65.5	2	B
	Westbound	65.5	2	C
Grove to Archibald	Eastbound	64.9	2	C
	Westbound	64.2	2	D
Archibald to Milliken	Eastbound	64.9	2	C
	Westbound	64.2	2	D
Milliken to I-15	Eastbound	65.5	2	C
	Westbound	65.0	2	C

Source: SR 60 Truck Lane Feasibility Study Final Report, Southern California Association of Governments, February 2001

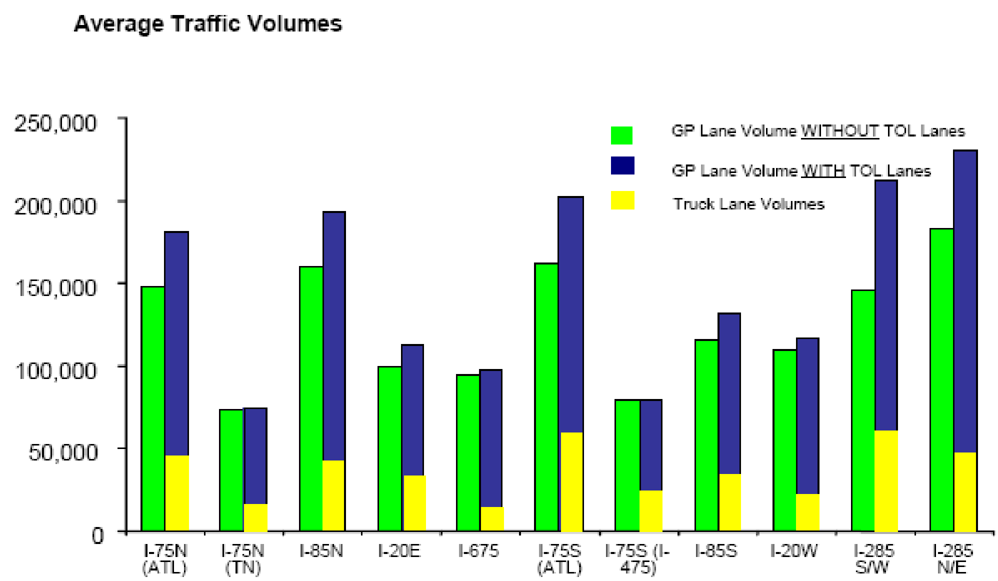
Table 2.24 Example of Exploratory Summary Evaluation Results

Segment	Facility	Start	End	Truck Volume Rating	Traffic Congestion Rating	Market Accessibility Rating	Freight Bottleneck Rating	Truck-Only Lane Demand (1)	Overall Rating
1	I-75	GA/FL State Line	I-475 – South	2	0	1	0	0	0
2	I-75	I-475 - South	I-475 North	0	1	1	0	0	0
3	I-75	I-475 - North	I-285 – South	2	2	2	0	2	2- √
4	I-75	I-285 - North	GA/TN State Line	2	2	2	2	2	2- √
5	I-95	GA/FL State Line	GA/SC State Line	2	0	1	2	0	1
6	I-85	GA/AL State Line	I-285 – South	1	1	2	0	2	1- √ **ATL**
7	I-85	I-285 North	GA/SC State Line	2	2	2	2	1	2- √ **ATL**
8	I-20	GA/AL State Line	I-285 West	1	2	2	2	2	2- √ **ATL**
9	I-20	I-285 East	GA/SC State Line	1	1	1	0	1	1- √ **ATL**
10	I-59	GA/AL State Line	GA/TN State Line	2	2	1	0	1	1
11	I-575	I-75	End	0	1	0	0	0	0
12	I-285	I-75	I-75	2	2	2	2	2	2- √
13	I-985	I-85	End	0	2	0	0	0	0
14	I-185	End	I-85	0	1	0	0	0	0
15	I-16	I-75	I-95	0	0	0	0	0	0
16	I-516	I-16	End	1	0	0	0	0	0
17	SR 400	I-285	End	0	0	0	0	0	0
18	US 78	I-285	West Park Place	0	2	0	0	0	0
19	SR 166	I-285	I-75/85	0	0	0	0	0	0

(1) Truck-only lane demand taken from Technical Memorandum 2: Forecasting and Analysis, Figure 24.

Source: Truck Only Lanes Needs Analysis and Engineering Assessment, Georgia Department of Transportation, April 2008

Figure 2.16 Example of 2035 Corridor Demand With and Without Truck Only Lanes



Source: Truck Only Lanes Needs Analysis and Engineering Assessment, Georgia Department of Transportation, April 2008

Table 2.25 Example of Overall Corridor Demand Year 2035

Corridor (See Table 9 for Corridor Definitions)	Corridor Demand WITHOUT Truck-Only Lanes			Corridor Demand WITH Truck-Only Lanes				Rating (2=Best) (0=Worst)
	Cars	Trucks	Total	Cars	Trucks (in GP)	Truck-Only Lanes	Totals	
3A: I-75 South	96,430	65,168	161,598	122,493	25,843	53,354	201,690	2
3B: I-75 South	41,183	38,324	79,507	41,649	18,012	20,620	80,281	0
4A: I-75 North	91,555	56,621	148,176	112,116	21,578	47,578	181,272	2
4B: I-75 North	45,444	27,895	73,338	45,866	14,026	14,964	74,872	0
6B: I-85 South	71,888	44,422	116,310	82,375	19,106	30,765	132,247	1
7A: I-85 North	101,353	58,334	159,687	122,798	29,519	41,047	193,365	2

Source: Truck Only Lanes Needs Analysis and Engineering Assessment, Georgia Department of Transportation, April 2008

Table 2.26 Example of Access and Connectivity Performance Measures

Corridor (See Table 9 for Corridor Definitions)	Serves Truck Generators	Opportunities to Avoid Major Freight Bottlenecks	Connect Freight Origins and Destinations	Average Travel Times (h/min)			Rating (2=Best) (0=Worst)
				General Purpose Lanes – WITHOUT TOL	General Purpose Lanes – WITH TOL	Truck-Only Lanes	
3A: I-75 South	Yes	Yes	Yes	1h 57m	54m	42m	2
3B: I-75 South	Yes	N/A	Yes	27m	26m	26m	0
4A: I-75 North	Yes	Yes	No	2h 18m	1h 29m	56m	1
4B: I-75 North	Yes	N/A	Yes	50m	46m	45m	0
6B: I-85 South	Yes	N/A	No	1h 06m	51m	39m	0

Source: Truck Only Lanes Needs Analysis and Engineering Assessment, Georgia Department of Transportation, April 2008

Table 2.27 Example of Major Truck Activity Centers and Routes Summary

Segment	Facility	Start	End	Serves Major Truck Activity?	Gateway Corridor?	Rating
1	I-75	GA/FL State Line	I-475 – South	No	Yes	1
2	I-75	I-475 - South	I-475 North	No	Yes	1
3	I-75	I-475 - North	I-285 – South	Yes	Yes	2
4	I-75	I-285 - North	GA/TN State Line	Yes	Yes	2
5	I-95	GA/FL State Line	GA/SC State Line	Yes	Yes	2
6	I-85	GA/AL State Line	I-285 – South	Yes	Yes	2
7	I-85	I-285 North	GA/SC State Line	Yes	Yes	2
8	I-20	GA/AL State Line	I-285 West	Yes	Yes	2
9	I-20	I-285 East	GA/SC State Line	No	Yes	1
10	I-59	GA/AL State Line	GA/TN State Line	No	Yes	1
11	I-575	I-75	End	No	No	0
12	I-285	I-75	I-75	Yes	Yes	2
13	I-985	I-85	End	No	No	0
14	I-185	End	I-85	No	No	0
15	I-16	I-75	I-95	No	No	0
16	I-516	I-16	End	No	No	0
17	SR 400	I-285	End	No	No	0
18	US 78	I-285	West Park Place	No	No	0
19	SR 166 (Langford Parkway)	I-285	I-75/85	No	No	0

Source: Truck Only Lanes Needs Analysis and Engineering Assessment, Georgia Department of Transportation, April 2008

2.3 Safety

Table 2.28 Example of Number and Type of Truck Accidents on SR 60

Year of Accident	Property Damage Only	Injury Accident	Fatal Accident	Total Accidents
1996	313	84	2	399
1997	303	87	4	394
1998	377	87	1	465
Total	993	258	7	1,258

Source: SR 60 Truck Lane Feasibility Study Final Report, Southern California Association of Governments, February 2001

Table 2.29 Example of Annual Truck Accident Rates per 100 Million VMT on SR 60

Year of Accident	SR 60 (Los Angeles County)	Urban Freeways in California[2]
1996	25	N/A
1997	25	N/A
1998	29	N/A
Average Rate	27	273

Notes:
1) Annual and average truck rates for SR 60 were based on CHP SWITRS database and Caltrans Truck Volumes for 1996, 1997, and 1998.
2) Average truck rates for urban freeways in California were based on California Urban Freeway Gridlock Study from 1988.

Sources:
- California Highway Patrol SWITRS database and Caltrans.
- Perkins, David B. *Urban Freeway Gridlock Study: Technical Memorandum 1-4.* Prepared for California Department of Transportation. Cambridge Systematics, Inc., Cambridge, Massachusetts, November 1988, Table 2.

Source: SR 60 Truck Lane Feasibility Study Final Report, Southern California Association of Governments, February 2001

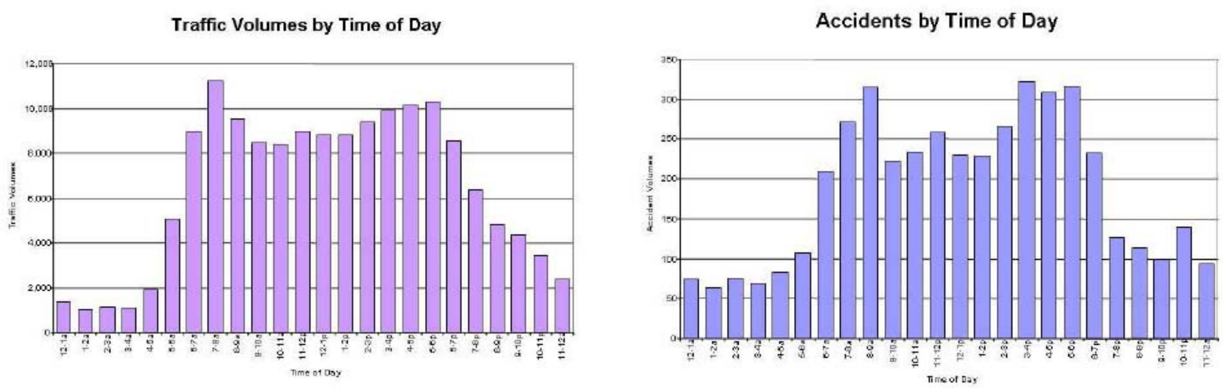
Table 2.30 Example of Annual SR 60 Truck Accidents by Vehicle Type for 1997 and 1998

Vehicle Type	Number of Accidents	Percentage of Truck Accidents
Truck/Truck Trailer	88	27.6%
Truck/Tractor & 1 Trailer	213	66.8%
Truck/Tractor & 2 Trailers	15	4.7%
Truck/Tractor & 3 Trailers	0	0.0%
Single Unit Tanker	0	0.0%
Truck/Tractor & 1 Tank Trailer	3	0.9%
Truck/Tractor & 2 Tank Trailers	0	0.0%
Total	319	100.0%

Source: Caltrans

Source: SR 60 Truck Lane Feasibility Study Final Report, Southern California Association of Governments, February 2001

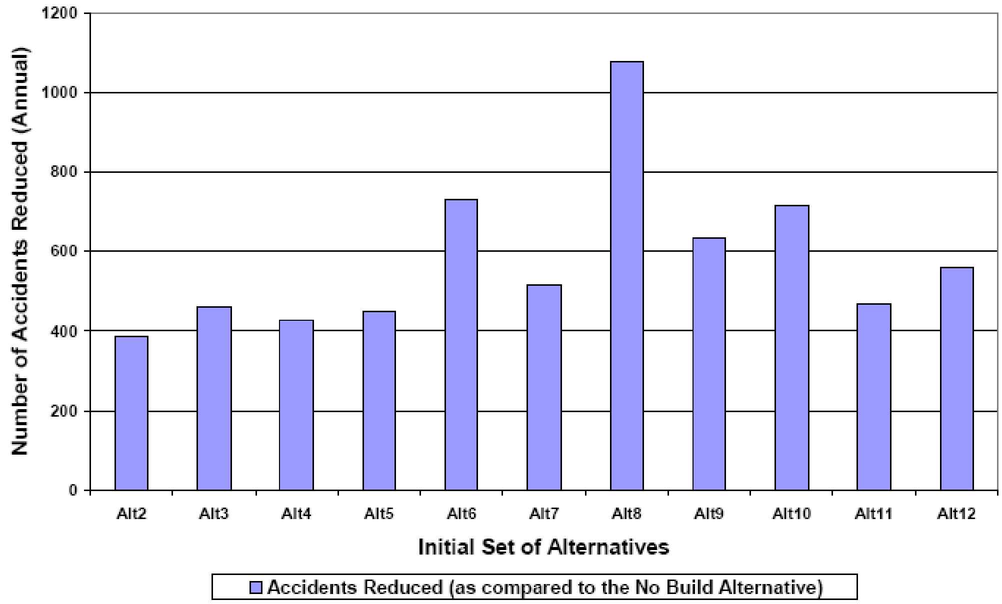
Figure 2.17 Example of Correlation between Traffic Volumes and Accidents



Source: Caltrans Traffic Operations, Traffic Counts, October 1999, and Traffic Accident Surveillance and Analysis System (TASAS) Data Files, July 2000.

Source: I-710 Major Corridor Study Final Report, Los Angeles County MTA, March 2005

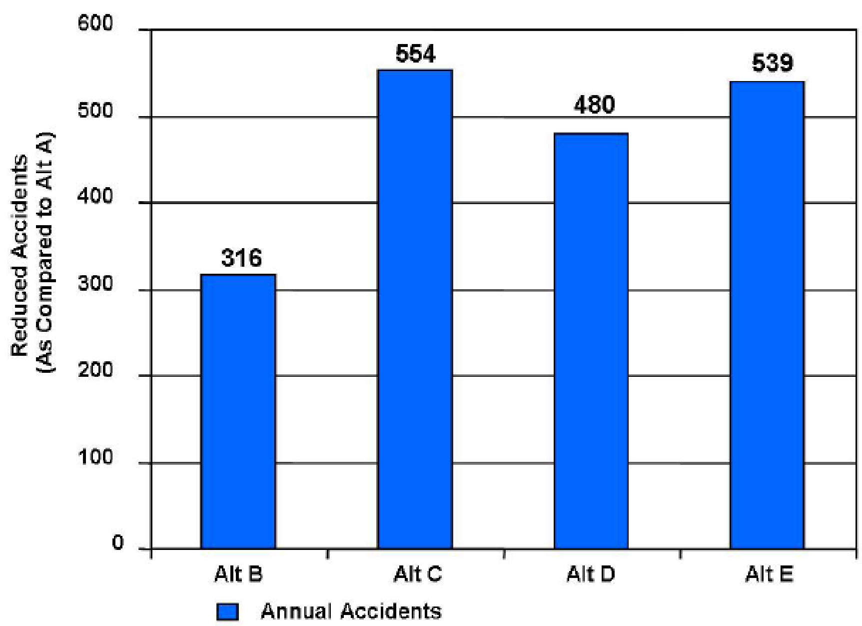
Figure 2.18 Example of Estimated Accident Reduction



Source: Cambridge Systematics, Inc., Data Analysis Files, April 2002.

Source: I-710 Major Corridor Study Final Report, Los Angeles County MTA, March 2005

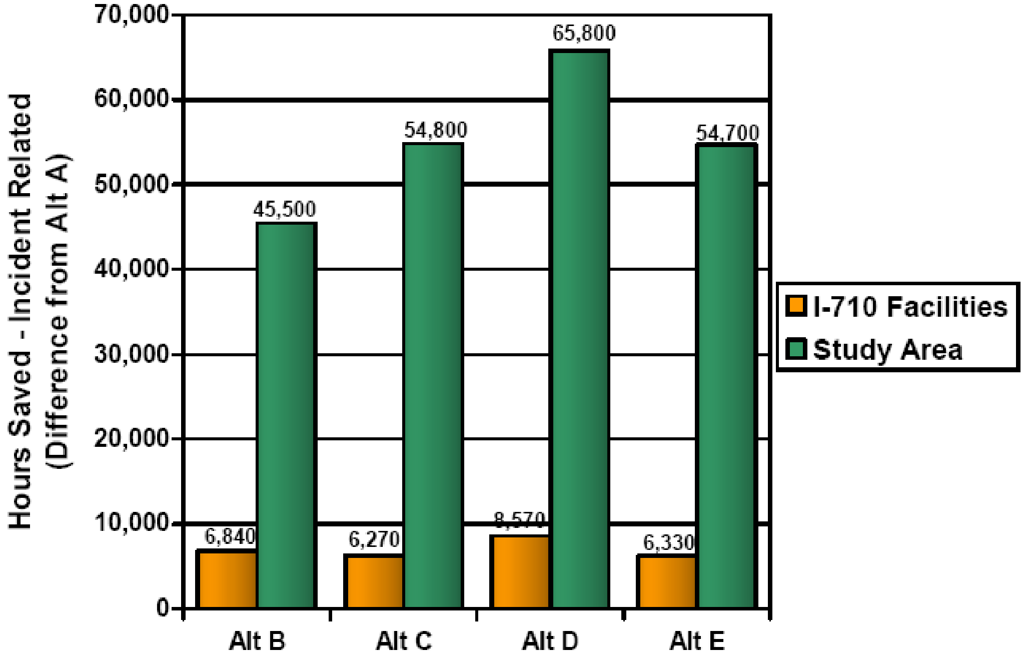
Figure 2.19 Example of Annual Accident Reductions



Source: Cambridge Systematics, Inc., April 2003.

Source: I-710 Major Corridor Study Final Report, Los Angeles County MTA, March 2005

Figure 2.20 Example of Time Savings due to Reduction in Accidents, Travel time Reliability



Source: Cambridge Systematics, Inc., April 2003.

Source: I-710 Major Corridor Study Final Report, Los Angeles County MTA, March 2005

Table 2.31 Example of Safety Assessment

Corridor (See Table 9 for Corridor Definitions)	Estimated Annual Fatality Crashes			Rating (2=Best) (0=Worst)
	WITHOUT Truck-Only Lanes	WITH Truck-Only Lanes	Estimated Annual Savings	
3A: I-75 South	11	7	4	2
3B: I-75 South	10	7	3	1
4A: I-75 North	14	9	6	2
4B: I-75 North	10	7	3	1
6B: I-85 South	9	6	3	1
7A: I-85 North	10	7	3	1
8: I-20 West	10	6	4	2
9: I-20 East	8	5	3	1

Source: Truck Only Lanes Needs Analysis and Engineering Assessment, Georgia Department of Transportation, April 2008

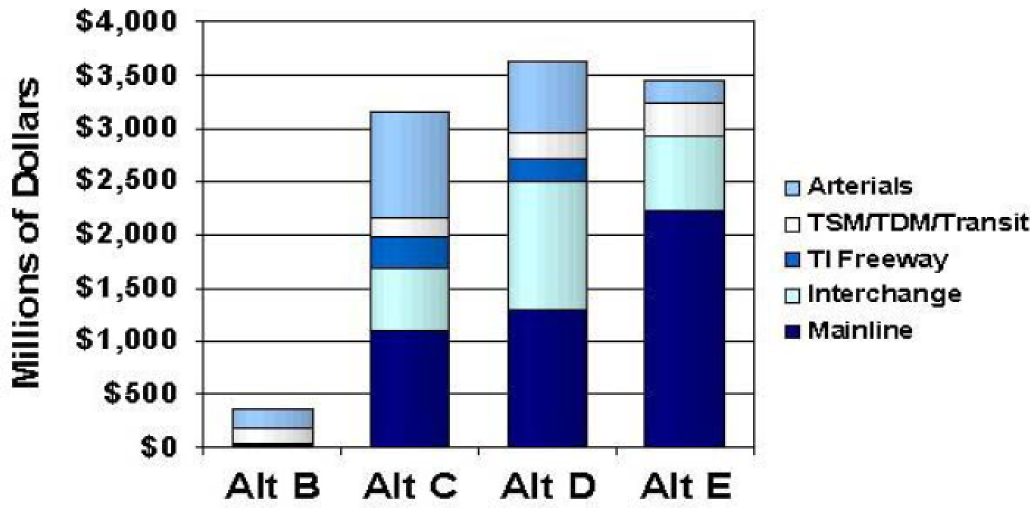
Table 2.32 Example of Highway Network Security Assessment

Corridor (See Table 9 for Corridor Definitions)	Truck Stop Access (with/without TOL)	Rest Stop Access (with/without TOL)	Weight Station Access (with/without TOL)	Rating (2=Best) (0=Worst)
3A: I-75 South	3/2	0/0	1/0	1
3B: I-75 South	7/4	0/0	0/0	1
4A: I-75 North	5/3	1/0	0/0	1
4B: I-75 North	4/2	1/0	1/1	2
6B: I-85 South	0/0	0/0	1/0	0
7A: I-85 North	0/0	0/0	0/0	2
8: I-20 West	4/3	0/0	2/0	1

Source: Truck Only Lanes Needs Analysis and Engineering Assessment, Georgia Department of Transportation, April 2008

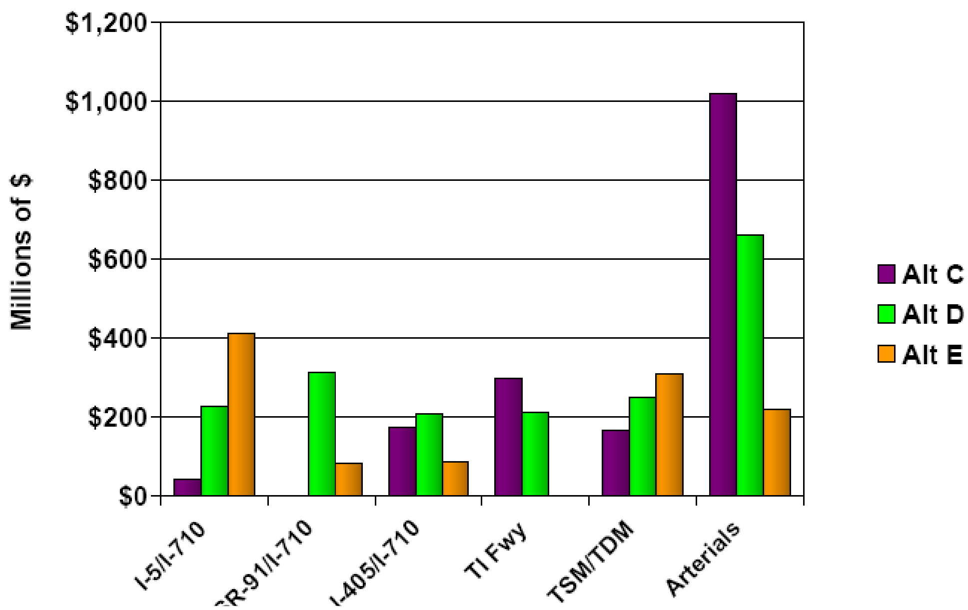
2.4 Economic

Figure 2.21 Example of Total Cost Comparison, Alternative Types



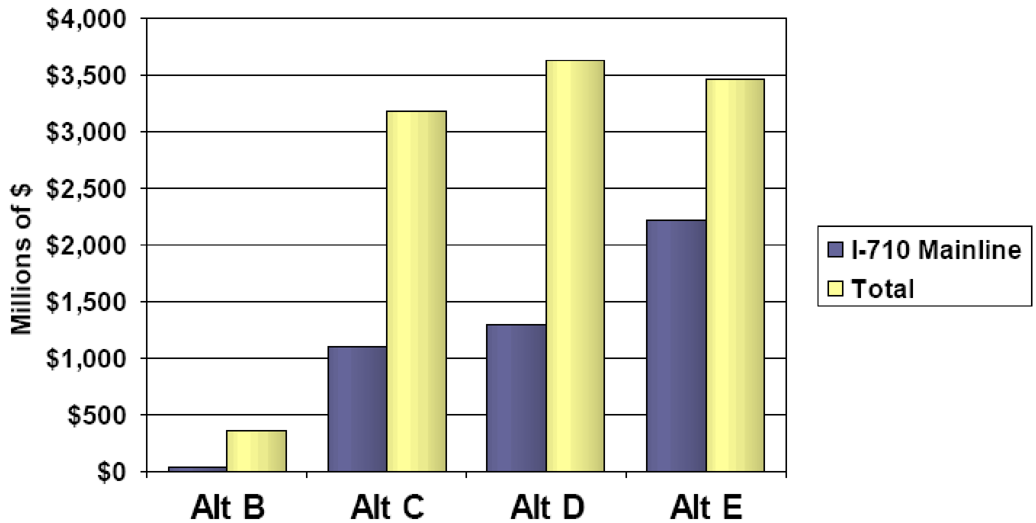
Source: I-710 Major Corridor Study Final Report, Los Angeles County MTA, March 2005

Figure 2.22 Example of Component Cost Comparison



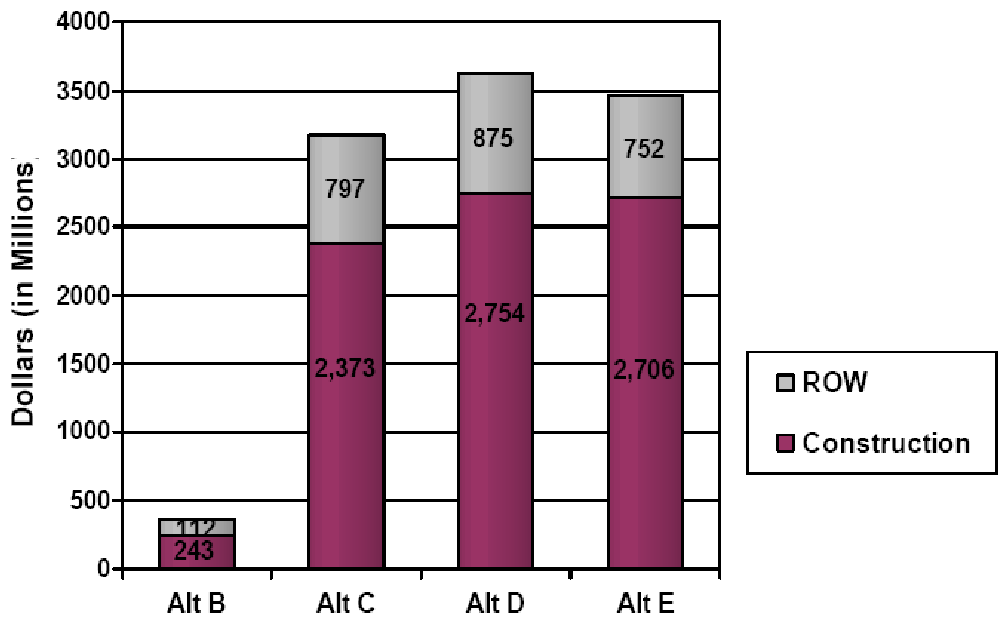
Source: I-710 Major Corridor Study Final Report, Los Angeles County MTA, March 2005

Figure 2.23 Example of I-710 Mainline vs. Total Cost Comparison



Source: I-710 Major Corridor Study Final Report, Los Angeles County MTA, March 2005

Figure 2.24 Example of Construction vs. ROW Cost Comparison



Source: I-710 Major Corridor Study Final Report, Los Angeles County MTA, March 2005

Table 2.33 Example of Capital and Operating and Maintenance Costs (millions) 2007 Dollars

Corridor (See Table 9 for Corridor Definitions)	Capital Costs				Total Capital Costs	Total Capital Costs per Mile	Annual O&M Cost	Rating (2=Best) (0=Worst)
	Preliminary Engineering	Cost of Construction	Right-of-Way	Cost of Utilities				
3A: I-75 South	$112.8	$1,127.9	$130.0	$56.4	$1,427.1	$43.3	$28.5	1
3B: I-75 South	$47.3	$473.0	$19.1	$23.7	$563.1	$20.9	$11.3	2
4A: I-75 North	$184.0	$1,840.1	$211.6	$92.0	$2,327.7	$49.5	$46.6	0
4B: I-75 North	$81.7	$817.0	$56.3	$40.9	$995.9	$21.7	$19.9	2
6B: I-85 South	$72.0	$719.7	$54.9	$36.0	$882.6	$23.9	$17.7	2
7A: I-85 North	$184.0	$1,840.1	$211.6	$92.0	$2,327.7	$70.5	$46.6	0
8: I-20 West	$134.0	$1,337.0	$97.0	$67.0	$1,635.0	$39.9	$32.7	1
9: I-20 East	$160.0	$1,601.0	$128.4	$80.0	$1969.4	$63.5	$39.4	1
12A: I-285 North/East	$177.1	$1,771.1	$273.8	$88.6	$2,310.6	$59.2	$46.2	0
12B: I-285 West/South	$110.0	$1,101.1	$135.0	$55.1	$1,401.1	$53.9	$28.0	1

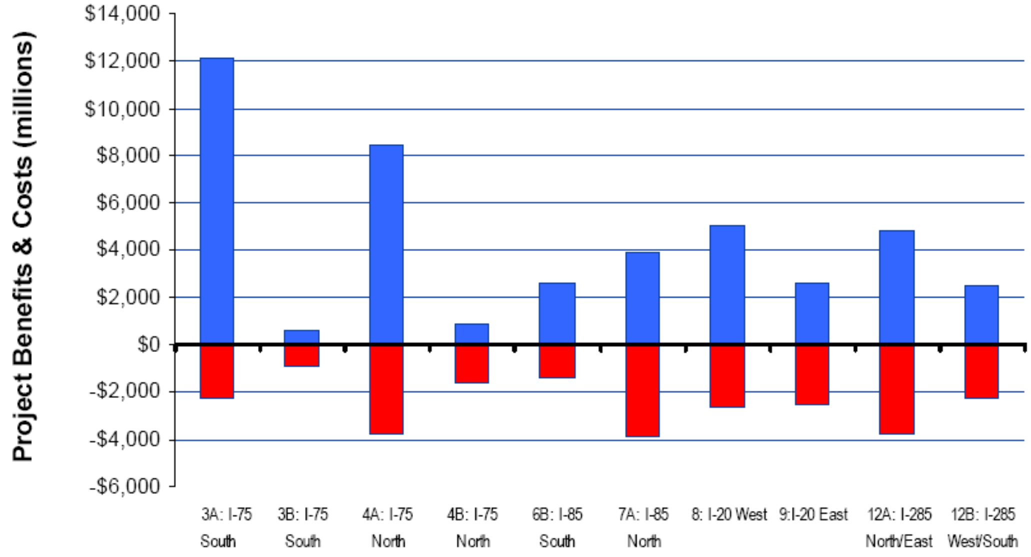
Source: Truck Only Lanes Needs Analysis and Engineering Assessment, Georgia Department of Transportation, April 2008

Table 2.34 Example of 2035 Cumulative Benefits and Costs (millions)

Corridor (See Table 9 for Corridor Definitions)	Cumulative Travel Benefits	Cumulative safety Benefits	Total Cumulative Benefits	Rating (2=Best) (0=Worst)
3A: I-75 South	$11,823	$344	$12,167	2
3B: I-75 South	$392	$258	$650	0
4A: I-75 North	$7,976	$431	$8,407	2
4B: I-75 North	$730	$171	$901	0
6B: I-85 South	$2,330	$258	$2,588	1
7A: I-85 North	$3,676	$258	$3,934	1
8: I-20 West	$4695	$344	$5,039	1
9: I-20 East	$2,330	$258	$2,588	1
12A: I-285 North/East	$4,412	$431	$4,843	1
12B: I-285 West/South	$2,154	$344	$2,498	0

Source: Truck Only Lanes Needs Analysis and Engineering Assessment, Georgia Department of Transportation, April 2008

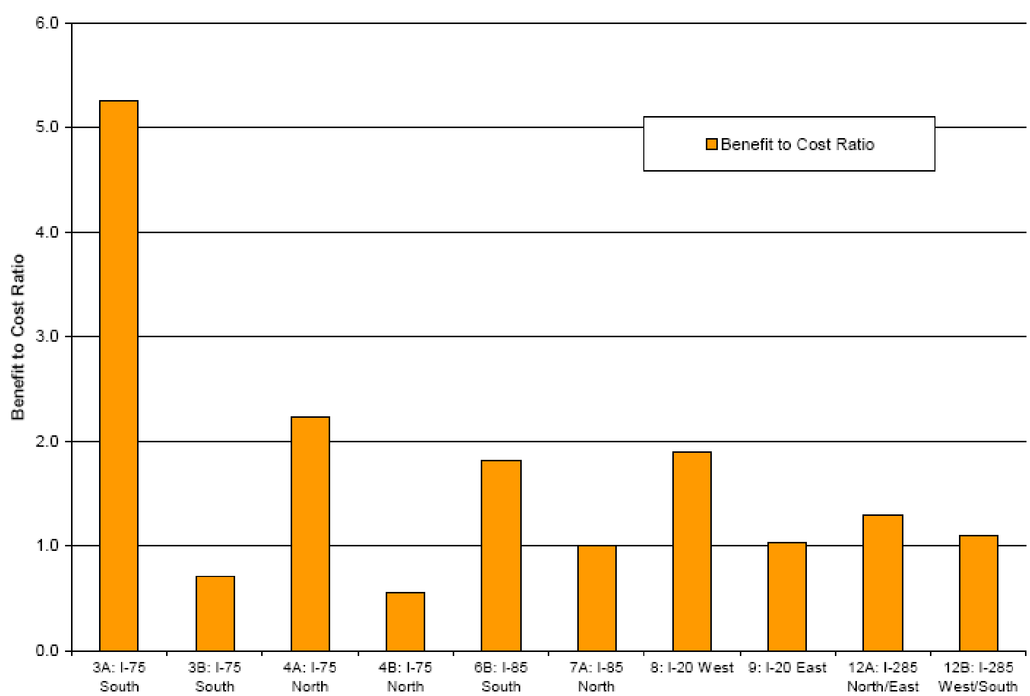
Figure 2.25 Example of 30-year User Benefits and Costs



*Note: The benefits should not be summed since the buffer and region would cause double counting.

Source: Truck Only Lanes Needs Analysis and Engineering Assessment, Georgia Department of Transportation, April 2008

Figure 2.26 Example of Benefit-Cost Ratio Summary



Source: Truck Only Lanes Needs Analysis and Engineering Assessment, Georgia Department of Transportation, April 2008

Table 2.35 Example of Cost Effectiveness Summary

Corridor (See Table 9 for Corridor Definitions)	30-Year Cumulative Benefits	30-Year Cumulative Cost	Benefit-to-Cost Ratio	Rating (2=Best) (0=Worst)
3A: I-75 South	$12,167	$2,312	5.26	2
3B: I-75 South	$650	$912	.71	0
4A: I-75 North	$8,407	$3,771	2.23	1
4B: I-75 North	$901	$1,613	.56	0
6B: I-85 South	$2,588	$1,430	1.81	1
7A: I-85 North	$3,934	$3,912	1.01	1
8: I-20 West	$5,039	$2,649	1.90	1
9: I-20 East	$2,588	$2,517	1.03	1
12A: I-285 North/East	$4,843	$3,743	1.29	1
12B: I-285 West/South	$2,498	$2,270	1.10	0

Source: Truck Only Lanes Needs Analysis and Engineering Assessment, Georgia Department of Transportation, April 2008

Table 2.36 Example of Cost Effectiveness Feasibility

Evaluation Criterion	Measure	Segment	Existing Condition	Future Alternative: A No Build	B TSM/TDM	C HOV Lanes	D Truck Lanes	E Managed Lanes
Category 3: Cost-Effectiveness & Feasibility	Cost Estimate Range (Millions of Dollars)	1	na	na	na	$56 - $81	$453 - $1045	$22 - $32
		2	na	na	na	$38 - $55	$187 - $271	$33 - $48
		3	na	na	na	$43 - $62	$168 - $243	$109 - $158
		4	na	na	na	$119 - $172	$200 - $357	$141 - $204
		5	na	na	na	$71 - $103	$276 - $398	$109 - $158
		6	na	na	na	$68 - $98	$461 - $666	$64 - $93
		7	na	na	na	$42 - $61	$205 - $296	$27 - $39
		I-15/I-215 Interchange	na	na	na	$60 - $87	$95 - $272	$68 - $98
		TOTAL	na	na	$10 - $25	$497 - $719	$2045 - $3548	$573 - $830

Segment 1 - Mojave River Crossing to Bear Valley Road
Segment 2 - Bear Valley Road to US-395
Segment 3 - US-395 to SR-138
Segment 4 - SR-138 to I-215
Segment 5 - I-215 to I-210
Segment 6 - I-210 to I-10
Segment 7 - I-10 to SR-60

Source: I-15 Comprehensive Corridor Study, SCAG, December 2005

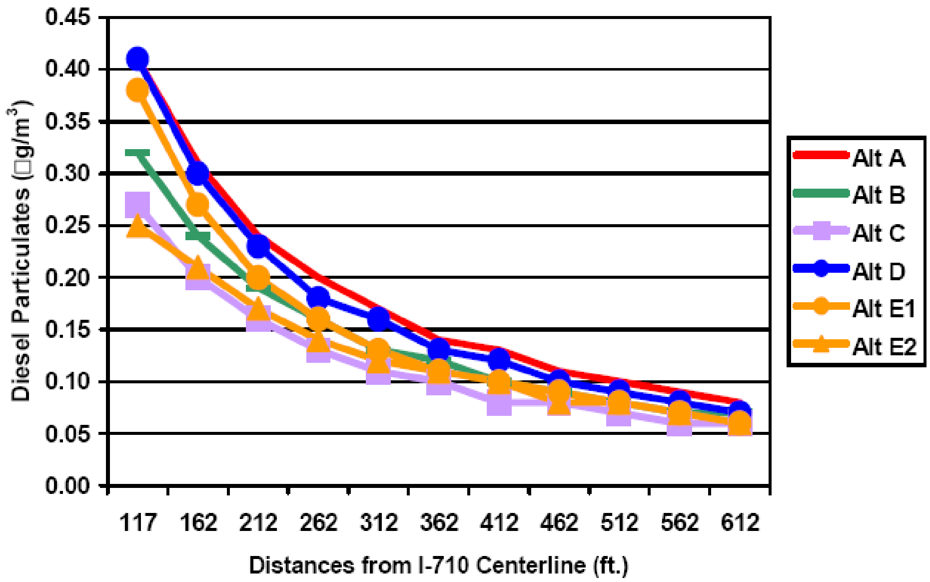
2.5 Environmental

Table 2.37 Example Summary of Effect on the Natural Environment

Corridor (See Table 9 for Corridor Definitions)	Effects on Air Quality	Effects on Noise	Effects on Water Resources (1)	Rating (2=Best) (0=Worst)
3A: I-75 South	Low: not anticipated to affect or cause National Ambient Air Quality Standard violation	Low; improved speeds for through traffic and no increase in gradation	Medium	2
3B: I-75 South	Low: not anticipated to affect or cause National Ambient Air Quality Standard violation	Medium; road traffic will affect some properties - no severe impacts to residential sites	Low	2
4A: I-75 North	Low: not anticipated to affect or cause National Ambient Air Quality Standard violation	High; road traffic affects some properties and some residential sites are severely impacted	Medium	0
4B: I-75 North	Low: not anticipated to affect or cause National	Medium; road traffic will affect some properties - no severe	Low	2

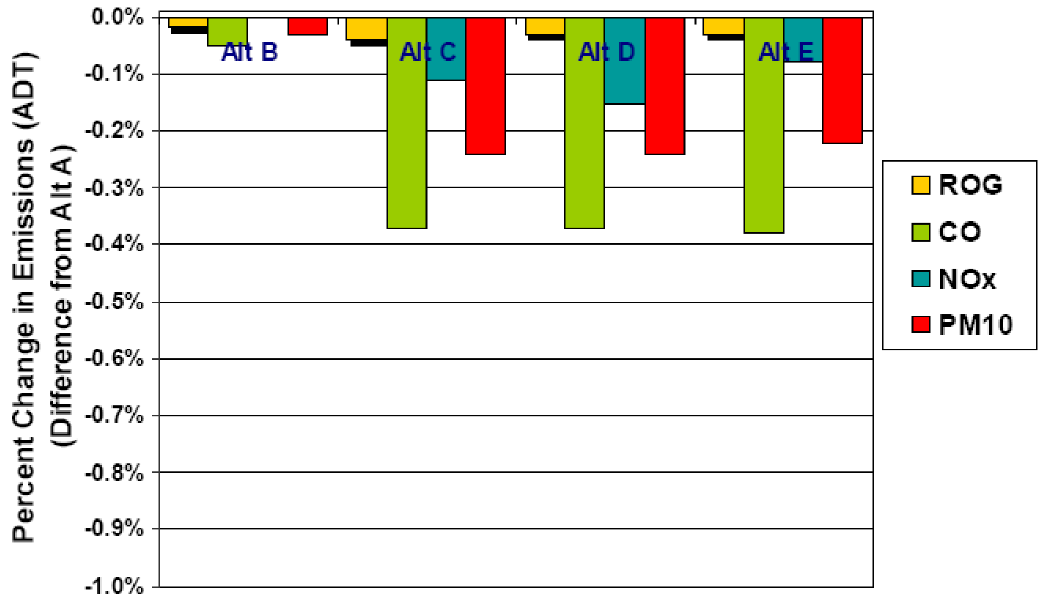
Source: Truck Only Lanes Needs Analysis and Engineering Assessment, Georgia Department of Transportation, April 2008

Figure 2.27 Example of I-710 Concentrations of Diesel Particulate Matter



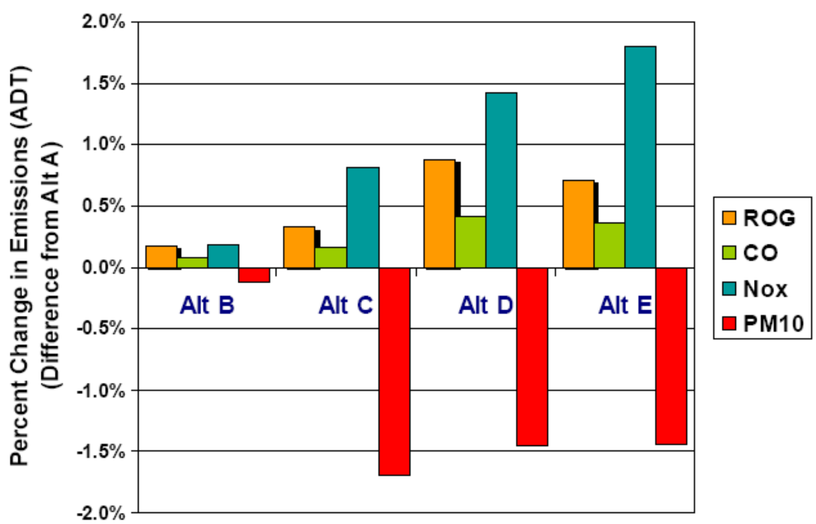
Source: I-710 Major Corridor Study Final Report, Los Angeles County MTA, March 2005

Figure 2.28 Example of Estimated Percentage Change in Regional Emissions



Source: I-710 Major Corridor Study Final Report, Los Angeles County MTA, March 2005

Figure 2.29 Example of Estimated Percentage Change in I-710 Study Area Emissions



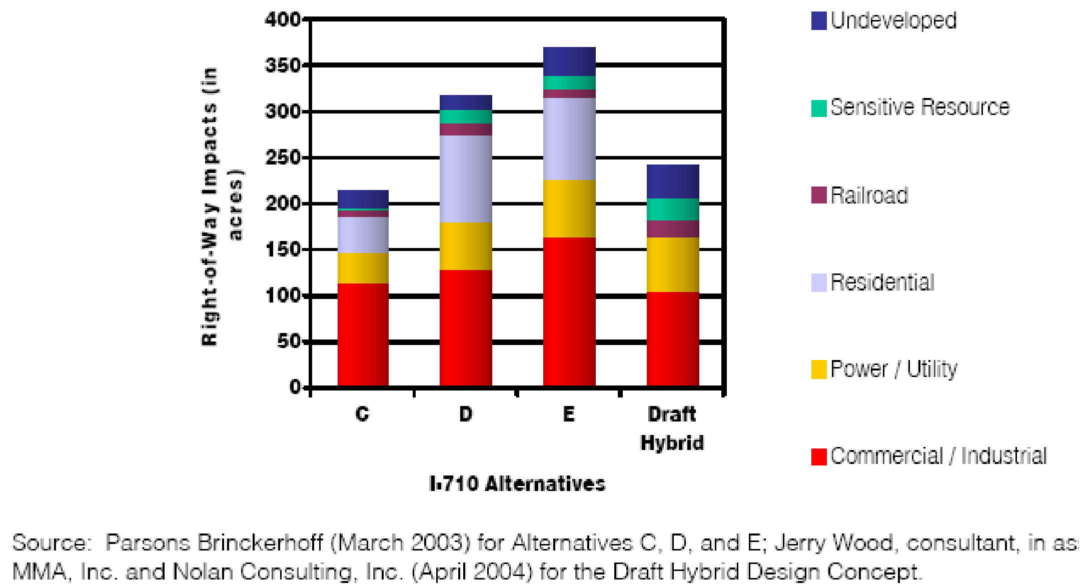
Source: I-710 Major Corridor Study Final Report, Los Angeles County MTA, March 2005

Table 2.38 Example Summary of Social and Cultural Effects

Corridor (See Table 9 for Corridor Definitions)	Effects on known historic, archaeological, and cultural resources (#of sites impacted)	Effects on aesthetics and visual quality	Effects on neighborhood and business access, circulation, and emergency services	Rating (2=Best) (0=Worst)
3A: I-75 South	2	Medium; changes for some existing properties and adjacent neighborhoods	Medium; access and circulation impact in some neighborhoods	1
3B: I-75 South	0	Medium; changes for some existing properties and adjacent neighborhoods	Medium; access and circulation impact in some neighborhoods	1
4A: I-75 North	7	High; Alternatives Analysis/Draft Environmental Impact Statement - substantial changes for adjacent neighborhoods	Medium; Alternatives Analysis/Draft Environmental Impact Statement - access, circulation, and community cohesion impacts in several neighborhoods	0
4B: I-75 North	0	Medium; changes for some existing properties and adjacent neighborhoods	Medium; access and circulation impact in some neighborhoods	1
6B: I-85 South	7	Medium; changes for some existing properties and adjacent neighborhoods	Low; much of the corridor already developed industrial.	2
7A: I-85 North	16	Low; some changes at interchange locations	Low; much of the corridor already developed industrial.	2

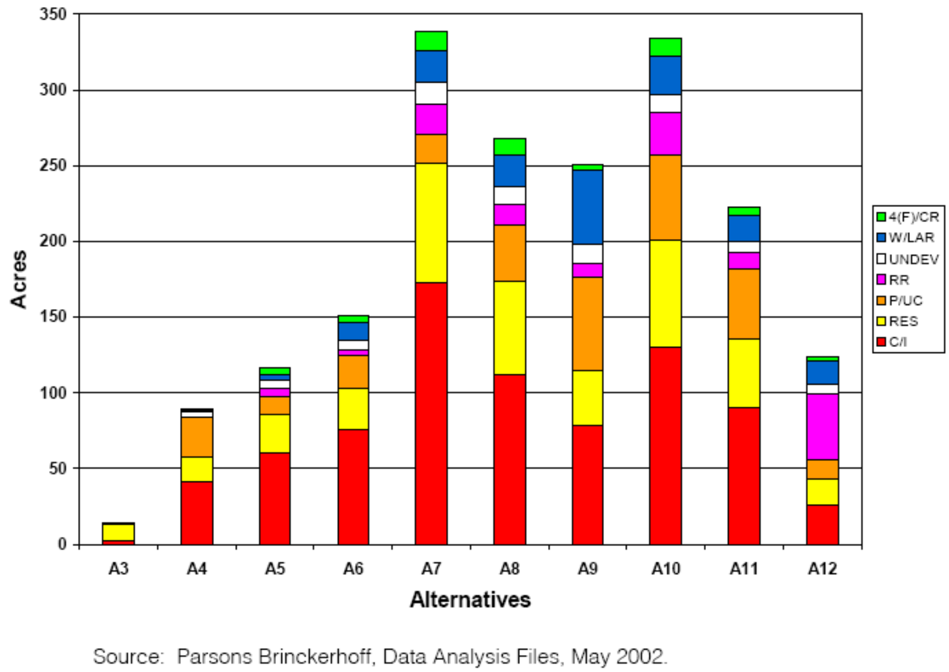
Source: Truck Only Lanes Needs Analysis and Engineering Assessment, Georgia Department of Transportation, April 2008

Figure 2.30 Example of Acreage Impacts by Land Use Type by Alternative



Source: I-710 Major Corridor Study Final Report, Los Angeles County MTA, March 2005

Figure 2.31 Example of Estimated Land Use Impacts



Source: I-710 Major Corridor Study Final Report, Los Angeles County MTA, March 2005

Table 2.39 Example Summary of Land Use Effects

Corridor (See Table 9 for Corridor Definitions)	Effects on Land Use Patterns/Compatibility	Effects on Potential land Development	Rating (2=Best) (0=Worst)
3A: I-75 South	Medium; supportive of existing patterns in some locations - may impact new interchange locations	Medium; some impacts at Truck-Only Lanes interchanges	1
3B: I-75 South	Medium; supportive of existing patterns in some locations - may impact new interchange locations	Medium; some impacts at Truck-Only Lanes interchanges	1
4A: I-75 North	Low; Alternatives Analysis/Draft Environmental Impact Statement - supportive	Medium; Alternatives Analysis/Draft Environmental Impact Statement - no interchanges for portion of corridor. Some impacts at Truck-Only Lane interchanges	2
4B: I-75 North	Medium; supportive of existing patterns in some locations - may impact new interchange locations	Medium; some impacts at Truck-Only Lanes interchanges	1
6B: I-85 South	Medium; supportive of existing patterns in some locations - may impact new interchange locations	Medium; some impacts at Truck-Only Lanes interchanges	1
7A: I-85 North	Medium; supportive of existing patterns in some locations - may impact new interchange locations	Medium; some impacts at Truck-Only Lanes interchanges	1
8: I-20 West	Medium; supportive of existing patterns in some locations - may impact new interchange locations	Medium; some impacts at Truck-Only Lanes interchanges	1
9: I-20 East	High; impacts current development patterns at some locations and future development at some interchange locations	High; impacts at Truck-Only Lanes Interchanges and along frontage roads	0
12A: I-285 North/East	High; impacts current development patterns at some locations and future development at some interchange locations	Medium; some impacts at Truck-Only Lanes interchanges	0
12B: I-285 West/South	High; impacts current development patterns at some locations and future development at some interchange locations	Medium; some impacts at Truck-Only Lanes interchanges	0

Source: Truck Only Lanes Needs Analysis and Engineering Assessment, Georgia Department of Transportation, April 2008

Table 2.40 Example of Detailed Evaluation Summary Results – Environmental Impact

EVALUATION CRITERION	MEASURE	SEGMENT	EXISTING CONDITION	FUTURE ALTERNATIVE A No Build	B TSM/TDM	C HOV Lanes	D Truck Lanes	E Managed Lanes
CATEGORY 2: ENVIRONMENTAL IMPACTS	Right of Way (acres)		na	0	0	22.4	275.1	9.6
	Lane Use Type Affected (acres							
	Residential		na	0	0	1.6	8.7	0
	Commercial/Industrial		na	0	0	1.3	52.8	0
	Parks/Recreation		na	0	0	0.3	26.3	0
	Public Services/Utilities		na	0	0	0.4	6.7	0
	Local Roadway		na	0	0	0	159.0	0
	Other (Vacant, Vineyards, Undeveloped, Open Space)		na	0	0	5.7	160.3	3.4
	Special Resources Affected							
	Biological (# of sensitive species)		na	0	0	21	32	21
	Biological (CNDDB habitat - acres)		na	0	0	5,244.1	8,810.2	6,221.6
	Historic (# of resources)		na	0	0	0	2	0
	Water (# of waterways)		na	0	0	3	10	0
	Farmland (acres)		na	0	0	0.3	14.9	0.0
	Environmental Justice (acres)		na	0	0	12.6	132.9	4.3
	Noise		na	low	low	moderate	high	moderate
	Air Quality							
	ROC/ROG		na	not significant	not significant	not significant	not significant	not significant
	CO		na	not significant	not significant	not significant	significant	significant
	NOx		na	not significant	not significant	not significant	significant	significant
	PM10		na	not significant	not significant	not significant	not significant	not significant

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Segment 5 - I-215 to I-210
Segment 6 - I-210 to I-10
Segment 7 - I-10 to SR-60

Source: I-15 Comprehensive Corridor Study, SCAG, December 2005

2.6 Constructability

Table 2.41 Example Summary of Constructability Analysis

Corridor (See Table 9 for Corridor Definitions)	Available Right-of-Way	Typical Section	Bridge Replacement	Environmental	Overall Constructability Score	Rating (2=Best) (0=Worst)
3A: I-75 South	8	7	6	6	7	
3B: I-75 South	9	8	8	6	8	2
4A: I-75 North	9	8	6	7	7	1
4B: I-75 North	9	7	6	6	7	1
6B: I-85 South	8	7	7	5	7	1
7A: I-85 North	7	7	6	5	6	1

Source: Truck Only Lanes Needs Analysis and Engineering Assessment, Georgia Department of Transportation, April 2008

3.0 Configurations and Design Issues and Related Institutional Questions (Task 3)

3.1 Data on Truck Facility Configurations and Design Criteria

Table 3.1 Design Criteria for Truck Only Lanes – Minimum Lane and Shoulder Widths

Variable	# of Lanes on Truck Facility			Notes
	1 Lane	2 Lanes	3+ Lanes	
Lane Width	12-13’	12-13’	12-13’	13 feet is desirable minimum; 12 feet is absolute minimum
Left Shoulder	0’	10’	12’	
Right Shoulder	12’	12’	12’	

Source: James G. Douglas, *Handbook for Planning Truck Facilities on Urban Highways,* August 2004

Table 3.2 Truck Facility Design Speeds, Horizontal Curvatures, and Grades

Variable	Truck Facility Type					Notes
	Climbing Lane	Mainline Truck Lanes	Truck Roads	Truck Bypass	Truck Ramp	
Design Speed	same as mainline	70 mph	45-70 mph	60-70 mph	within 10 mph of mainline design speed	
Minimum Radius on Horizontal Curve		2,000 ft.				Depends on design speed and superelevation. 2,000 ft is typical minimum for 70 mph
Maximum Grade	6%	5-6%	5-6%	5-6%	6%	

Source: James G. Douglas, *Handbook for Planning Truck Facilities on Urban Highways,* August 2004

Table 3.3 Examples of Truck Facility Geometric Characteristics and Design Criteria

Facility	Truck Facility Type	Geometric Elements				Notes
		Lane Width	**Left Shoulder**	**Right Shoulder**	**Maximum Grade**	
South Boston Bypass	Truck road	12'	0'	2-4'	< 2%	
New Jersey Turnpike Dual Roadway	Separated mainline lanes	12'	6-12'	10-12'		
Tigard Interchange	Interchange bypass	12'	4'	6'	6%	
I-5/SR-14/I-210 Truck Bypass	Interchange bypass/separated mainline lanes	12'	4'	10-12'		
I-5/I-405 Truck Bypass (Los Angeles)	Interchange bypass	12'	3'	10'	< 2%	
I-5/I-405 Truck Bypass/C-D (Orange County)	Interchange bypass/collector-distributor	12'	4'	10'		
New Jersey Portway Design Criteria	Roadways	12'		15'	4%	
	Ramps	12-22'	2'	10'	5%	
ITE Design and Operational Criteria for Trucks	Freeways	11.5-12'	4-12'	10-12'	6%	Lane width for 70 mph design speed; max. grade for mountainous terrain
"Geometric Design of Exclusive Truck Facilities"	Freeways	13'	10'	12'	10 mph speed reduction	10' left shoulder recommended in sections with many through lanes

Source: James G. Douglas, *Handbook for Planning Truck Facilities on Urban Highways,* August 2004

Table 3.4 Truck Facility Capacities (based on VISSIM simulation results)

Geometry (Case) Description	Grade	Longitudinal Coverage of Grade (%)	Interchanges Per 20 Miles		
			0	2 [a] (higher volume per ramp)	5 [b] (lower volume per ramp)
Level	0	0	1475	1175	1200
Low Grades/Gently Rolling	2	20	1425	1125	1175
Low Grades/Rolling	2	40	1425	1125	1175
High Grades/Gently Rolling	4	20	1225	1100	1075
High Grades/Rolling	4	40	1200	1050	1025

[a] t/h/l = trucks per hour per lane
[b] Interchange volume fixed at a level where 1/3 of mainline volume exits/enters over the 20-mile simulation; where fewer interchanges are present, ramp volumes are higher.

Source: Dan Middleton, Steve Venglar, Cesar Quiroga, Dominique Lord, and Debbie Jasek, *Strategies for Separating Trucks from Passenger Vehicles: Final Report,* Research Report 0-4663-2, September 2006

Table 3.5 Exclusive Truck Lane (ETL) Configurations

Typical Truck Lane Configurations

ETF type	Median width	Total # truck lanes	ETF location	Inside shoulder width	Advantages	Disadvantages
Minimum median	36 ft.	2	inside	5 ft.	Applicable in narrow medians Specific pavement structure for trucks Longer life for existing lanes Most economical	Limited control of exit/entrance maneuvers No provision for truck-only passing lanes Long weaving distances near interchanges Lack of shoulder room for disabled trucks
Desirable median	44-48 ft.	2	inside	10-12 ft.	Same as above	Limited control of exit/entrance maneuvers No provision for truck-only passing lanes Long weaving distances near interchanges
Outside lane	44-48 ft.	2	outside	10-12 ft.	Applicable in narrow medians Specific pavement structure for trucks Longer life for existing lanes Minimized weaving, Slower vehicles on right Smaller median barrier (for cars) required	Existing pavement may be insufficient for total truck loads Lack of capacity near interchanges Provides small incremental improvement
Four-lane	60 ft.	4	inside	5 ft.	Pavement designed exclusively for trucks Passing lane	Limited control of exit/entrance maneuvers Long weaving distances near interchanges Lack of shoulder room for disabled trucks
Depressed median	76 ft.	2	inside	10 ft.	Lower cost: no barrier required because of wide median Exclusive pavement for trucks	Limited control of exit/entrance maneuvers Long weaving distances near interchanges Lack of shoulder room for disabled trucks
Protected w/ variable passing lane	76 ft.	3	inside	4 ft.	Total control of exit/entrance maneuvers Exclusive pavement design for trucks Compatible with separate truck interchanges and elevated facility	Greater required median width Less clearance for wide loads
Elevated w/ variable passing lane	n/a	3	center	4 ft.	Minimal median width required Passing maneuvers provided Control of access by large vehicles Potential for transit use Compatible with protected lane option	High cost Difficulty in future expansion Icing potential in winter Less clearance for wide loads Potential noise problems

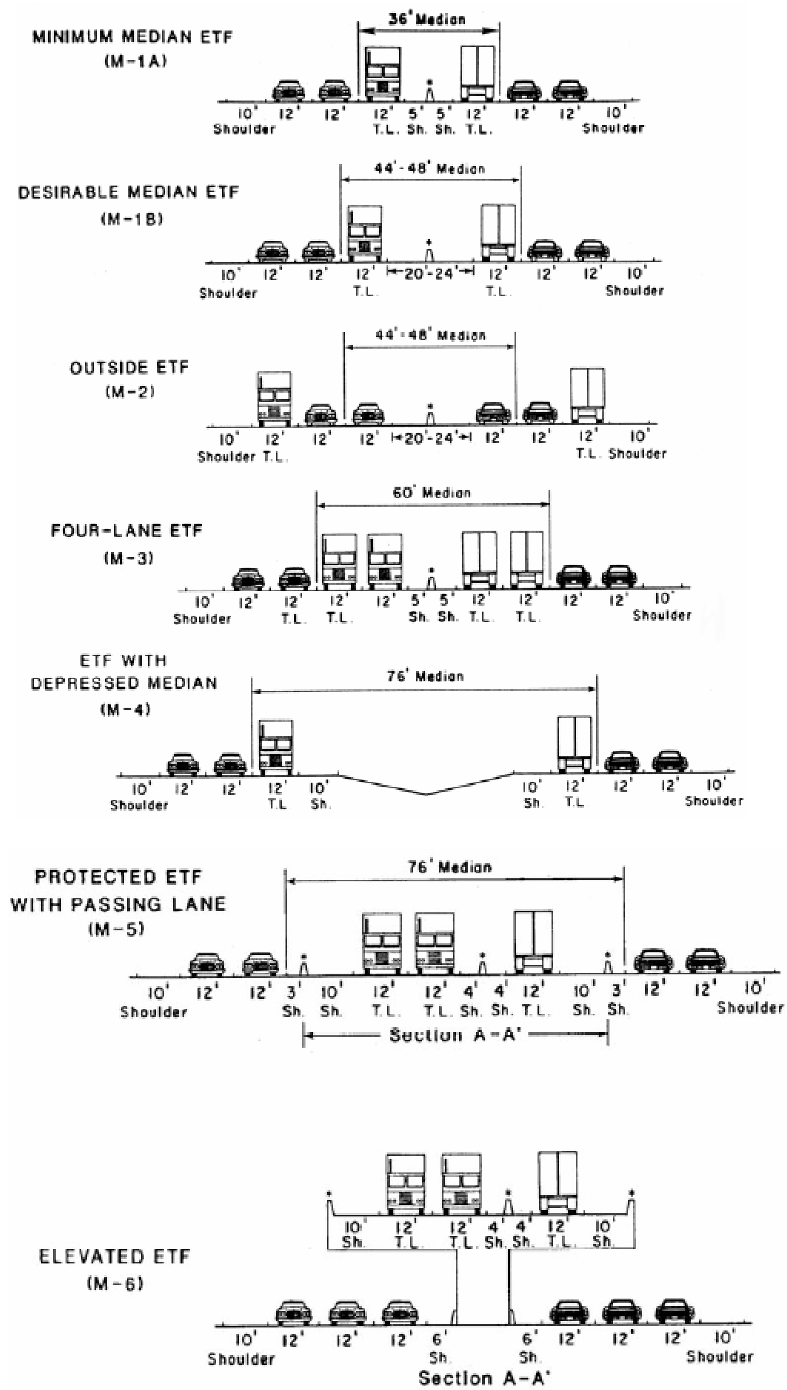
Source: *Operational and Geometric Evaluation of Exclusive Truck Lanes*, Research Report 331-3F. pp. 18-23. TTI, May 1986

Table 3.6 Key Design Criteria for Truck Only Lanes

Design Speed	Desirable	Reduced
	70 mph	50 mph
Alignment		
Stopping Distance	730 ft	425 ft
Horizontal Curvature	1820-2500 ft	760-835 ft
Superelevation	0.06 ft/ft	0.08 ft/ft
Gradients		
Maximum	5 percent	6 percent
Minimum	0.5 percent	0.5 percent
Clearance		
Vertical	16.5 ft	14.5 ft
Lateral	4 ft	4 ft
Lane Width		
Travel Lanes	12 ft	12 ft
Cross Slopes		
Maximum	0.020 ft/ft	0.020 ft/ft
Minimum	0.015 ft/ft	0.015 ft/ft

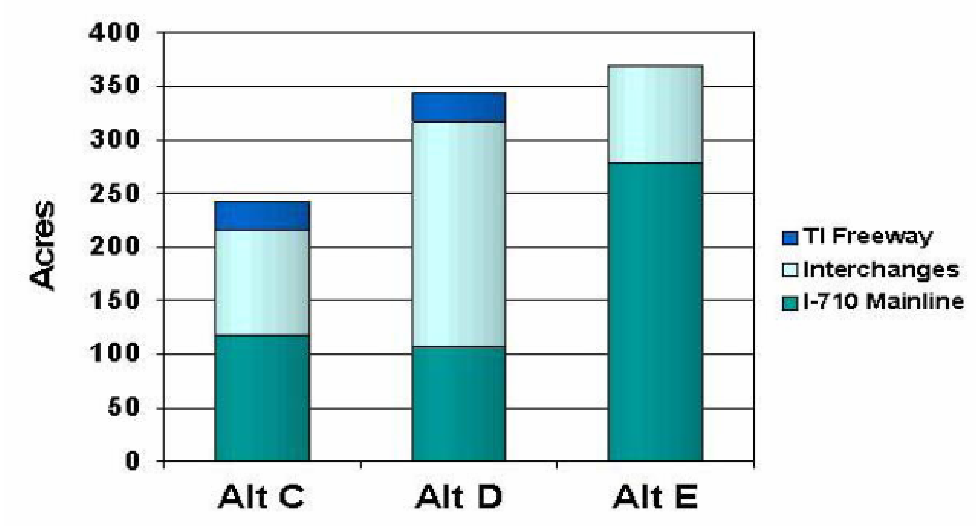
Source: *Truck Only Lanes Needs Analysis and Engineering Assessment*, HNTB Technical Memorandum

Figure 3.1 Truck Facility Cross-Sectional Design Criteria



Source: Dan Middleton, Steve Venglar, Cesar Quiroga, Dominique Lord, and Debbie Jasek, *Strategies for Separating Trucks from Passenger Vehicles: Final Report,* Research Report 0-4663-2, September 2006

Figure 3.2 I-710 Major Corridor Study – Comparison of Right-of-way Requirements (Acreage) by Alternative*



* TI Freeway : Terminal Island Freeway
Alternative C: Medium General Purpose/Medium Truck Alternative
Alternative D: High General Purpose/High HOV Alternative
Alternative E: High Truck Alternative (included exclusive truck only lanes)

Source: : I-710 Major Corridor Study, Final Report, March 2005

3.2 Data on Truck Facility Capital and Operational/Maintenance Costs

Table 3.7 Truck Only Toll (TOT) Lane Annual Operations and Maintenance (O & M) Cost Projections, 2030

Annual Costs	Administrative Costs (K)	Maintenance Costs (K)	Potential Annual O&M Costs * (K)
A1: Major Truck Corridors	$ 8,800	$ 7,600	$16,400
A2: Service to Deliveries	$10,100	$10,400	$20,500
A3: Regional TOT Network	$20,100	$21,100	$41,200

Note:
*Assumes 30 year bonds at 5% interest. These are 2004 dollar values.
These are general numbers; more detailed numbers will be developed in further studies. Operations and maintenance costs include administration and equipment/infrastructure maintenance.

Source: Parsons Brinckerhoff, Quade & Douglas, Inc., *Truck Only Toll Facilities: Potential for Implementation in the Atlanta Region,* July, 2005

Table 3.8 TOT Lane Annualized Capital Costs

Annual Capital Cost*	Projected TOT Infostructure Capital Costs [1] (K)	Projected TOT Infrastructure Cost[2] (K)	Projected Managed Lane Infrastructure Cost [2] (K)
A1: Major Truck Corridors	$ 4,700	$ 331,800	$ 909,900
A2: Service to Deliveries	$ 7,000	$ 331,800	$ 909,900
A3: Regional TOT Network	$ 11,000	$ 507,100	$ 578,000

Note:
1. TOT capital costs include TOT "infostructure" such as electronic toll collection equipment and infrastructure such as pylons (where needed).
2. Capital infrastructure cost projections are assumed to be similar to those developed as part of the GDOT *HOV System Plan*; Managed Lane infrastructure costs include the entire managed lane system of assumed HOV/HOT and TOT lanes and do not include additional costs associated with infrastructure requirements (such as pavement design) for exclusive truck use.
*Assumes 30 year bonds at 5% interest; values are expressed in 2004 dollars.

Source: Parsons Brinckerhoff, Quade & Douglas, Inc., *Truck Only Toll Facilities: Potential for Implementation in the Atlanta Region,* July, 2005

Table 3.9 Comparison of Surface, Elevated, and Tunnel Section Costs for the Miami Toll Truckway

Route/Segment	Miles	ROW	Type of Construction	Unit cost ($M/mi.)	Cost ($M)	ROW ($M/mi.)	ROW cost ($M)	Total ($M)
Northern								
I-395 to I-95	2.175	FDOT	Elevated	45	97.9	0	0.0	
I-95 to SR 112	1.625	FDOT	Elevated	45	73.1	0	0.0	
SR 112 to MIA	3.7	MDX	Elevated	45	166.5	0	0.0	
MIA to Ludlum	2.625	MIA	Tunnel	200	525.0	0	0.0	
Ludlum to 25th St.	0.75	FEC	Surface	7	5.3	23	17.3	
Medley extension	8.5	FEC	Surface	7	59.5	23	195.5	
	19.375				927.3		212.8	1140.0
Mid-North								
I-395 to I-95	2.175	FDOT	Elevated	45	97.9	0	0.0	
SFRC to MIA	4.475	SFRC	Elevated	45	201.4	0	0.0	
MIA to Ludlum	2.625	MIA	Tunnel	200	525.0	0	0.0	
Ludlum to 25th St.	0.75	FEC	Surface	7	5.3	23	17.3	
Medley extension	8.5	FEC	Surface	7	59.5	23	195.5	
	18.525				889.0		212.8	1101.8
Mid-South								
I-395 to I-95	2.175	FDOT	Elevated	45	97.9	0	0.0	
SFRC to Miami River	3.25	SFRC	Elevated	45	146.3	0	0.0	
33rd Ave/21st St.	1.325	County	Elevated	45	59.6	20.5	27.2	
MIA to west end	3.075	MIA	Tunnel	200	615.0	0	0.0	
Tunnel under runway	0.5	MIA	Tunnel	200	100.0	0	0.0	
FEC to 25th St.	0.5	FEC	Surface	7	3.5	23	11.5	
Medley extension	8.5	FEC	Surface	7	59.5	23	195.5	
	19.325				1081.8		234.2	1315.9
Southern								
I-395 to I-95	2.175	FDOT	Elevated	45	97.9	0	0.0	
SR 836 to LeJeune	3.925	MDX	Elevated	45	176.6	0	0.0	
LeJeune to MIA	0.55	City	Tunnel	200	110.0	0	0.0	
MIA to west end	2.375	MIA	Tunnel	200	475.0	0	0.0	
Tunnel under runway	0.5	MIA	Tunnel	200	100.0	0	0.0	
FEC to 25th St.	0.5	FEC	Surface	7	3.5	23	11.5	
Medley extension	8.5	FEC	Surface	7	59.5	23	195.5	
	18.525				1022.5		207.0	1229.5

Source: Robert Poole, Jr., *Miami Toll Truckway: Preliminary Feasibility Study*, Reason Foundation Policy Study 365, November 2007

Table 3.10 Atlanta Toll Truckway Cost Relative to Other Facilities

Major Project Costs and Revenues ($B)					
Project	**Cost, 2005 $**	**Base Year**	**NPV Cost**	**NPV Revenues**	**Difference**
ETL Network	$9.14	2008	$9.43	$17.02	+$7.59
N-S Tunnel	$4.88	2012	$6.21	$2.41	-$3.80
Toll Truckway	$7.58	2015	$10.70	$6.56	-$4.14
Lakewood	$3.51	2018	$5.49	$1.80	-$3.69

Source: Robert W. Poole, Jr., *Reducing Congestion in Atlanta: A Bold New Approach to Increasing Mobility,* Reason Foundation Policy Study 351, November 2006

Table 3.11 Comparison of Construction Costs Per Mile between Mixed Flow Facilities and Facilities with Truck Only Lanes (Equal Number of Lanes)

No. Lanes by Direction	Mixed	Scenario	Separated	Difference
4	$10,699,845	2+2	$16,964,429	$6,264,584
5	$16,018,968	2+3 [a]	$19,767,232	$3,748,264
6	$16,518,089	2+4	$21,699,845	$5,181,756
7	$19,069,090	2+5	$27,018,968	$7,949,878
8	Unavailable	2+6	$27,518,089	N/A
9	Unavailable	2+7	$30,069,090	N/A

[a] 2+3 is two truck lanes and 3 mixed lanes by direction.

Source: Dan Middleton, Steve Venglar, Cesar Quiroga, Dominique Lord, and Debbie Jasek, *Strategies for Separating Trucks from Passenger Vehicles: Final Report,* Research Report 0-4663-2, September 2006

Table 3.12 Comparison of Construction Costs Per Mile between Mixed Flow Facilities and Facilities with Truck Only Lanes (Different Number of Lanes)

Lanes by Direction	Cost Mixed	Separated Scenario	Cost Separated	Difference	Separated Scenario	Cost Separated
4	$10,699,845	2+3 [a]	$19,767,232	$9,067,387	2+4	$21,699,845
5	$16,018,968	2+4	$21,699,845	$5,680,877	2+5	$27,018,968
6	$16,518,089	2+5	$27,018,968	$10,500,879	2+6	$27,518,089
7	$19,069,090	2+6	$27,518,089	$8,448,999	2+7	$30,069,090

[a] 2+3 is two truck lanes and 3 mixed lanes by direction.

Source: Dan Middleton, Steve Venglar, Cesar Quiroga, Dominique Lord, and Debbie Jasek, *Strategies for Separating Trucks from Passenger Vehicles: Final Report,* Research Report 0-4663-2, September 2006

Table 3.13 Incremental Costs Converted to Annualized Costs Per Mile (Equal Number of Lanes)

Total Lanes	Rate of Return	2%	3%	4%	5%	6%	7%
	Cap.Recov.Factor	0.06116	0.06722	0.07358	0.08024	0.08719	0.09439
4	$6,264,584	$383,142	$421,105	$460,948	$502,670	$546,209	$591,314
5	$3,748,264	$229,244	$251,958	$275,797	$300,761	$326,811	$353,799
6	$5,181,756	$316,916	$348,318	$381,274	$415,784	$451,797	$489,106
7	$7,949,878	$486,215	$534,391	$584,952	$637,898	$693,150	$750,389

Source: Dan Middleton, Steve Venglar, Cesar Quiroga, Dominique Lord, and Debbie Jasek, *Strategies for Separating Trucks from Passenger Vehicles: Final Report,* Research Report 0-4663-2, September 2006

Table 3.14 Incremental Costs Converted to Annualized Costs Per Mile (Different Number of Lanes)

Lanes by Direction	Cost Mixed	Separated Scenario	Cost Separated	Annual Payment	Separated Scenario	Annual Payment
2	$5,964,429	2+2	$16,964,429	$882,640	N/A	N/A
3	$8,767,232	2+2	$16,964,429	$657,743	2+3	$882,640
4	$10,699,845	2+3 [a]	$19,767,232	$727,567	2+4	$882,640
5	$16,018,968	2+4	$21,699,845	$455,834	2+5	$882,640
6	$16,518,089	2+5	$27,018,968	$842,591	2+6	$882,640
7	$19,069,090	2+6	$27,518,089	$677,948	2+7	$882,640

[a] 2+3 is two truck lanes and 3 mixed lanes by direction.

Source: Dan Middleton, Steve Venglar, Cesar Quiroga, Dominique Lord, and Debbie Jasek, *Strategies for Separating Trucks from Passenger Vehicles: Final Report,* Research Report 0-4663-2, September 2006

Table 3.15 Summary of Capital Costs of Alternatives in the I-710 Major Corridor Study (MCS)*

Alternative	Total Cost Estimate	Cost per Mile
Alternative 3 Low General Purpose Alternative	$ 689	$ 35.3
Alternative 4 Low Truck Alternative	$ 498	$ 25.5
Alternative 5 Medium HOV Alternative	$ 1,094	$ 58.2
Alternative 6 Medium General Purpose Alternative	$ 1,168	$ 67.1
Alternative 7 Medium Truck Alternative	$ 1,164	$ 85.3
Alternative 8 High General Purpose Alternative	$ 1,696	$ 83.1
Alternative 9 High Truck Alternative	$ 2,166	$ 124.5
Alternative 10 High Goods Movement Alternative	$ 3,066	$ 137.5
Alternative 11 High HOV Alternative	$ 2,659	$ 141.4
Alternative 12 High Rail Alternative	$ 3,542	$ 149.4

* Specific characteristics of each of the alternatives are presented in the final report of the I-710 Major Corridor Study.

Source: I-710 Major Corridor Study, Final Report, March 2005

Table 3.16 Cost Comparisons for Exclusive Truck Facilities (ETFs)

EFT Option	Cost (per mile)	Description
Build in existing median	$4 million	At least 36 feet required for construction Trucks share shoulder & passing lanes with normal roadway No grade separation ramps or exclusive connections to other roadways
Convert frontage road to EFT	$4.5 million	One travel lane and one shoulder/passing lane Grade separation for ramps and crossings
	$9 million	Two travel lanes (bi-directional) and two shoulder/passing lanes Grade separation for ramps and crossings Additional width required
Completely separate roadway	$7-8 million	Four-lane facility Separate right-of-way in new location New structures required

Source: The Feasibility of Exclusive Truck Lanes for the Houston-Beaumont Corridor, Research Report 393-3F, p. 71, TTI, March 1987

Table 3.17 High Cost Factors for Toll Truckways along Selected Corridors in the U.S.

Route	State	Mileage	% <48ft	Miles <48ft	Terrain	ROW Cost 25 max	Terr. Cost 25 max	Tot. Cost Factor
I-5	CA	333	5	17	flat	1	0	101
I-15	CA	112	0	0	20% hilly	0	5	105
I-75	FL, GA to Tpk	125	100	125	flat			
	FL, Tpk-Tampa	59	10	6	flat			
	GA, I-75	355	83	295	part hilly			
	GA, I-285W	63	98	62	flat			
	TN	162	11	18	hilly			
	KY	193	13	25	hilly			
	OH	213	9	19	flat			
	MI	395	16	63	flat			
	Total I-75 Corr.	1565	39	613	30% hilly	10	8	118
I-75 OH-MI	OH	16	40	6	flat			
	MI	48	46	22	flat			
	Total I-75 short	64	44	28	flat	11	0	111
I-81	TN	75	0	0	flat			
	VA	325	23	75	hilly			
	WV	19	15	3	flat			
	MD	26	5	1	flat			
	PA	72	7	5	flat			
	Total I-81 Corr.	517	16	84	50% hilly	4	12	116
I-90	PA	49	2	1	flat			
	OH	85	9	8	flat			
	Total I-90 Corr.	134	7	9	flat	2	0	102
I-80	IA	306	7	21	flat			
	IL	163	24	39	flat			
	Total I-80 Corr.	469	13	60	flat	3	0	103
I-76 PA Tpk.	PA	359	100	359	80% hilly	25	20	145
I-65	TN	118	14	17	hilly			
	KY	137	21	29	hilly			
	IN	259	12	31	flat			
	Total I-65 Corr.	514	15	76	30% hilly	4	8	112
I-94	IL	44	80	35	flat			
	WI	353	18	64	flat			
	MN	18	75	14	flat			
	Total I-94 Corr.	415	27	112	flat	7	0	107

Source: Robert W. Poole, Jr. and Peter Samuel, *Corridors for Toll Truckways: Suggested Locations for Pilot Projects,* Reason Foundation, Policy Study 316, February 2004

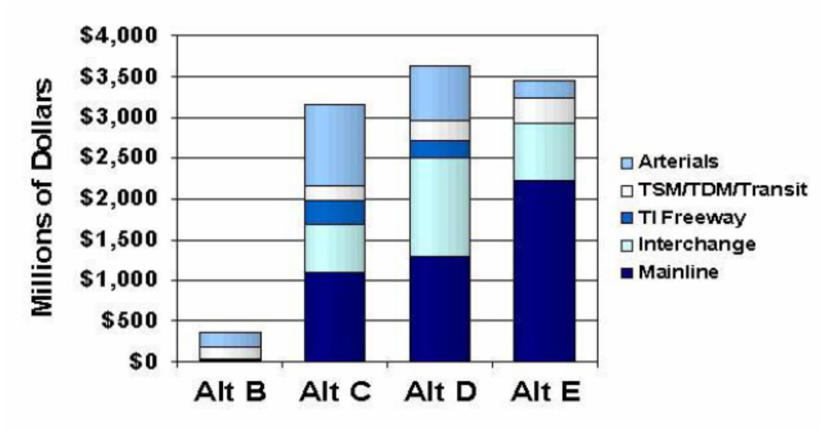
Table 3.18 Comparison of Highway Tunnel Construction Costs Across the World

Name	Place	Lanes	Length	Lane-miles	Cost	Lane-mile cost	Construction method
A100	Berlin, Germany	2x3	1.1 miles	6.6	$217m	$33m	Cut & cover
B96	Berlin, Germany	2x2	1.5 miles	6	$460m	$77m	Cut & Cover
A86 West	Paris, France	2x3 lanes	6.2 miles	37.2	$1300m	$35m	Tunnel-boring machine
Central Artery/ Tunnel	Boston, MA	2x5 lanes & 2x2 lanes	7.5 miles totalled	161 (Half is bridge)	$14.6 billion	$91m	Cut&Cover, immersed tube, jacked
Westerschelde	Holland	2x2 lanes	4.1 miles	16.5	$910m	$55m	Tunnel-boring machine
A71 Rennsteig	Thuringen Forest Germany	2x2 lanes	5 miles	20	$300m	$15m	Mined
Eastern Distributor	Sydney	2x2 & 2x3 lanes	1 mile	5	$160m	$33m	Mined
Boulevard Periph-erique Nord de Lyon	Lyon, France	2x2 lanes	2.3, 0.7, 0.7, 0.4 miles	13	$900m	$69m	Mined
Dublin Port Tunnel (u/c)	Dublin, Ireland	2x2 lanes	2.9 miles	11.4	$530m	$46m	Mined, cut and cover
CityLink	Melbourne, Australia	2x3 lanes	2.1, 1.4 miles	58 (includes bridging)	$1560m	$27m	Mined
Prado Carenage	Marseille, France	2x2 lanes	1.5 miles	6.0	$196m	$33m	Deepening old railroad tunnel
Cross City Tunnel	Sydney, Aus-tralia	2x2 lanes	1.4 miles	6.7 (incl ramps)	$545m	$81m	Mined
Herrentunnel	Lubeck, Ger-many	2x2 lanes	0.65 miles	2.6	$201m	$77m	Tunnel-boring machine
LBJ I-635 Managed Lanes Tunnel (esti-mated)	Dallas, Texas	2x3 lanes	2.1 miles	12.6	$588m (incl some surface work)	$47m	Mined
Addison Airport Tunnel	Dallas, Texas	2 lanes	0.3 miles	0.7	$15m	$21m	Mined
Lane Cove Tunnel (u/c)	Sydney, Aus-tralia	2 + 3 lanes	2.25 miles	11.3	$1.3 billion	$115m	Mined

Cautionary note: We have tried to get total project cost and divide that by travel lane-miles. It is usually impossible to isolate tunnel costs from other costs associated with the tunnel, such as approach roads. Some projects with tunnels include substantial additional costs on associated surface roads and even some bridging, while others are mostly tunnel. Tunnels vary in the extent to which breakdown shoulder is provided, which adds greatly to cost per travel lane-mile. The tunnels above have been built at different times and no attempt has been made to account for different year costs. Costs will vary according to soil conditions, and the extent of fit-out with safety systems. The table gives an indication of the range of costs likely to be incurred.

Source: Peter Samuel, *Innovative Roadway Design: Making Highways More Likeable,* Reason Foundation Policy Study 348, September 2006

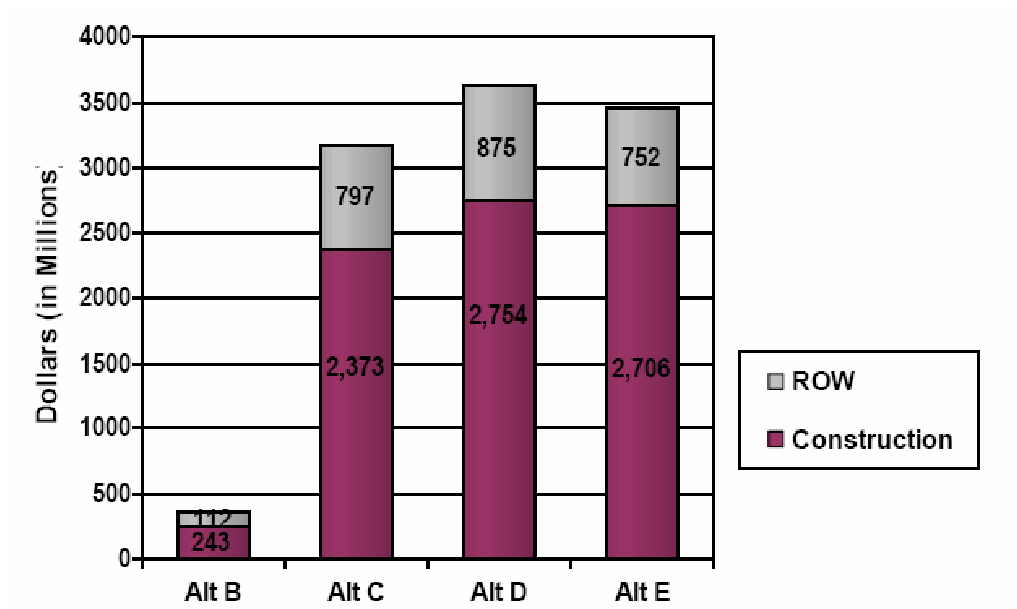
Figure 3.3 Comparison of Costs by Component between Alternatives, I-710 Major Corridor Study



* Alt B: Transportation Systems Management (TSM)/Transportation Demand Management (TDM) Alternative

Source: I-710 Major Corridor Study, Final Report, March 2005

Figure 3.4 Comparison of Construction and Right-of-way (ROW) Costs between Alternatives, I-710 Major Corridor Study



Source: I-710 Major Corridor Study, Final Report, March 2005

3.3 Data on Truck Physical and Operating Characteristics Pertinent to Truck Facility Design

Table 3.19 Truck Speed-Distance Characteristics

3% Grade		5 % Grade	
Distance (feet)[1]	Speed (mph)	Distance	Speed
500	27	500	22
1,000	29	1,000	24
1,500	31	1,500	25

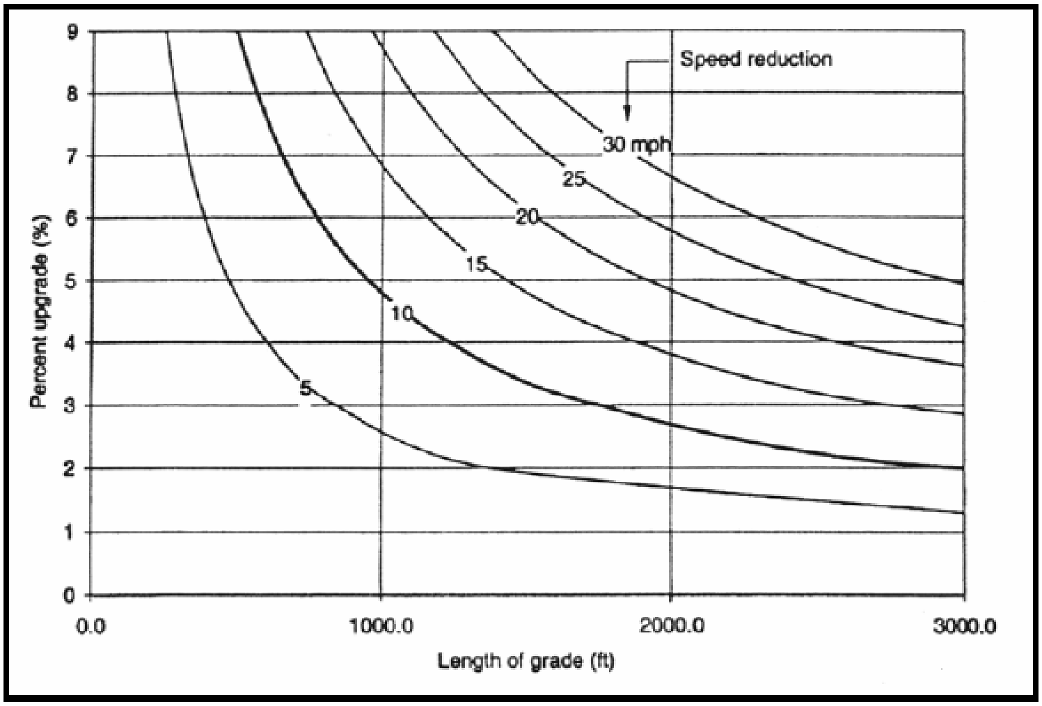
Source: American Association of State Highway and Transportation Officials (AASHTO), *A Policy on Geometric Design of Highways and Streets,* 2004, Exhibit 3-56

Table 3.20 Design Vehicle Characteristics for Exclusive Truck Lanes

Height	13.5 ft.
Width	102 inches
Length	Single unit truck: 30 feet Single unit bus: 40 feet Intermediate semi-trailer: 55 feet Articulated bus: 60 feet Double-bottom semi-trailer: 65 feet
Driver Eye Height	Passenger car: 3.5 feet Trucks (20-30 mph): 6 feet Trucks (35-45 mph): 7 feet Trucks (50-70 mph): 8 feet
Vehicle Headlight Height	2 feet (with 1-degree divergence of light beam from the vehicle longitudinal axis)
Weight-to-Horsepower Ratio	300 to 1
Vehicle Braking Distance	14 feet per second for trucks (a car should stop in 2/3 the distance required by a truck.)

Source: Operational and Geometric Evaluation of Exclusive Truck Lanes, Research Report 331-3F, pp. 8-9, Texas Transportation Institute (TTI), May 1986

Figure 3.5 Relationship between Percent Grade, Length of Grade and Truck Speeds



Source: Dan Middleton, Steve Venglar, Cesar Quiroga, Dominique Lord, and Debbie Jasek, *Strategies for Separating Trucks from Passenger Vehicles: Final Report,* Research Report 0-4663-2, September 2006

3.4 Data on Pavement Design

Table 3.21 Pavement Design Parameters for Toll Truckways

Layer properties

Mr =	7000 Psi	Layer	Structural Coefficient	Drainage Coefficient
R =	90%	Asphalt Concrete	0.42	1
S_{0} =	0.45	Asphalt-Treated Permeable Base	0.23	1
P_{0} =	4.5	Subbase	0.12	0.9
P_{t} =	2.5	Select Granular Subgrade	0.10	0.9

Layer thicknesses

Scenario	*One TTW LANE*					*Three Mixed Lanes*				
	ESAL (Millions)	Selected Granular Subgrade (in)	Subbase Course (in)	Asphalt-Treated Permeable Base (in)	Asphalt Concrete Layer (in)	ESAL (Millions)	Selected Granular Subgrade (in)	Subbase Course (in)	Asphalt-Treated Permeable Base (in)	Asphalt Concrete Layer (in)
I (base case)	0	0	0	0	0	135	6	12	4	10
II (25% trucks)	48	0	12	4	9	101	6	12	4	10
III (50% trucks)	96	6	12	4	10	67	0	12	4	10
IV (75% trucks)	145	6	12	4	10	34	0	12	4	9
V (100% trucks)	193	12	12	4	10	6	0	12	4	6

1. Computation of ESAL's is based on NYSDOT "simplified procedure" 1994 manual.

2. FHWA class 1-4 vehicles (motorcycle, cars, SUVs and buses) are ignored. Design is based on class 5-13.

Source: Samuel et. al, *Toll Truckways: A New Path Toward Safer and More Efficient Freight Transportation,* Reason Foundation Policy Study 294, June 2002

Table 3.22 Inventory of Pavement Design Software and Models

Software Name	Method Used as Response Model	Type[2]	Non Linearity	Rheology	Anisotropy	Interface	Climatic effects	Dynamic loading	Axle spectrum	Tire characteristics	Stochastic	Crack propagation	Thermal effects	Cumulated damage	Fatigue	Permanent Deform.
APAS-WIN	Multi-layer	3					Y		Y	Y			Y		Y	
AXYDIN	Axisymetric FEM[1]	1						Y								
BISAR/SPDM	Multi-layer	3				Y	Y		Y						Y	Y
CIRCLY	Multi-layer	3			Y	Y			Y	Y				Y	Y	
CAPA-3D	3D-FEM	3	Y	Y	Y	Y		Y		Y		Y	Y			
CESAR	3D-FEM	3	Y	Y	Y	Y	Y	Y		Y	Y	Y		Y	Y	Y
ECOROUTE	Multi-layer	1				Y				Y				Y		
ELSYM 5	Multi-layer	1														
KENLAYER	Multi-layer	2	Y	Y		Y		Y		Y				Y	Y	Y
MICHPAVE	Axisymetric FEM	1	Y												Y	
MMOP	Multi-layer	2	Y				Y	Y	Y	Y	Y	Y				
NOAH	Multi-layer	3			Y	Y	Y		Y		Y				Y	Y
ROADENT	Multi-layer	2				Y	Y		Y	Y						
SYSTUS	3D-FEM	2	Y	Y	Y	Y		Y		Y		Y				
VAGDIM 95	Multi-layer	3					Y						Y	Y	Y	Y
VEROAD	Multi-layer	1		Y					Y	Y	Y					
VESYS	Multi-layer	3					Y		Y	Y	Y			Y	Y	Y

[1] FEM = finite element method

[2] Type 1, response models (i.e., those that provide results only in terms of stresses and strains); Type 2, response + partial performance (i.e., those that consider the effects of loading, climate, etc. on rutting, crack initiation, etc. but do not provide a full design procedure); Type 3, full design procedure (i.e., those that provide a recommended structure (thicknesses, materials) and long-term performance predictions.)

Source: Joe W. Button, Emmanuel G. Fernando and Dan R. Middleton, *Synthesis of Pavement Issues Related to High Speed Corridors,* Texas Transportation Institute, September 2004

4.0 Integration with Intelligent Transportation Systems (Task 4)

Table 4.1 Costs and Benefits of Truck Lane Concepts Compared to Baseline ($Million)

	Alternative 2 (Without CVHAS)	Alternative 3 (Automatic Steering)	Alternative 4 (Fully Automated)	Alternative 5 (Time-Staged Automation)
Cost Components				
Construction	692	424	424	459
ROW	74	48	48	52
Annual O&M	14	15	16	15
CVHAS – Facility	0	0.4	1.6	0.8
CVHAS – Vehicle	0	146	269	40
Total Costs	780	634	758	566
Benefit Components				
Travel Time Savings	2,938	2,186	1,931	2,982
Reduction of Fuel Consumption	10	8	49	28
Total Benefits	2,949	2,194	1,980	3,010
Benefit/Cost Ratio	3.78	3.46	2.61	5.32

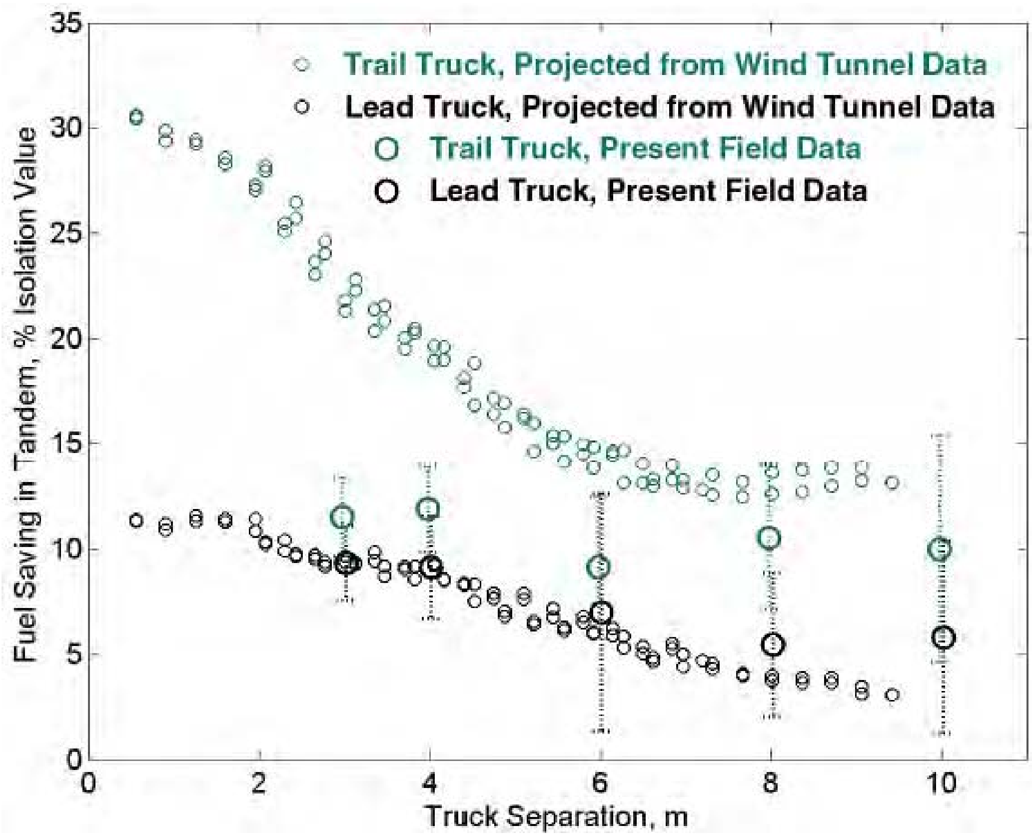
Source: Steven E. Shladover, *Advanced Vehicle Technologies and Exclusive Truck Lanes: Research from California PATH Program*, Transportation Research Board Annual Meeting, January 2006.

Table 4.2 Platooning Costs per Truck

	Near Term (annual production of hundreds of trucks)	Long Term (annual production of thousands of trucks)
Forward sensors	$2,500	$500
Wireless communication	$500	$100
Brake actuation	$5,000	$1,000
Driver interface	$1,000	Assume included
Installation/integration	$1,000	$300
Total	$10,000	$1,900

Source: Steven E. Shladover, *Advanced Vehicle Technologies and Exclusive Truck Lanes: Research from California PATH Program*, Transportation Research Board Annual Meeting, January 2006.

Figure 4.1 Fuel Savings from Close-Formation Automated Platoons



Source: Steven E. Shladover, Advanced Vehicle Technologies and Exclusive Truck Lanes: Research from California PATH Program, Transportation Research Board Annual Meeting, January 2006.

5.0 Longer Combination Vehicle Operations (Task 5)

Table 5.1 Base Year and Forecast Commercial Vehicle Travel by Truck Type (million VMT)

State	Single Unit Truck		Tractor Semi-trailer with 3 to 4 axles		Tractor Semitrailer with 5 axles		Tractor Semi-trailer with 6 or more axles		Truck Trailer with 3 to 4 axles		Truck Trailer with 5 axles		Truck Trailer with 6 or more axles		Double trailer with 5 or 6 axles		Double trailer with 7 axles		Double trailer with 8 axles or more axles		Triple Trailer	
Year	**2000**	**2010**	**2000**	**2010**	**2000**	**2010**	**2000**	**2010**	**2000**	**2010**	**2000**	**2010**	**2000**	**2010**	**2000**	**2010**	**2000**	**2010**	**2000**	**2010**	**2000**	**2010**
Colorado	1,263	1,716	155	209	1,096	1,452	82	112	16	21	27	37	6	8	37	50	21	28	3	5	2	2
Idaho	341	453	49	66	482	635	110	147	2	2	14	19	26	37	30	39	22	30	7	10	7	10
Kansas	933	985	126	138	1,151	1,280	132	144	11	13	11	13	22	27	47	54	3	4	1	1	1	1
Montana	240	255	28	30	396	422	95	104	6	7	9	10	45	53	41	45	14	15	11	13	0	0
Nebraska	454	300	126	76	2,051	318	97	133	6	8	3	8	21	40	9	14	-	-	-	-	1	0
Nevada	520	429	79	119	656	1,954	31	92	0	6	40	3	30	21	32	9	20	-	4	-	2	1
North Dakota	265	646	65	107	272	887	115	42	7	0	6	55	32	43	12	43	-	27	-	6	0	3
Oklahoma	1,410	1,710	389	467	2,639	3,153	169	203	21	25	28	35	3	4	54	65	1	2	-	-	1	1
Oregon	1,044	1,176	234	260	1,078	1,217	291	327	0	0	21	24	29	34	705	820	12	14	35	42	22	26
South Dakota	262	282	36	39	389	417	77	83	4	4	5	5	16	19	19	20	10	11	21	25	0	0
Utah	482	651	89	121	753	991	65	87	6	8	20	28	92	132	49	66	25	33	13	19	1	2
Washington	1,510	1,472	120	116	856	829	385	383	18	18	73	74	145	152	72	71	22	21	81	84	-	-
Wyoming	149	166	62	73	731	921	56	65	6	8	22	30	44	57	40	54	3	4	6	8	-	-
Total	**8,873**	**10,240**	**1,558**	**1,821**	**12,551**	**14,476**	**1,706**	**1,924**	**102**	**120**	**279**	**341**	**511**	**626**	**1,147**	**1,351**	**154**	**188**	**183**	**213**	**37**	**45**
Percent of Fleet	**31.8%**	**32.7%**	**5.6%**	**5.8%**	**45.0%**	**46.2%**	**6.1%**	**6.1%**	**0.4%**	**0.4%**	**1.0%**	**1.1%**	**1.8%**	**2.0%**	**4.1%**	**4.3%**	**0.6%**	**0.6%**	**0.7%**	**0.7%**	**0.1%**	**0.1%**

Source: Western Uniformity Scenario Analysis: A Regional Truck Size and Weight Scenario Requested by the Western Governors' Association, U.S. DOT, April 2004

Table 5.2 2010 LCV VMT in Study Area by Commodity Group and Flow Type

Commodity Group	Flow	VMT By Flow and Commodity Group			
		Base Case		Low Cube	
		Total VMT (millions)	Percent in LCVs	Total VMT (millions)	Percent in LCVs
Bulk, Tank, Flatbed (Specialized Freight)	Intra-Regional	2,101	12.7%	1,713	88.8%
	Inbound	1,098	0.8%	958	40.5%
	Outbound	2,285	0.8%	2,150	23.8%
	Through	887	0.0%	895	7.1%
	Total	6,370	4.6%	5,716	43.5%
Dryvan, Reefer (General Freight)	Intra-Regional	2,406	6.2%	2,063	53.9%
	Inbound	2,700	0.1%	2,382	35.7%
	Outbound	4,589	0.0%	4,041	34.1%
	Through	2,758	0.0%	2,827	5.0%
	Total	12,452	1.2%	11,313	30.8%
All Traffic	Intra-Regional	4,506	9.2%	3,775	69.7%
	Inbound	3,798	0.3%	3,341	37.1%
	Outbound	6,874	0.3%	6,191	30.5%
	Through	3,645	0.0%	3,722	5.5%
	Total	18,823	2.4%	17,029	35.0%

Source: Western Uniformity Scenario Analysis: A Regional Truck Size and Weight Scenario Requested by the Western Governors' Association, U.S. DOT, April 2004

Table 5.3 Overall Fatal Crash Rates of Single- and Double- Trailers

Configuration	1985 VMT (millions)	1980 – 1984 Fatal Involvements	1985 Fatal Involvement Rate (involvement/100 million VMT)[1]
Single-Trailer	33,452	16,260	10.2
Double-Trailer	2,008	829	8.6

1. According to the National Highway Traffic Safety Administration's Fatal Accident Reporting System, the average number of fatal involvements by all heavy trucks was 4,294 per year during 1980 – 1984 period and 4,492 in 1985. To obtain 1985 fatal involvement rates for each of the three types of truck configurations, 4492/4294 multiplied average 1980 – 1984 fatal involvements.

Source: Western Uniformity Scenario Analysis: A Regional Truck Size and Weight Scenario Requested by the Western Governors' Association, U.S. DOT, April 2004

Table 5.4 Example of Collision Rates on the LCV Sub-Network by Vehicle Type 1995-1998

Vehicle Type	**Crash**	**Total Distance Traveled** (100 million Km)	**Total Distance Traveled** (100 million miles)	**Crash Rate** (per 100 million Km)	**Crash Rate** (per 100 million Miles)
Tractor Semi	918	11.54	7.17	79.55	128.10
Multi Trailer	418	4.03	2.50	103.72	167.02
Rocky Mountain Doubles	11	1.07	0.66	10.28	16.55
Turnpike Double	20	1.19	0.74	16.81	27.06
LCV Doubles – all	31	2.26	1.40	13.72	22.09
Triples	6	0.09	0.06	66.67	107.35

*Crashes for the LCV sub network only - no urban miles included
To convert to miles, kilometers was multiplied by 0.621.
Multi-Trailer includes RMDs, TPDs and Triples

Source: Western Uniformity Scenario Analysis: A Regional Truck Size and Weight Scenario Requested by the Western Governors' Association, U.S. DOT, April 2004

Table 5.5 Summary of Truck Crash Rates (per Million VMT)

Source		Time Period Analyzed	Type of Crash: Non-Fatal Injury	Type of Crash: Fatal
Longer Dimensioned Vehicle Study - FHWA		1983 - 1991		
Single Trailers			31.46	2.44
	Rural Interstate		19.48	1.16
	Rural Other		34.86	4.77
	Urban Interstate		41.85	1.6
	Urban Other		114.55	7.37
Multi Trailers			25.15	2.08
	Rural Interstate		17.68	1.09
	Rural Other		32.29	4.5
	Urban Interstate		29.9	1.31
	Urban Other		137.3	12.87
Analysis of Accident Rates of Heavy-Duty Vehicles - Campbell et al		1980 - 1984		
Tractor plus single trailer				
	Rural - Limited			4.50
	Rural - Other			18.77
	Urban - Limited			5.80
	Urban - Other			14.32
Tractor plus double trailers (includes STAA Doubles)				
	Rural - Limited			4.06
	Rural - Other			23.72
	Urban - Limited			4.30
	Urban - Other			13.98
Truck Weight Limits Issues and Options - TRB		1980-1984, presented for 1985		
Tractor plus single trailer			245	10.20
Tractor plus double or Triple trailers (includes STAA Doubles)			269	11.20
Accident Rates of Multi-Unit Combination Vehicles Derived from Large-Scale Databases - Mingo et al		1986		
Tractor plus single trailer				6.02
Tractor plus double or Triple trailers (includes STAA Doubles)				9.96
Long Combination Vehicle Safety Performance in Alberta – Woodrooffe		1995 - 1998	Collisions	
Tractor plus single trailer			128.10	
Rocky Mountain Doubles			16.55	
Turnpike Doubles			27.06	
Tractor plus double trailers			22.09	1.42
Tractor plus three trailers			107.35	

*The reader should exercise care when comparing across studies since different data sources and definitions of variables were used in each study.

Source: Western Uniformity Scenario Analysis: A Regional Truck Size and Weight Scenario Requested by the Western Governors' Association, U.S. DOT, April 2004

Table 5.6 Current Use by Truck Configuration Type

Configuration Type	Number of Axles	Common Maximum Weight (pounds)	Current Use
Semitrailer	5	80,000 - 99,000	Most used combination vehicle. It is used for long and short hauls in all urban and rural areas to carry and distribute all types of materials, commodities, and goods
	6 or more	80,000 - 100,000	Used to haul heavier materials, commodities, and goods for hauls longer than those of the four-axle single-unit truck.
STAA Double	5, 6	80,000	Most common multi-trailer combination. Used for less-than-truckload (LTL) freight mostly on rural freeways between LTL terminals.
B-train Double	8	105,500 - 137,800	Mostly used in flatbed trailer operations and for liquid bulk hauls
Rocky Mountain Double (RMD)	7	105,500 - 129,000	In the Western States used as a resource hauling vehicle, usually open hopper, tank, or flat.
Turnpike Double (TPD)	9	105,500 - 147,000	Some truckload operations similar to a 5 or 6 axle Semitrailer but mostly a western State resource-hauling vehicle.
Triple Trailer Combination	7	90,000 – 129,000	Similar to an STAA Double, used for less-than-truckload (LTL) freight mostly on rural freeways between LTL terminals.

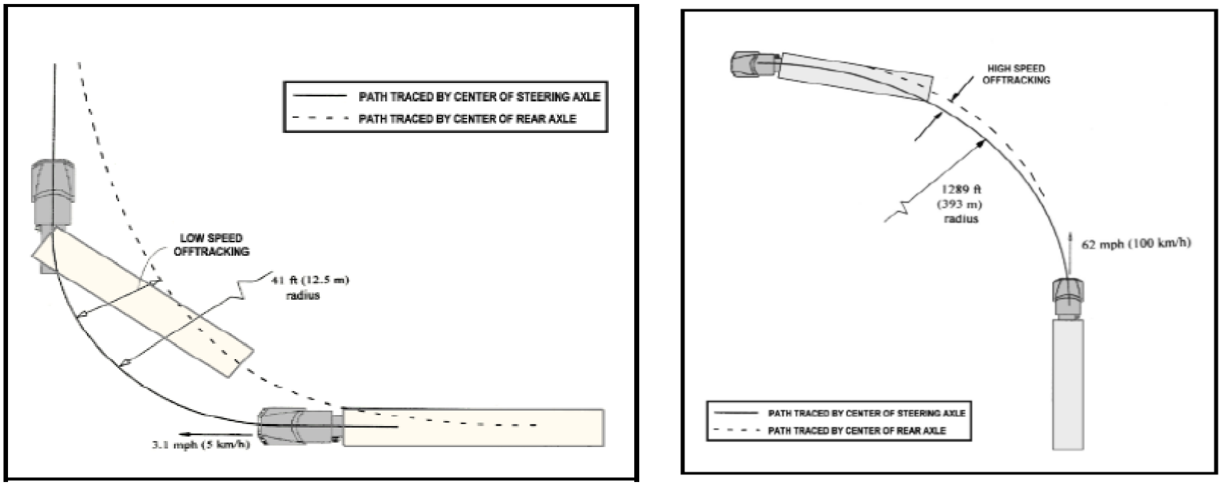
Source: Western Uniformity Scenario Analysis: A Regional Truck Size and Weight Scenario Requested by the Western Governors' Association, U.S. DOT, April 2004

Table 5.7 Likely Truck Configuration Impacts of Western Uniformity Scenario

Original Truck Configuration		Likely Reaction to the Scenario
Five-axle tractor semitrailer	→	Change to Rocky Mountain Double
	→	Change to Turnpike Double
Five- or Six-axle double-trailer combination (LTL freight)	→	Change to triple-trailer combination (LTL freight)
Rocky-Mountain (or short) double-trailer combination	→	More payload
Turnpike (or long) double-trailer combination	→	More payload
Triple-trailer combination	→	No change

Source: Western Uniformity Scenario Analysis: A Regional Truck Size and Weight Scenario Requested by the Western Governors' Association, U.S. DOT, April 2004

Figure 5.1 Low Speed and High Speed Offtracking



Source: Western Uniformity Scenario Analysis: A Regional Truck Size and Weight Scenario Requested by the Western Governors' Association, U.S. DOT, April 2004

Table 5.8 Scenario Roadway Geometry Impacts

Analytical Case	Worst Offtracking Vehicle On Roadway	Improvement Costs ($ million)				
		Mainline Curves	Intersections	Interchanges	Total	Incremental to Base Case
Base Case	RMD	$47	$99	$5	$152	
	TPD	$112	$214	$387	$713	
	Total Cost	**$159**	**$313**	**$393**	**$864**	**NA**
Western Uniformity Low Cube	RMD	$165	$394	$12	$571	
	TPD-45	$109	$159	$445	$714	
	Total Cost	**$274**	**$553**	**$457**	**$1,284**	**$420**
Western Uniformity High Cube	RMD	$165	$394	$12	$571	
	TPD-48	$150	$221	$698	$1,069	
	Total Cost	**$314**	**$615**	**$710**	**$1,639**	**$775**

Source: Western Uniformity Scenario Analysis: A Regional Truck Size and Weight Scenario Requested by the Western Governors' Association, U.S. DOT, April 2004

Table 5.9 Scenario Pavement Impacts

Analytical Case	VMT in Region (millions)		Impacts (millions of 2000 $)			
	All Highway Vehicles	**Study Vehicles**	**Annual Pavement Cost**	**20-Year Pavement Cost**	**Change from Base Case**	**Study Vehicles' Share**
2010 Base Case	381,801	18,823	$3,297	$65,934	--	76.0%
Low Cube Scenario	380,008	17,029	$3,284	$65,676	-0.4%	75.4%
High Cube Scenario	377,006	14,028	$3,157	$63,147	-4.2%	73.0%

Source: Western Uniformity Scenario Analysis: A Regional Truck Size and Weight Scenario Requested by the Western Governors' Association, U.S. DOT, April 2004

Table 5.10 Example of Costs Associated with Full Replacement/Less than Full Replacement for 8 Overstress Thresholds

Overstress Threshold (Percentage of Inventory Rating)	Number of Actual Deficient Bridges	Full Replacement Costs ($ millions)	Less Than Full Replacement Costs ($ millions)
1.00	15,749	$12,922	$8,614
1.05	11,041	$8,628	$5,746
1.10	7,315	$5,317	$3,544
1.15	5,079	$3,257	$2,171
1.20	3,756	$2,379	$1,586
1.25	2,931	$1,656	$1,104
1.30	2,431	$1,294	$ 863
1.3664	1,975	$839	$ 559

Source: Western Uniformity Scenario Analysis: A Regional Truck Size and Weight Scenario Requested by the Western Governors' Association, U.S. DOT, April 2004

Table 5.11 Current LCV Access Provisions

State	Provision
Colorado	Limited to 10 miles
Idaho	Specified Staging Areas (privately operated)
Kansas	State Issued Access Permit
Montana	Triples Limited to 2 miles off Interstate; Doubles - Reasonable Access
Nebraska	Within 6 miles of Interstate and approved by State
Nevada	Reasonable Access
North Dakota	Reasonable Access
Oklahoma	Limited to 5 miles from Interstate or 4 lane divided highway
Oregon	Staging at Private Facilities for Triples
South Dakota	Reasonable Access
Utah	Off-Interstate Routes as authorized by State
Washington	Reasonable Access
Wyoming	Reasonable Access

Source: Western Uniformity Scenario Analysis: A Regional Truck Size and Weight Scenario Requested by the Western Governors' Association, U.S. DOT, April 2004

Table 5.12 Example of Horsepower Requirements

Weight/ Horsepower Ratio (pounds)	Horsepower Required for Weight-to-Horsepower Ratio in Right Column					
	Typical 3S2* Tare Weight 30,000 lbs	**Typical 3S2* Partial Load 60,000 lbs**	**Maximum 3S2* Load 80,000 lbs**	**Triples Uniformity Weight 110,000 lbs**	**Typical Uniformity 8-axle LCV 120,000 lbs**	**Maximum Uniformity LCV 129,000 lbs**
150	200	400	533	733	800	860
200	150	300	400	550	600	645
250	120	240	320	440	480	516

*3S2 is a 5-axle tractor semitrailer with 3-axles on the tractor and 2-axles on the semitrailer.

Source: Western Uniformity Scenario Analysis: A Regional Truck Size and Weight Scenario Requested by the Western Governors' Association, U.S. DOT, April 2004

Table 5.13 Miles per Gallon by Truck Configuration and Weight

Configurations	Gross Vehicle Weight (pounds)				
	60,000	**80,000**	**100,000**	**120,000**	**140,000**
Five-Axle Semitrailer	5.44	4.81	4.31		
Six-Axle Semitrailer	5.39	4.76	4.27		
Five-Axle STAA Double	5.95	5.29	4.79		
Seven-Axle Rocky Mountain Double		5.08	4.58	4.36	4.16
Eight-Axle (or more) Double		5.08	4.82	4.58	4.36
Triple-Trailer Combination		5.29	5.01	4.76	4.54

Source: Western Uniformity Scenario Analysis: A Regional Truck Size and Weight Scenario Requested by the Western Governors' Association, U.S. DOT, April 2004

Table 5.14 Noise Passenger Car Equivalents for Trucks

Vehicle Type	Speed				
	20	**30**	**40**	**50**	**60**
Passenger	1.00	1.00	1.00	1.00	1.00
Truck	84.85	43.82	27.42	19.06	14.16

Source: Western Uniformity Scenario Analysis: A Regional Truck Size and Weight Scenario Requested by the Western Governors' Association, U.S. DOT, April 2004

Table 5.15 Summary of Energy and Environment Impacts for 13 States Analyzed

Impact	Base Case	Low Cube – Change from Base Case		High Cube – Change from Base Case	
		Absolute	**Percentage**	**Absolute**	**Percentage**
Energy Consumption (million gallons)	5,084	4,921	- 3.20%	4,471	- 12.06%
Emissions			-3.20%		-12.06%
Air Pollution Costs	NA	NA	NA	NA	NA
Noise Cost ($ millions)	$539	$532	- 1.43%	$487	- 9.67%

Source: Western Uniformity Scenario Analysis: A Regional Truck Size and Weight Scenario Requested by the Western Governors' Association, U.S. DOT, April 2004

Table 5.16 Comparative Productivity of Existing Truck Configurations

	Tractor / Semitrailer	STAA Double	Rocky Mountain Double	Turnpike Double	Triple
Configuration	3-S2	2-S1-T2	3-S2-T2	3-S2-T4	2-S1-T2-T2
	5-axle	5-axle	7-axle	9-axle	7-axle
Trailers (ft)	to 53 ft (1)	2x28 ft	48+28 ft	2x48 ft	3x28 ft
Gross wt. (000lbs)	80	80	119	148	132
Empty wt. (000lbs)	30	30	43	47	44
Payload (000lbs)	50	50	76	101	88
Payload Ratio (relative to tractor/semi)	1.0	1.0	1.52	2.02	1.76
Trips to move 500,000 lb	10	10	7	5	6

(1) Longer lengths have been "grandfathered"

Source: Toll Truckways: A New Path Toward Safer and More Efficient Freight Transportation, The Reason Foundation

Table 5.17 Urban Toll Truckway Productivity

		Mixed Freeway Semitrailer	Truckway Semitrailer	Truckway Triple Short	Truckway Turnpike Double
A	Payload (lbs)	45,000	45,000	67,500	90,000
B	Metric tons	20	20	30	40
C	100 mile delivery (2004 freight rates)	$500	$500	$750	$1,000
D	Average speed on the road	38 MPH	60 MPH	60 MPH	60 MPH
E	Miles driven in 8-hr shift (6 hrs driving)	228 mi	360 mi	360 mi	360 mi
F	Revenue from 6 hrs payload at 2004 rates	$1,140	$1,800	$2,700	$3,600
G	Variable costs	$684	$684	$1,007	$1,165
H	Available for overhead, profits, tolls	$456	$1,116	$1,693	$2,435
I	Extra earnings from using truckways/shift/day	n/a	$660	$1,237	$1,979
J	Assume extra productivity split 3 ways	n/a	$220	$412	$660
K	Shippers savings on 100 mile delivery	n/a	$61 / 12.2%	$76 / 15.2%	$91 / 18.3%

Source: TOLL TRUCKWAYS: Increasing Productivity and Safety in Goods Movement, presentation by Robert W. Poole, Jr. and Peter Samuel

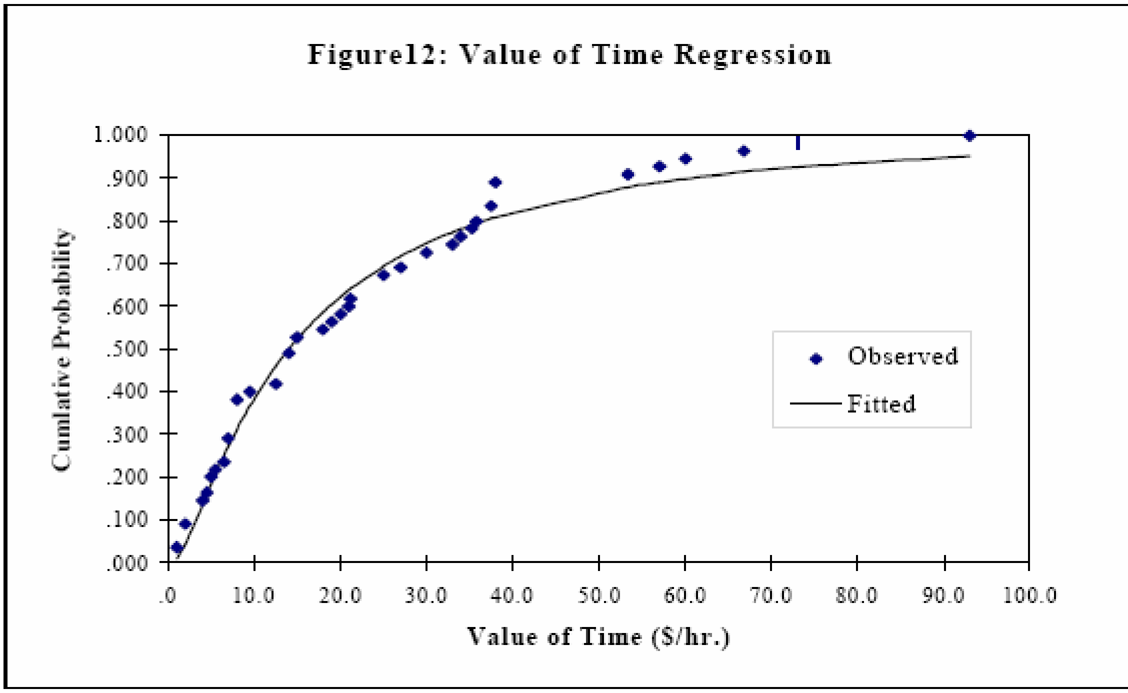
Table 5.18 Example of Lost Revenue, Freight Service Expense, and Contribution – Freight Rail ($, millions)

Railroad	Revenues Lost from Diversion	Revenues Lost from Rail Discounting	Total Lost Revenues	Lost Freight Service Expense	Lost Rail Contribution
Industry	$12.09	$25.96	$38.05	$3.55	$34.50
Burlington Northern Santa Fe	$5.77	$9.94	$15.71	$0.99	$14.72
Union Pacific	$6.12	$15.51	$21.62	$2.16	$19.46

Source: Western Uniformity Scenario Analysis: A Regional Truck Size and Weight Scenario Requested by the Western Governors' Association, U.S. DOT, April 2004

6.0 Tolling and Privatization (Task 6)

Figure 6.1 Cumulative Density Function (CDF) for Truck Value of Time



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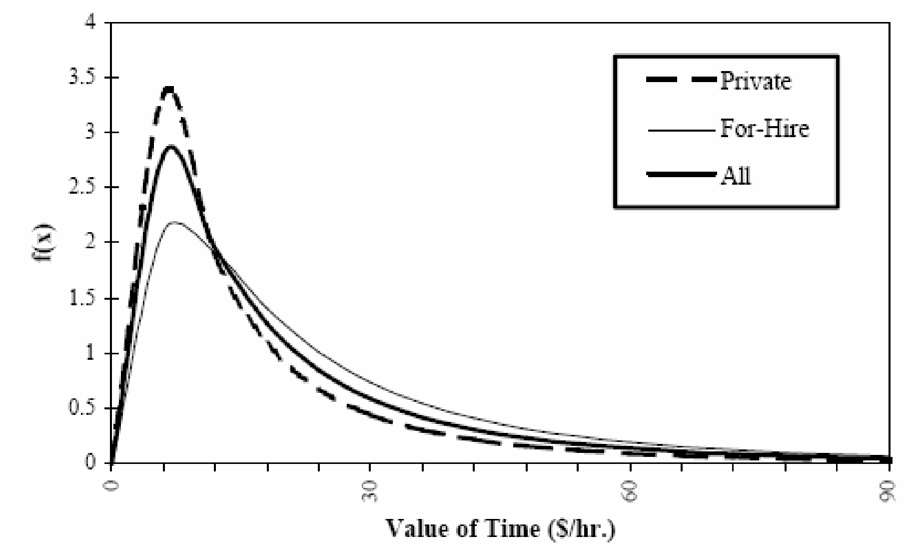
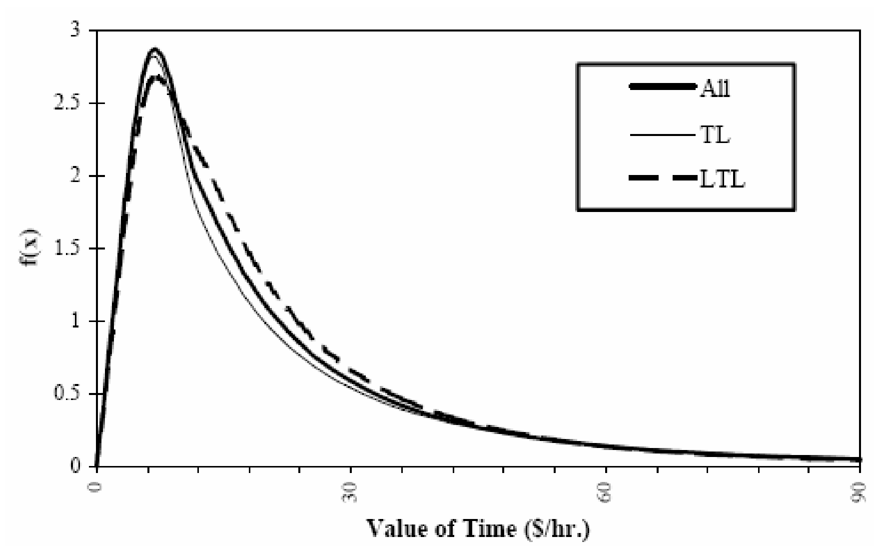
Source: Kazura Kawamura, Commercial Vehicle Value of Time and Perceived Benefit of Congestion Pricing, UC Berkeley Dissertation, 1999

Figure 6.2 Probability Density Function (PDF) for Truck Value of Time (Private vs. For-hire Trucks)



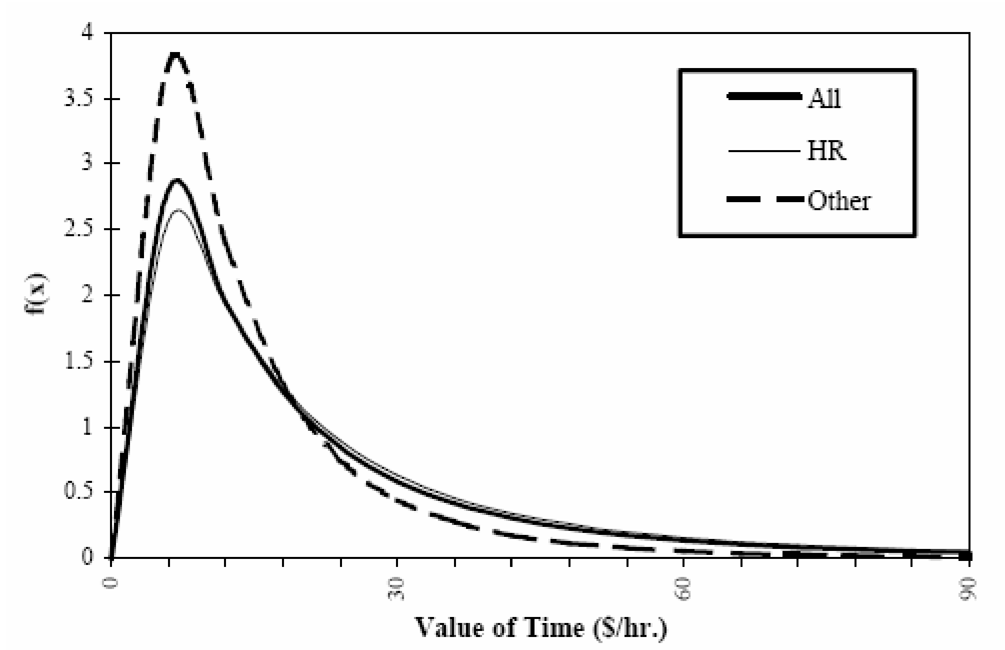
Source: Kazura Kawamura, Commercial Vehicle Value of Time and Perceived Benefit of Congestion Pricing, UC Berkeley Dissertation, 1999

Figure 6.3 Probability Density Function (PDF) for Truck Value of Time (TL vs. LTL)



Source: Kazura Kawamura, Commercial Vehicle Value of Time and Perceived Benefit of Congestion Pricing, UC Berkeley Dissertation, 1999

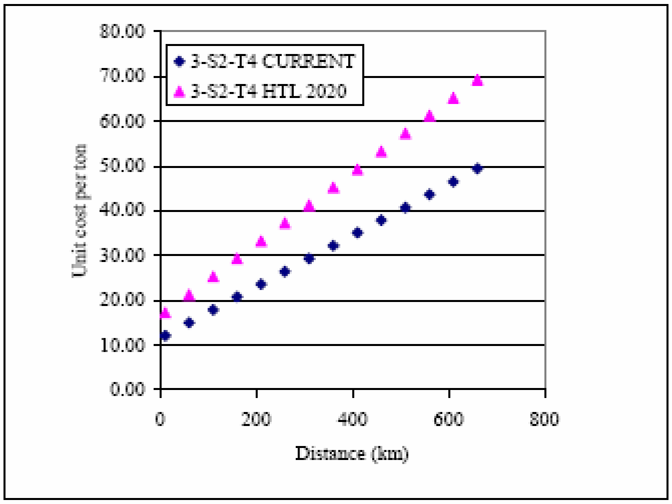
Figure 6.4 Probability Density Function (PDF) for Truck Value of Time (Hourly vs. Other Pay Base)



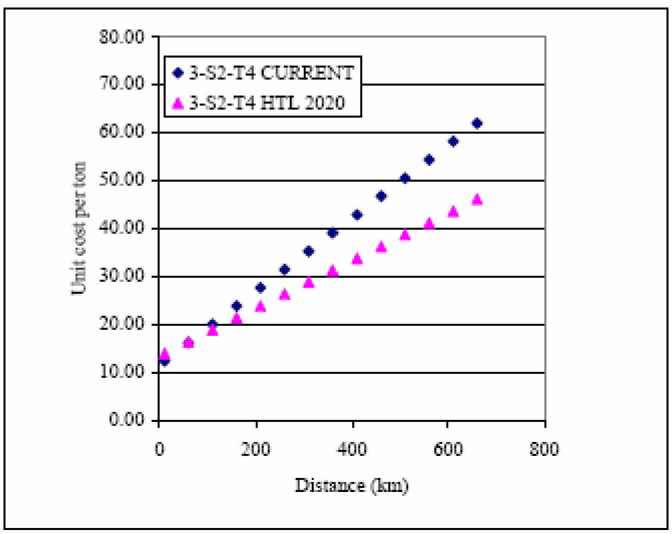
Source: Kazura Kawamura, Commercial Vehicle Value of Time and Perceived Benefit of Congestion Pricing, UC Berkeley Dissertation, 1999

Figure 6.5 Truck Unit Cost Per Ton Graphs

a) transporting 15 tons

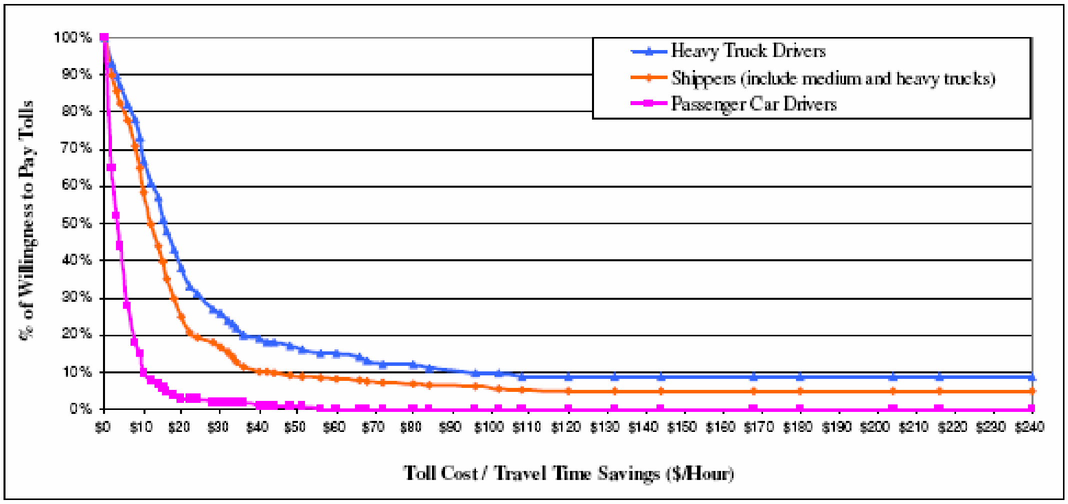


b) transporting 30 tons



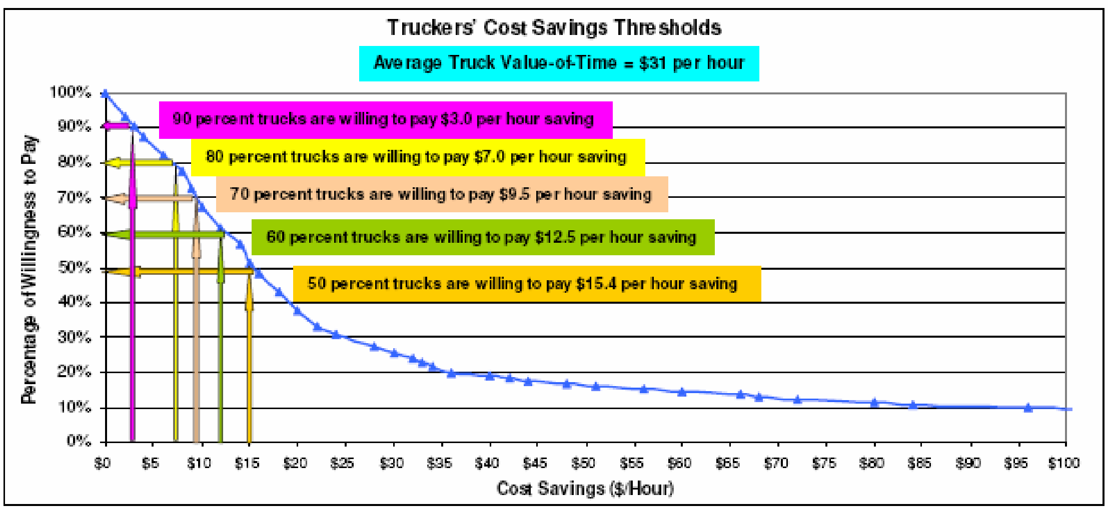
Source: Holguin-Veras, Sackey, Hussain and Ochieng, *On the Economic and Financial Feasibility of Toll Truckways,* TRB 2003 Annual Meeting

Figure 6.6 Trucker Willingness to Pay Distributions



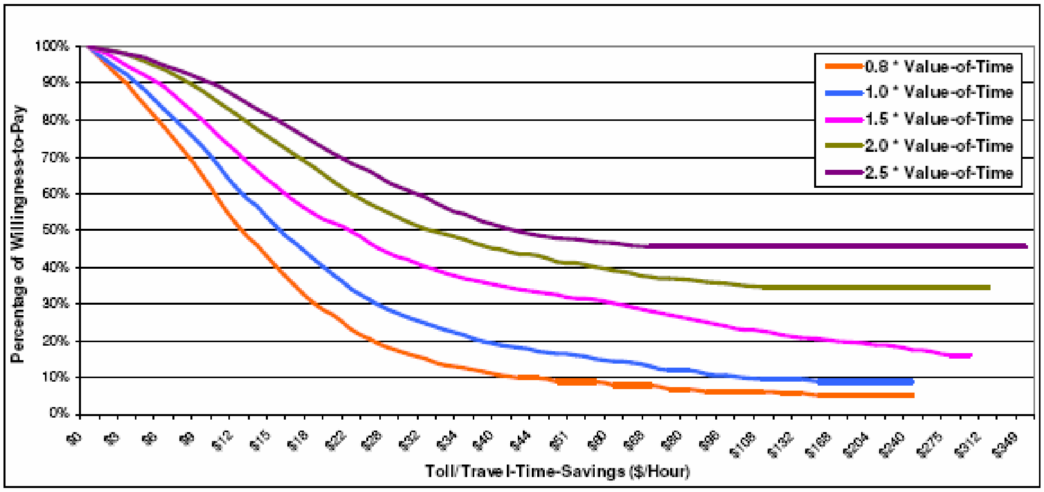
Source: State Road & Tollway Authority (SRTA), *Value Pricing on the I-75 HOV/BRT Project*, 2006

Figure 6.7 Trucker Cost Saving Thresholds



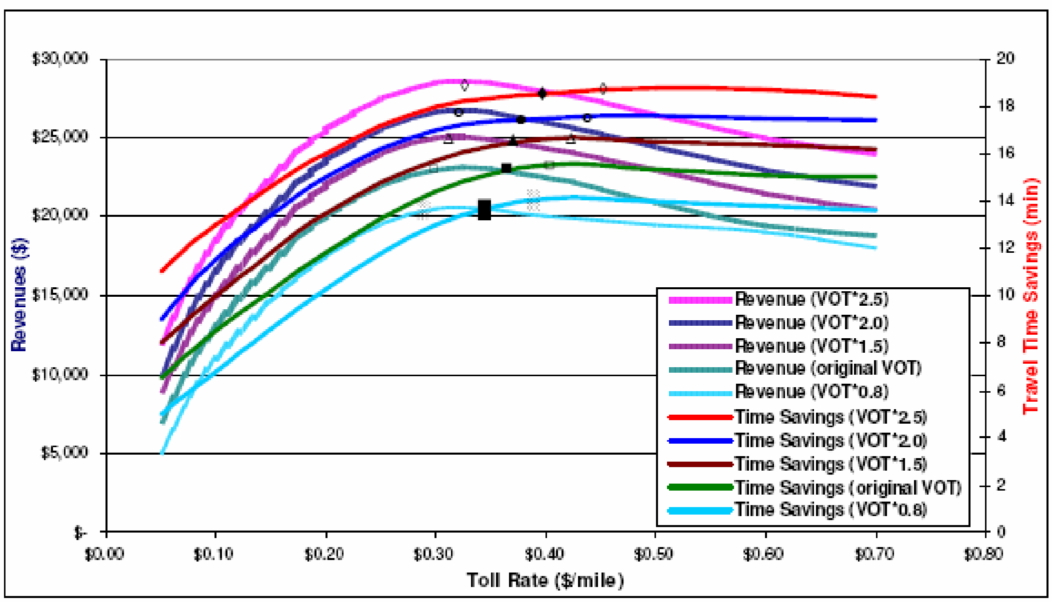
Source: Hsing-Chung Chu, *Implementing Truck-Only Toll Lanes at the State, Regional, and Corridor Levels: Development of a Planning Methodology*, PhD Dissertation, Georgia Institute of Technology, December 2007

Figure 6.8 Truck Driver Willingness to Pay Curves



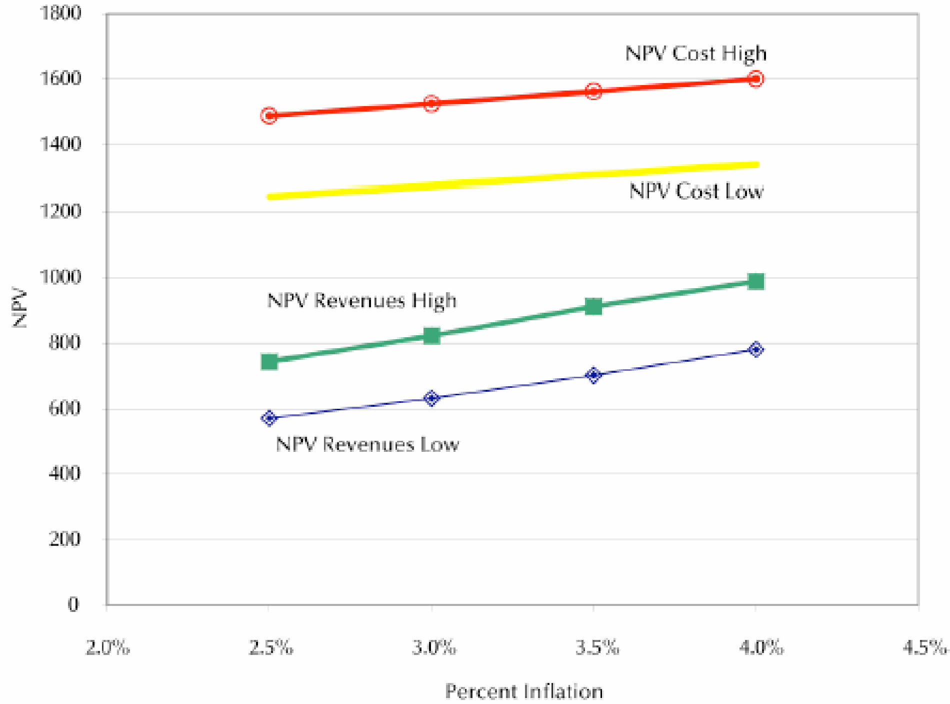
Source: Hsing-Chung Chu, *Implementing Truck-Only Toll Lanes at the State, Regional, and Corridor Levels: Development of a Planning Methodology*, PhD Dissertation, Georgia Institute of Technology, December 2007

Figure 6.9 Relationship between Toll Rates, Revenues and Travel Time Savings



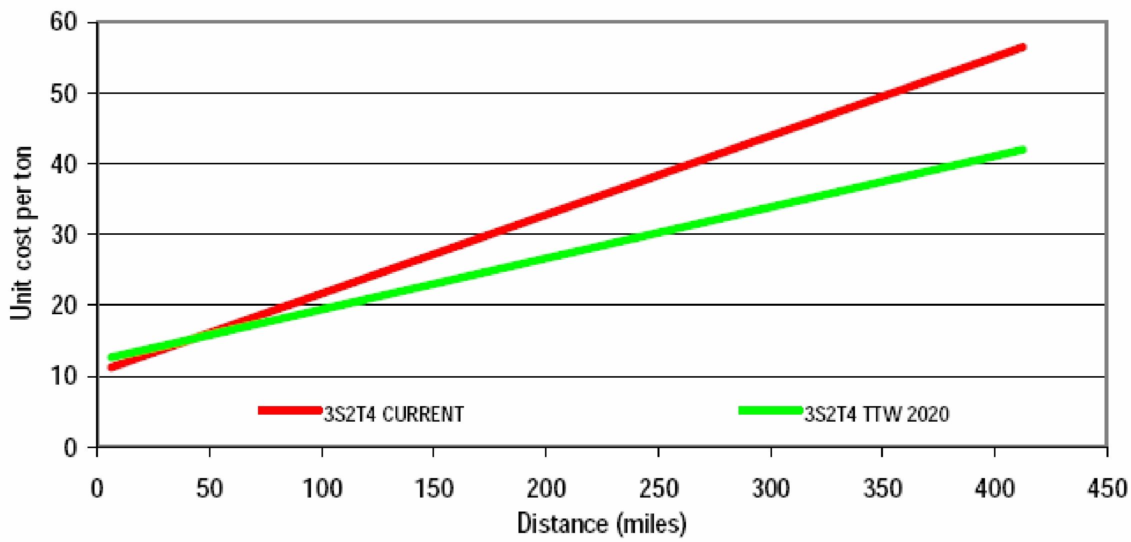
Source: Hsing-Chung Chu, *Implementing Truck-Only Toll Lanes at the State, Regional, and Corridor Levels: Development of a Planning Methodology*, PhD Dissertation, Georgia Institute of Technology, December 2007

Figure 6.10 Sensitivity of Net Present Value (NPV) to Inflation Rate (Consumer Price Index)



Source: Robert Poole, Jr., *Miami Toll Truckway: Preliminary Feasibility Study*, Reason Foundation Policy Study 365, November 2007

Figure 6.11 Toll Truckway Cost Function



Source: Samuel et. al, *Toll Truckways: A New Path Toward Safer and More Efficient Freight Transportation*, Reason Foundation Policy Study 294, June 2002

Table 6.1 Truck Value of Time Distributions by Type of Trucking Operation

Data Group	Mean	St. Dev.	Mode	Median
All	23.4	32.0	4.8	13.9
Private	17.6	24.8	3.4	10.1
For-Hire	28.0	32.4	7.8	18.3
TL	25.0	40.4	3.6	13.1
LTL	22.6	25.0	6.8	15.2
Hourly Pay	25.4	33.5	5.6	15.3
Other Pay Scale	15.1	14.9	5.5	10.7

Note: Values are in $/hour.

Source: Kazura Kawamura, Commercial Vehicle Value of Time and Perceived Benefit of Congestion Pricing, UC Berkeley Dissertation, 1999

Table 6.2 Summary of Previous Value of Time Studies

Authors	Year of Publication	Focus	Location	Adjusted to 2003	Average
Haning and McFarland	1963	Truck Operators		$19.57 to $25.42	$22.50
Waters et al.	1995	Truck Operators		$6.86 to $38.92	$22.89
Kawamura	1998	Truck Operators		$30.14	$30.14
Brownstone et al.	2002	Autombiles	San Diego, CA	$30.58	$30.58
Small and Yan	2001	Autombiles	California	$21.36	$21.36
Adkins et al.	1967	Cargo Vehicles		$25.81	$25.81
				Overall Average	$25.55
				Standard Deviation	$4.01

Source: Smalkoski, Brian, and Levinson, D. (2005) Value of Time for Commercial Vehicle Operators, Journal of the Transportation Research Forum 44:1 89-102.

Table 6.3 Switching Point Analysis for Truck Value of Time

	P1: Trucks	P1: Time (min.)	P2: Permit, Time Savings Per Truck Load ($)	P3: Permit, Total Truck Load Savings ($)	P4: Seasonal Permit, Total Truck Load Savings ($)	P4/40: Seasonal Adjusted to Single Savings ($)	P5: Fine, Time Savings Per Truck Load ($)	P6: Fine, Total Truck Load Savings ($)	Mean ($)	Max P ($)
Mean	5.82	176.61	36.70	30.23	653.41	16.34	19.50	17.35	24.10	46.78
Median	5.00	176.00	38.75	13.75	300.00	7.50	3.75	1.88	10.00	48.75
Mode	4.00	120.00	0.00	0.00	0.00	0.00	0.00	0.00		
Max	8.00	240.00	78.75	78.75	3,150.00	78.75	78.75	78.75		
Min	4.00	120.00	0.00	0.00	0.00	0.00	0.00	0.00		
Standard Deviation	1.85	55.44	28.10	30.34	857.82	21.45	27.86	25.88	27.98	27.07

Notes:

- *P refers to presentation*
- *P2 is a scenario where there is a trade-off between an hour of time savings for each truck with a single use permit versus no time savings for zero cost.*
- *P3 is a scenario where there is a trade-off between a savings of one truck load with a single use permit versus no truck load savings for zero cost.*
- *P4 is a scenario where there is a trade-off of having to run fewer truck loads over the SLR period for the cost of a seasonal permit, or more truck loads for the same amount of product for zero cost.*
- *P4/40 adjusts the 40 hours of time savings to one hour.*
- *P5 is similar to the second presentation except in this case, fines are used instead of single use permits.*
- *P6 is the same as P3, except that fines were used in the place of single use permits. The second set of data presented in this table averages the two single use permit scenarios and the two fine scenarios.*

Source: Smalkoski, Brian, and Levinson, D. (2005) Value of Time for Commercial Vehicle Operators, Journal of the Transportation Research Forum 44:1 89-102.

Table 6.4 Payload Factors from Truck Only Lane Implementation (HTL – Heavy Truck Lane)

	BASE CASES									
		Base case A		Base case B		Heavy Truck Lane (HTL)			% increase	
Type of vehicle	Empty weight	GWL	Pay-load	GWL	Pay-load	Empty weight	GWL	Pay-load	HTL vs. BCA	HTL vs. BCB
SU2	5.80	18.00	12.20	15.50	9.70	7.54	23.25	15.71	28.77%	61.96%
SU3	10.80	21.50	10.70	23.50	12.70	14.04	35.25	21.21	98.22%	67.01%
SU4	12.00	22.00	10.00	29.50	17.50	15.60	44.25	28.65	186.50%	63.71%
2-S1	11.40	23.00	11.60	25.50	14.10	14.82	38.25	23.43	101.98%	66.17%
2-S2	13.35	30.00	16.65	33.50	20.15	17.36	50.25	32.90	97.57%	63.25%
2-S3	23.25	35.00	11.75	39.50	16.25	30.23	59.25	29.03	147.02%	78.62%
3-S1	13.25	30.00	16.75	33.50	20.25	17.23	50.25	33.03	97.16%	63.09%
3-S2	15.20	35.00	19.80	41.50	26.30	19.76	62.25	42.49	114.60%	61.56%
3-S3	25.10	36.00	10.90	47.50	22.40	32.63	71.25	38.62	254.31%	72.41%
SU2-T2 (1)	10.05	30.00	19.95	26.50	16.45	13.07	39.75	26.69	33.76%	62.22%
SU2-T2 (2)	11.05	32.00	20.95	35.50	24.45	14.37	53.25	38.89	85.61%	59.04%
SU3-T2 (1)	15.05	34.00	18.95	34.50	19.45	19.57	51.75	32.19	69.84%	65.48%
SU3-T3 (2)	15.80	35.00	19.20	43.50	27.70	20.54	65.25	44.71	132.86%	61.41%
2-S1-T2 (1)	15.65	35.00	19.35	36.50	20.85	20.35	54.75	34.41	77.80%	65.01%
2-S1-T2 (2)	16.65	36.00	19.35	45.50	28.85	21.65	68.25	46.61	140.85%	61.54%
3-S1-T2 (1)	17.50	36.00	18.50	44.50	27.00	22.75	66.75	44.00	137.84%	62.96%
3-S1-T2 (2)	18.50	36.00	17.50	53.50	35.00	24.05	80.25	56.20	221.14%	60.57%
3-S1-T4	19.00	36.00	17.00	69.50	50.50	24.70	104.25	79.55	367.94%	57.52%
3-S2-T2 (1)	19.45	36.00	16.55	52.50	33.05	25.29	78.75	53.47	223.05%	61.77%
3-S2-T2 (2)	20.45	36.00	15.55	61.50	41.05	26.59	92.25	65.67	322.28%	59.96%
3-S2-T4	20.95	36.00	15.05	77.50	56.55	27.24	116.25	89.02	491.46%	57.41%
Average									163.4%	63.46%

Note: (1) trailers with single tires; (2) trailers with dual tires; (2) GWL refers to gross weight limit.

Source: Holguin-Veras, Sackey, Hussain and Ochieng, *On the Economic and Financial Feasibility of Toll Truckways,* TRB 2003 Annual Meeting,

Table 6.5 Private Return on Investment Estimates (For total volume of 20,000 vehicles/day)

Indicators of private return on investment (20,000 vehicles/day)

a) Base investment

	1 to 1 truck shift			1.5 to 1 truck shift		
TRAFFIC	Toll=$0.05	Toll=$0.25	Toll=$0.5	Toll=$0.05	Toll=$0.25	Toll=$0.5
25% Trucks (1000)	---	9.18%	17.26%	---	6.07%	12.23%
50% Trucks (2000)	1.84%	17.44%	33.28%	---	12.13%	22.84%
75% Trucks (3000)	3.16%	23.92%	48.46%	1.91%	23.92%	48.46%
100% Trucks (4000)	5.89%	33.11%	64.60%	3.46%	22.65%	43.72%

b) Base investment + 0.588 million dollars/km

	1 to 1 truck shift			1.5 to 1 truck shift		
TRAFFIC	Toll=$0.05	Toll=$0.25	Toll=$0.5	Toll=$0.05	Toll=$0.25	Toll=$0.5
25% Trucks (1000)	---	4.39%	9.44%	---	2.22%	6.40%
50% Trucks (2000)	---	9.32%	17.62%	---	6.38%	12.30%
75% Trucks (3000)	---	13.29%	25.50%	---	9.33%	17.63%
100% Trucks (4000)	2.27%	17.34%	33.38%	---	12.04%	22.87%

c) Base investment + 1.176 million dollars/km

	1 to 1 truck shift			1.5 to 1 truck shift		
TRAFFIC	Toll=$0.05	Toll=$0.25	Toll=$0.5	Toll=$0.05	Toll=$0.25	Toll=$0.5
25% Trucks (1000)	---	2.38%	6.42%	---	---	4.04%
50% Trucks (2000)	---	6.34%	12.28%	---	4.09%	8.57%
75% Trucks (3000)	---	9.16%	17.57%	---	6.34%	12.28%
100% Trucks (4000)	---	12.03%	22.86%	---	8.33%	15.83%

Source: Holguin-Veras, Sackey, Hussain and Ochieng, *On the Economic and Financial Feasibility of Toll Truckways,* TRB 2003 Annual Meeting,

Table 6.6 Private Return on Investment Estimates (For total volume of 40,000 vehicles/day)

Indicators of private return on investment (40,000 vehicles/day)

a) Base investment

	1 to 1 truck shift			1.5 to 1 truck shift		
TRAFFIC	Toll=$0.05	Toll=$0.25	Toll=$0.5	Toll=$0.05	Toll=$0.25	Toll=$0.5
25% Trucks (2000)	1.84%	17.44%	33.28%	---	12.13%	22.84%
50% Trucks (4000)	5.87%	33.11%	64.60%	3.54%	22.66%	43.72%
75% Trucks (6000)	9.26%	23.92%	48.46%	5.88%	23.92%	48.46%
100% Trucks (8000)	12.27%	64.46%	127.21%	8.06%	43.52%	85.47%

b) Base investment + 0.588 million dollars/km

	1 to 1 truck shift			1.5 to 1 truck shift		
TRAFFIC	Toll=$0.05	Toll=$0.25	Toll=$0.5	Toll=$0.05	Toll=$0.25	Toll=$0.5
25% Trucks (2000)	---	9.32%	17.62%	---	6.38%	12.30%
50% Trucks (4000)	2.26%	17.34%	3.38%	---	12.06%	22.88%
75% Trucks (6000)	4.61%	25.22%	49.13%	2.28%	17.34%	33.38%
100% Trucks (8000)	6.38%	33.07%	64.87%	3.86%	22.53%	43.86%

c) Base investment + 1.176 million dollars/km

	1 to 1 truck shift			1.5 to 1 truck shift		
TRAFFIC	Toll=$0.05	Toll=$0.25	Toll=$0.5	Toll=$0.05	Toll=$0.25	Toll=$0.5
25% Trucks (2000)	---	6.34%	12.28%	---	3.70%	8.30%
50% Trucks (4000)	---	12.02%	22.86%	---	8.03%	15.59%
75% Trucks (6000)	2.71%	17.33%	33.38%	---	11.76%	22.66%
100% Trucks (8000)	4.11%	22.56%	43.89%	3.31%	15.98%	30.03%

Source: Holguin-Veras, Sackey, Hussain and Ochieng, *On the Economic and Financial Feasibility of Toll Truckways,* TRB 2003 Annual Meeting,

Table 6.7 Net Present Value (NPV) Estimates

Net Present Value (base investment)

TRAFFIC		20,000 vehicles/day BASE INVESTMENT 1 to 1 truck shift	20,000 vehicles/day BASE INVESTMENT 1.5 to 1 truck shift	40,000 vehicles/day BASE INVESTMENT 1 to 1 truck shift	40,000 vehicles/day BASE INVESTMENT 1.5 to 1 truck shift
25% Trucks (1000)	Agency costs	1.52	1.50	1.62	1.58
	VOC savings	5.27	9.27	17.40	25.63
	Travel time savings	6.15	6.21	29.30	29.45
	NPV:	9.90	13.97	45.07	53.50
	IRR (%):	28.90	38.50	58.10	78.00
50% Trucks (2000)	Agency costs	1.55	1.51	1.72	1.66
	VOC savings	-2.82	5.41	1.16	18.30
	Travel time savings	11.10	11.34	43.79	44.09
	NPV:	6.81	15.24	43.22	60.73
	IRR (%):	20.20	37.40	40.40	76.90
75% Trucks (3000)	Agency costs	1.57	1.52	1.74	1.68
	VOC savings	-11.75	0.33	-17.74	8.51
	Travel time savings	14.29	14.50	53.58	54.05
	NPV:	0.97	13.31	34.10	60.87
	IRR (%):	8.60	35.60	22.60	73.90
100% Trucks (4000)	Agency costs	1.63	1.56	1.80	1.73
	VOC savings	-20.70	-3.57	-36.51	0.29
	Travel time savings	19.31	19.62	64.25	64.93
	NPV:	-3.02	14.49	25.94	63.49
	IRR (%):	---	34.00	13.30	70.50

Note: NPV values are discounted with a 6% rate (in millions of US dollars/km)
VOC: vehicle operating costs

Source: Holguin-Veras, Sackey, Hussain and Ochieng, *On the Economic and Financial Feasibility of Toll Truckways,* TRB 2003 Annual Meeting

Table 6.8 Germany's Truck Toll Rates

Emission Category	3 Axles or Fewer	4 Axles or More
Category A (Euro 5)	0.09 ($/km)	0.10 ($/km)
Category B (Euro 3 and Euro 4)	0.11 ($/km)	0.12 ($/km)
Category C (Euro 1, Euro 2, and vehicles not in any emission category)	0.13 ($/km)	0.14 ($/km)

Source: Federal Ministry of Transport, Building and Urban Affairs, 2007

Table 6.9 Examples of Truck Value of Time by Region

	Value-of-Time ($/Hr)		Shipper / Carrier	Survey Year	Survey Method	Survey Interstate Corridor
	Average	Range				
California[1]	52	22 ~ 193	Heavy truck	1999	SP	
USA[2]	25 (national average)		Heavy truck	2000		
Minnesota[3]	50	0 ~ 80	Heavy truck	2003	SP	
26 States[4]		25 ~ 200	Shipper / Driver	2005		I-5, I-10, I-45, I-65, I-70
SCAG[5]	73		Heavy truck	2005		I-10, I-15
Virginia[6]	60		Heavy truck	2006		I-81
Georgia[7]	22 / 31	0 ~ 240	Shipper / Driver	2006	SP	I-75

Source: Hsing-Chung Chu, *Implementing Truck-Only Toll Lanes at the State, Regional, and Corridor Levels: Development of a Planning Methodology,* PhD Dissertation, Georgia Institute of Technology, December 2007

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Table 6.10 Comparisons of Truck Operating Parameters between Standard Truck and LCV*

	3-S2		3-S2-T4	
Input data	Current	TTW	Current	TTW
Driver wages and benefits	$25.00	$30.00	$25.00	$30.00
Other crew members	$0.00	$0.00	$0.00	$0.00
Crew insurance	$1.00	$1.00	$1.00	$1.00
Cargo value ($/hr-ton)	$1.82	$1.82	$1.82	$1.82
Operational speed (mi/hr)	65.00	65.00	65.00	65.00
Cost of diesel (gallon)	$1.40	$1.40	$1.40	$1.40
Fuel mileage (mi/gallon)	3.98	2.35	3.98	2.35
Fixed cost per stop ($/stop)	$10.00	$10.00	$10.00	$25.00
Ratio of equipment investment costs	1.00	1.50	1.00	2.00
Daily depreciation of tractor ($/day)	$14.41	$21.62	$14.41	$28.82
Daily depreciation of trailer ($/day)	$3.94	$5.91	$3.94	$7.88
Daily interest of tractor ($/day)	$12.00	$18.00	$12.00	$24.00
Daily interest of trailer ($/day)	$3.20	$4.80	$3.20	$6.40
Maintenance ($/mi)	$0.07	$0.07	$0.07	$0.16
Max Payload (tons) *	27.5	44	55	88
Number of hours per day	10	10	10	10
Handling productivity (tons/hr)	3.30	3.30	3.30	3.30
Load being transported (tons)	44.00	44.00	33.00	33.00

* 3-S2: Standard Tractor-Trailer
3-S2-T4: Long-Double LCV

Source: Samuel et. al, *Toll Truckways: A New Path Toward Safer and More Efficient Freight Transportation,* Reason Foundation Policy Study 294, June 2002

Table 6.11 Toll Truckway Private Return on Investment (ROI)

Private Return on Investment (1 to 1 truck shift) at 40,000 ADT		
a) $1 million/mile capital cost		
TRAFFIC	Toll=$0.40	Toll=$0.80
25% Trucks (1000)	8.60%	17.26%
50% Trucks (2000)	16.85%	33.12%
75% Trucks (3000)	23.92%	48.46%
100% Trucks (4000)	32.72%	64.52%
b) $2 million/mile capital cost		
TRAFFIC	Toll=$0.40	Toll=$0.80
25% Trucks (1000)	4.12%	9.17%
50% Trucks (2000)	8.85%	17.34%
75% Trucks (3000)	13.04%	25.31%
100% Trucks (4000)	16.97%	33.19%
c) $3 million/mile capital cost		
TRAFFIC	Toll=$0.40	Toll=$0.80
25% Trucks (1000)	2.26%	6.23%
50% Trucks (2000)	5.97%	12.02%
75% Trucks (3000)	9.03%	17.40%
100% Trucks (4000)	11.76%	22.66%

Source: Samuel et. al, *Toll Truckways: A New Path Toward Safer and More Efficient Freight Transportation,* Reason Foundation Policy Study 294, June 2002

Table 6.12 Toll Truckway Private Return on Investment (ROI)

Private Return on Investment (1.5 to 1 truck shift) at 40,000 ADT		
a) $1 million/mile capital cost		
TRAFFIC	Toll=$0.40	Toll=$0.80
25% Trucks (1000)	5.43%	11.81%
50% Trucks (2000)	11.49%	22.61%
75% Trucks (3000)	23.92%	48.46%
100% Trucks (4000)	22.67%	43.72%
b) $2 million/mile capital cost		
TRAFFIC	Toll=$0.40	Toll=$0.80
25% Trucks (1000)	1.96%	6.10%
50% Trucks (2000)	5.89%	11.99%
75% Trucks (3000)	8.70%	17.20%
100% Trucks (4000)	12.06%	22.88%
c) $3 million/mile capital cost		
TRAFFIC	Toll=$0.40	Toll=$0.80
25% Trucks (1000)	---	3.84%
50% Trucks (2000)	3.70%	8.30%
75% Trucks (3000)	5.88%	11.91%
100% Trucks (4000)	8.35%	15.84%

Source: Samuel et. al, *Toll Truckways: A New Path Toward Safer and More Efficient Freight Transportation,* Reason Foundation Policy Study 294, June 2002

Table 6.13 Toll Truckway Private Return on Investment (ROI)

Private Return on Investment (1.5 to 1 truck shift) at 80,000 ADT		
a) $1 million/mile capital cost		
TRAFFIC	Toll=$0.40	Toll=$0.80
25% Trucks (1000)	11.49%	22.61%
50% Trucks (2000)	22.13%	43.59%
75% Trucks (3000)	23.92%	48.46%
100% Trucks (4000)	43.74%	85.48%
b) $2 million/mile capital cost		
TRAFFIC	Toll=$0.40	Toll=$0.80
25% Trucks (1000)	5.89%	11.99%
50% Trucks (2000)	11.63%	22.63%
75% Trucks (3000)	16.97%	33.19%
100% Trucks (4000)	22.98%	43.97%
c) $3 million/mile capital cost		
TRAFFIC	Toll=$0.40	Toll=$0.80
25% Trucks (1000)	3.70%	8.30%
50% Trucks (2000)	8.03%	15.59%
75% Trucks (3000)	11.76%	22.66%
100% Trucks (4000)	15.98%	30.03%

Source: Samuel et. al, *Toll Truckways: A New Path Toward Safer and More Efficient Freight Transportation*, Reason Foundation Policy Study 294, June 2002

Table 6.14 Impact of Toll Truckways on State DOT Funds

Annualized Impact on State DOT ($ per lane-mile of TTW)					
Truck % in TTW	Truck ADT in TTW	Fuel tax loss to DOT	O&M savings to DOT	Net cost to DOT	Avoided cost of new lane (1:1 case)*
25%	1,000	$58,400	$6,090	$52,310	$352,428
50%	2,000	$116,800	$13,298	$103,502	$366,250
75%	3,000	$175,200	$37,558	$137,642	$381,478
100%	4,000	$233,600	$47,101	$186,499	$389,788

*Annualized TTW costs were calculated in detail for the baseline capital cost case of $1 million per lane-mile extrapolated to the $2 million/lane-mile and $3 million/lane-mile cases. The figures shown in the table are for the $2 million/lane-mile case.

Source: Samuel et. al, *Toll Truckways: A New Path Toward Safer and More Efficient Freight Transportation*, Reason Foundation Policy Study 294, June 2002

Table 6.15 Financing Approach for SCAG Regional Toll Truckway System

Assumptions	
Par Amount (Senior Tax Exempt)	$12,100,000,000
TIFIA Loan	$6,800,000,000
Interest Rate	5.00%
Traffic Growth Rate per Year	2.60%
Average Annual Daily Truck Trips (AADTT)	143,500
Average Trip Length (Miles)	37
Annual Operations and Maintenance Costs	$4,359,000
Annual Electronic Tolling Costs	$14,760,736
Debt Issuance/Construction Start Year	FY 2005
Construction Draws	FY 2005 - FY 2009
Capitalized Interest Period	FY 2005 - FY 2009
Interest Earning Rate	5.00%
Commencement of Toll Operation	FY 2010
Average Toll Rate/Mile	$0.56

Sources	
Senior Bond Proceeds	$12,100,000,000
TIFIA Loan Proceeds	$6,800,000,000
Interest Earnings	$1,620,721,210
TOTAL SOURCES	$20,520,721,210

Uses	
Capital Dev. Costs (Cons. w/ Contingencies, Eng.,RoW)*	$16,532,586,000
Capitalized Interest During Construction	$3,025,000,000
Cost of Issuance	$180,183,029
Debt Service Reserve Fund	$782,952,181
TOTAL SOURCES	$20,520,721,210

Source: SCAG, *User Supported Regional Truckways in Southern California,* Briefing Paper, January 2004

Table 6.16 Toll Truckway Productivity Benefits and Associated Toll Scenarios

	Mixed freeway		Toll Truckway			
	Semi-trailer	Double-shorts	Semi trailer	Double-short	Triple-short	Double-long
Payload	45,000 lbs	45,000 lbs	45,000 lbs	45,000 lbs	67,500 lbs	90,000 lbs
metric tons	20t	20t	20t	20t	30t	40t
100 mile delivery – 2004 freight rates	$500	$500	$500	$500	$750	$1,000
Average speed on the road	38mph	38mph	60mph	60mph	60mph	60mph
Miles driven in 8-hr shift (6 hrs driving)	228 miles	228 miles	360 miles	360 miles	360 miles	360 miles
Revenue from 6 hrs payload at 2004 rates	$1,140	$1,140	$1,800	$1,800	$2,700	$3,600
Variable costs	$684	$684	$684	$684	$1,007	$1,165
Available for overhead, profits, tolls	$456	$456	$1,116	$1,116	$1,693	$2,435
Extra earnings from using truckway/shift/day			$660	$660	$1,237	$1,979
Drop assumption of no change in freight rates						
Assume the extra productivity split 3 ways			3x$220	3x$220	3x$412	3x$660
Shipper's savings on 100 mile delivery, %			$61 (12.2%)	$61 (12.2%)	$76 (15.2%)	$91 (18.3%)
Additional for trucker overhead & profit/day			$220	$220	$412	$660
Truck tollway – possible toll per mile			61c/mile	61c/mile	$1.15/mile	$1.83/mile

Source: Robert W. Poole Jr. and Peter Samuel, *Toll Truckways: Increasing Productivity and Safety in Goods Movement*, PowerPoint Presentation

Attachment D

Glossary

D. Glossary

AAA	American Automobile Association
AA	Alternatives Analysis
ADT	Average Daily Traffic
ATA	American Trucking Association
ATRI	American Transportation Research Institute
ATMS	Advanced Traffic Management Systems
APTS	Advanced Public Transportation Systems
ATIS	Advanced Traveler Information Systems
AVC	Automatic Vehicle Classification
AVI	Automatic Vehicle Identification
CDL	Commercial Drivers License
CMV	Commercial Motor Vehicle
CVO	Commercial Vehicle Operations
CVHAS	Cooperative Vehicle Highway Automation Systems
CVISN	Commercial Vehicle Information Systems and Networks
DEIS	Draft Environmental Impact Statement
DSRC	Dedicated Short-Range Communications
EIS	Environmental Impact Statement
ETC	Electronic Toll Collection
ETF	Exclusive Truck Facility
ETL	Exclusive Truck Lane
FAST	Freeing Alternatives for Speedy Transportation

FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
GAO	Government Accountability Office
GPS	Global Positioning System
GVW	Gross Vehicle Weight
HOV	High Occupancy Vehicle
HTF	Highway Trust Fund
ITS	Intelligent Transportation System
LCV	Longer Combination Vehicle
LOS	Level of Service
LPR	License Plate Reader
LRTP	Long-Range Transportation Plan
LTL	Less-than-Truckload
MPG	Miles per Gallon
MPH	Miles per Hour
MPO	Metropolitan Planning Organization
NAFTA	North American Free Trade Agreement
NCHRP	National Cooperative Highway Research Program
NN	National Network for Large Trucks
OBU	On-Board Units
O&M	Operations and Maintenance
PPP	Public Private Partnership
PATH	Partners for Advanced Transit and Highways
OCR	Optical Character Recognition
RMD	Rocky Mountain Double

ROI	Return on Investment
ROW	Right-of-Way
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users
TDM	Travel Demand Management
TOL	Truck-Only Lane
TOT	Truck-Only Toll Lane
TPD	Turnpike Double
TRB	Transportation Research Board
TRIS	Transportation Research Information Services
TS&W	Truck Size and Weight
TSM	Transportation System Management
TTI	Texas Transportation Institute
VMT	Vehicle Miles Traveled
VHT	Vehicle Hours Traveled
WASHTO	Western Association of State Highway and Transportation Officials
WGA	Western Governors' Association
WIM	Weigh-in-Motion
WRI	Wireless Roadside Inspection

Appendix B.

Performance Evaluation

B. Performance Evaluation

B.1 Scenario 1. Long-Haul Corridors

The following sections present a discussion of the performance results of truck-only lanes from each of the major literature sources reviewed under this scenario.

Reason Foundation Study

The Reason Foundation conducted a study[1] in 2004 on tolled truckways, which analyzed the incremental productivity benefits of truck-only lanes with standard trucking and LCV operations, compared to mixed-flow facilities without LCV operations (the no-build scenario). The study looked at the following three operational scenarios:

1. **Scenario 1 (No-Build).** Mixed-flow lanes along long-haul corridors with standard truck (tractor/semi-trailer) operations;

2. **Scenario 2.** Truck lanes along long-haul corridors with standard truck (tractor/semi-trailer) operations; and

3. **Scenario 3.** Truck lanes along long-haul corridors with LCV operations.

The results were based on assumptions related to congestion on mixed-flow facilities and (congestion reduction) speed improvements due to the implementation of truck lanes; average miles traveled per shift on mixed-flow and truck lanes (function of speeds), average freight rates as a function of payload (truck configuration) and distance hauled, and average variable costs for different truck configurations. The results of the quantification of relative productivity benefits of truck lanes compared to mixed-flow facilities are summarized in Table B.1 below.

[1] Toll Truckways: Increasing Productivity and Safety in Goods Movement, PowerPoint Presentation, Robert W. Poole, Jr., and Peter Samuel, The Reason Foundation.

Table B.1 Reason Foundation Study
Truck-Only Lane Productivity Benefits

	Mixed Freeway Semitrailers	Truckway Semitrailer	Truckway Triple Short	Truckway Turnpike Double
Payload (pounds)	45,000	45,000	67,500	90,000
Metric Tons	20	20	30	40
100-mile delivery (2004 freight rates)	500	500	750	1,000
Average Speed on the Road	38 mph	60 mph	60 mph	60 mph
Miles Driven in 8-hour Shift	228	360	360	360
Revenue from 6-hours Payload at 2004 Rates	$1,140	$1,800	$2,700	$3,600
Variable Costs	$684	$684	$1,007	$1,165
Earnings (Revenue – Costs)	$456	$1,116	$1,693	$2,435
Earnings (per ton-mile)	$0.100	$0.155	$0.157	$0.169
Productivity Benefit (% Increase in Earnings per ton-mile) (Truck Lanes Compared to Mixed-flow Lanes)	–	55%	63%	
Productivity Benefit (% Increase in Earnings per ton-mile) (Truck Lanes with LCVs Compared to Truck Lanes without LCVs)	–	–	5%	

Source: Toll Truckways: Increasing Productivity and Safety in Goods Movement, presentation by Robert W. Poole, Jr., and Peter Samuel, The Reason Foundation.

The Reason Foundation study did not look at a specific corridor in the analysis of productivity benefits of truck lanes. The results from the study, as indicated above, were based on assumptions about percent speed improvements due to the implementation of truck lanes, as well as freight rates and operating costs for various truck configurations. The study is useful in presenting an illustrative methodological framework for the analysis of productivity benefits, and providing estimates to determine the relationship between speed improvements/LCV operations on truck lanes and degree of productivity enhancement in terms of increase in trucking industry earnings.

Western Uniformity Scenario Analysis

The Western Uniformity Scenario Analysis study conducted by the U.S. DOT in 2004 analyzed the impacts of lifting the LCV freeze and allowing uniformity in LCV operations (weights and dimensions) among Western States with current LCV operations based on a key set of performance criteria, including safety, pavement, bridge and infrastructure costs, shipper costs,

energy consumption, environmental quality and traffic operations. This section presents the results from the study on shipper cost savings from uniform LCV operations, to understand the productivity benefits of LCVs compared to standard truck operations.

The study estimated total annual shipper cost savings resulting from uniform LCV operations in Western States of around $2 billion per year, representing savings of close to four percent of total shipper costs under existing conditions (no build). These savings were estimated to accrue to shippers diverting shipments from standard trucks to LCVs, as trucking companies operating LCVs are able to realize increased earnings per shipment due to the higher payloads of LCVs and translate these increased earnings to reductions in shipment costs for shippers. Additionally, the uniform LCV operations scenario was also estimated to benefit rail shippers, resulting in total annual cost savings of $3 million. Table B.2 presents the annual shipper cost savings estimated under the expanded LCV operations scenario in the study. The study does not provide information on the methodology used for the estimation of these shipper cost savings for the LCV uniformity scenario.

Table B.2 Annual Shipper Cost Savings from Western Uniformity Scenario

Source of Savings	Amount (Millions of 2000 Dollars)	Percentage of Change
Truck to Truck Diversion	2,036	3.9%
Rail to Truck Diversion	3	.01%
Rail Discounts	26	.11%
Total	**2,065**	**n/a**

Source: Western Uniformity Scenario Analysis: A Regional Truck Size and Weight Scenario Requested by the Western Governors' Association, U.S. DOT, April 2004.

I-35 Trade Corridor Study

The I-35 Trade Corridor Study completed in 1999 evaluated a set of alternatives with the objective of arriving at recommended corridor investment strategies to improve local, intrastate, interstate and international service along the I-35 corridor in the future (2025) between Laredo, Texas, and Duluth, Minnesota. The results from the study provide some useful insights into the performance benefits of truck-only lanes along long-haul corridors, compared to alternative investment strategies, including rail.

The final set of viable alternatives considered in the study in the performance evaluation and cost-benefit analysis process included the following:

- **Base Case Scenario.** This scenario includes all the committed investment projects, along with comprehensive ITS strategies along the corridor, pavement and bridge maintenance projects, and urban area demand management, growth management, and transit projects; and

- **Candidate Build Alternatives (Alternatives 2, 3, and 4).** Candidate build alternatives include all the improvements under the base case scenario, along with additional investment strategies.

  - Alternative 2. Urban Congestion Relief Strategy. Includes investments in relief routes, and/or I-35 Double Decking along urban area segments, along with comprehensive urban area ITS, growth/demand management and transit projects;
  - Alternative 3. Trade Focus Strategy. Includes implementation of dedicated truckway lanes between Laredo and Dallas/Fort Worth, along with investments in relief routes and double decking along specific segments, and comprehensive urban area ITS and transit, demand and growth management strategies; and
  - Alternative 4. Combined Strategy. Includes lane additions between Duluth and Kansas City, relief routes and/or double decking, rail implementation between Kansas City and Laredo, and comprehensive urban area ITS and transit, demand and growth management strategies.

The primary performance criteria evaluated in the study included savings in vehicle operating costs, and travel time savings, which were classified under travel efficiency performance of alternatives. Vehicle operating costs for the truck-only lane alternative were estimated using operating cost rates available from the Highway Performance Monitoring System (HPMS) as a function of the vehicle class and functional class of facility. Operating costs for the rail alternative (based on unit costs for transfer to rail, and rail operating costs) were derived using rates available from the Uniform Rail Costing System (URCS). Travel time savings estimates for the various alternatives were derived using the regional travel demand model, which uses volume-delay functions (VDF) to generate vehicle speeds (and travel times) as a function of congestion parameters (V/C).

Table B.3 presents the 2025 truck and total traffic volume forecasts along the various segments of the I-35 corridor, as well as the expected truck volumes diverted to the truckway lanes. These estimates were generated using a regional travel demand model, which was calibrated and validated specifically for the entire stretch of the study area corridor. Trucks in 2025 are estimated to account for between 20 percent to 35 percent of the total traffic volumes on I-35 between Laredo and Dallas/Fort Worth. The estimated truck volumes on the truck lanes have been adjusted to account for the use of LCVs on the truck lanes, based on assumptions related to the share of the diverted truck volumes that would convert to LCV operations (the study does not provide information on the methodology used for this adjustment). These estimates provide insights into the expected diversion potential of truck lanes along long-haul corridors – an average diversion of 79 percent. Table B.4 provides the estimated diversion of truck volumes to rail under Alternative 4.

Table B.3 Future Truck and Total Traffic Volumes Along the I-35 Corridor
2025

Location	2025 Truck Volume on I-35			Volume on Truckway Lanes	All Vehicles
	International	Other	Total		
Laredo-San Antonio	3,700	600	4,300	3,400	12,400
San Antonio-Austin	3,350	14,750	18,100	14,200	82,100
Austin-Waco	3,010	11,590	14,600	11,400	69,100
Waco-Dallas	3,050	6,250	9,300	7,300	41,600
Dallas-Oklahoma City	610	9,490	9,900	N/A	42,200
Oklahoma City-Kansas City	600	5,700	6,300	N/A	27,100
Kansas City-Des Moines	110	6,490	6,400	N/A	20,700
Des Moines-Minneapolis/St. Paul	170	6,330	6,500	N/A	21,700
Minneapolis/St. Paul-Duluth	100	3,000	3,100	N/A	23,700

Source: I-35 Trade Corridor Study.

Table B.4 Truck to Rail Diversion, Alternative 4

Trip Begin Point	Estimated Daily Traffic Diverted to Rail			
	Trucks		Payload (Tons)	
	1996	2025	1996	2025
Laredo, TX	1,600	3,000	37,100	67,900
San Antonio, TX	4,100	7,500	91,600	167,800
Austin, TX	4,700	8,600	105,600	193,400
Dallas, TX	3,500	6,500	79,300	145,200
Oklahoma City, OK	1,300	2,500	30,200	55,200
Wichita, KS	1,400	2,600	31,500	57,600
Kansas City, MO				
Total	**16,600**	**30,700**	**375,300**	**687,000**

Source: I-35 Trade Corridor Study.

Since the study does not provide estimates for each of the performance measures for the base case scenario, and alternatives 3 and 4 include the investments considered under Alternative 2, for the purpose of this performance evaluation, Alternative 2 is considered as the no-build alternative, to assess the relative change in performance of the corridor due to the

implementation of truck lanes. Table B.5 summarizes the performance of Alternatives 3 and 4 relative to Alternative 2, for the travel efficiency performance measures.

Table B.5 Percent Additional Performance Benefits of Truck-Only Lane and Rail Alternatives (Alternatives 3 and 4) Compared to Alternative 2
2025

	Operating Costs	Travel Time Savings (Autos Only)
Alternative 3 (truck-only lanes)	36%	21%
Alternative 4 (rail)	26%	12%

Source: I-35 Trade Corridor Study.

Since the I-35 study did not estimate percent reductions in accidents associated with truck-only lanes, an attempt was made to quantify the approximate percent improvement in safety, based on the estimation of percent reduction in Passenger Car Equivalents (PCEs) (assuming a PCE factor of 2.0 for trucks) on the general purpose lanes. Table B.6 presents the % change in PCEs on the general purpose lanes under the truck-only lane alternative compared to the alternative without truck-only lanes.

Table B.6 Percent Change in PCEs on GP Lanes due to Diversion of Trucks to Truck-Only Lanes

	Without Truck-Only Lanes				With Truck-Only Lanes		
Location	**Trucks**	**Autos**	**Total Vehicles**	**Total PCEs**	**Volume on Truck Lanes**	**Total PCEs on GP Lanes***	**Percentage of Change in PCEs**
Laredo – San Antonio	4,300	8,100	12,400	16,700	3,400	8,530	-49%
San Antonio – Austin	18,100	64,000	82,100	100,200	14,200	65,810	-34%
Austin – Waco	14,600	54,500	69,100	83,700	11,400	55,960	-33%
Waco – Dallas	9,300	32,300	41,600	50,900	7,300	33,230	-35%
Average							**-38%**

Source: I-35 Trade Corridor Study.

*Total PCEs on the GP lanes are estimated based on a 95 percent diversion of trucks to the truck lanes. Due to the conversion of some of the diverted trucks to LCVs, the truck volumes on the truck lanes would be lower than what would be estimated based on a 95 percent diversion.

The percent change in congestion (V/C) along the corridor for the truck-only lane alternative (relative to the alternative without truck lanes) would be the same as the percent change in

PCEs in Table B.6, since the general purpose lane capacity along the corridor does not change under the two alternatives. Safety benefits are directly proportional to change in corridor congestion. Results from Table B.6 indicate an average safety improvement of 38 percent along the corridor due to truck-only lanes, which is a conservative assumption since truck accident rates are typically higher than auto accident rates. Additionally, applying the 15 percent reduction factor as recommended by the Douglas Handbook results in a total percent reduction in accidents for the truck-only lane alternative of around 47 percent compared to the no build (without truck-only lanes) alternative.

Georgia Statewide Truck Lane Needs Identification Study

The Georgia Statewide Truck Lane Needs Identification Study (Georgia Study) was conducted to evaluate the feasibility of implementing truck-only lanes on the Georgia statewide highway network. The main objectives of the study included quantifying the performance benefits of truck lanes (relative to an alternative without truck lanes), identifying potential corridors for implementation (based on certain feasibility criteria such as truck volumes, congestion and market accessibility), and assessing the benefits and costs of implementing truck lanes.

The initial phase of the study considered all the major Interstate facilities and access controlled state routes in Georgia for the truck lane needs identification analysis. An initial screening process (based on a qualitative performance evaluation process) was undertaken to evaluate the feasibility of truck lanes along these corridors, which resulted in the identification of a set of "candidate corridors" showing the greatest potential for the implementation of truck lanes to meet the freight and transportation needs in the State.

The candidate long-haul corridors identified in the study to have the greatest potential for truck lanes included the following:

- I-75 (southern segment) between I-285 (south end) and I-475 (near Macon). This segment was divided into the following subsegments:
  - Segment 3A: Henry/Butts County line to I-285
  - Segment 3B: I-475 to Henry/Butts County line
- I-75 (northern segment) between I-285 (north end) and Georgia/Tennessee boundary. This segment was divided into the following subsegments:
  - Segment 4A: I-285 to Bartow/Gordon County line; and
  - Segment 4B: Bartow/Gordon to Tennessee.
- I-85 (southern segment) between I-285 and Georgia/Alabama boundary. This segment was divided into the following subsegments:
  - Segment 6A: Alabama to Coweta/Troup County line; and
  - Segment 6B: Coweta/Troup County line to I-285.

- I-85 (northern segment) between I-285 and Georgia/South Carolina boundary. This segment was divided into the following subsegments:
  - Segment 7A: I-285 to Gwinnett/Jackson County line
  - Segment 7B: Gwinnett/Jackson County line to South Carolina
- I-20 (western segment) between I-285 and Georgia/Alabama boundary.
- I-20 (eastern segment) between I-285 and Georgia/South Carolina boundary.

The results from the study on safety and travel time benefits of truck lanes along the corridors listed above are discussed in this section. Traffic volume forecasts for the various corridors, and estimates of performance metrics for the truck-only lane and the no-build alternatives were generated using a combination of the Georgia Statewide model, the Atlanta Regional Commission (ARC) model, and the Savannah MPO model, after making significant model improvements (primarily to the Statewide model, and the Savannah MPO model) to enhance the ability to forecast truck trip patterns across the State. Table B.7 presents the model estimates for corridor truck and auto traffic forecasts under the no-build and truck-only lane alternatives for 2035, while Table B.8 presents the travel speeds for the truck-only lane and no-build alternatives in 2035 generated from model outputs for each of the candidate corridor segments.

Table B.7 Corridor Demand Estimates With and Without Truck-only Lanes, 2035

Corridor	Corridor Demand WITHOUT Truck-Only Lanes			Corridor Demand WITH Truck-Only Lanes			
	Cars	Trucks	Total	Cars	Trucks (in GP)	Truck-Only Lanes	Totals
3A: I-75 South	96,430	65,168	161,598	122,493	25,843	53,354	201,690
3B: I-75 South	41,183	38,324	79,507	41,649	18,012	20,620	80,281
4A: I-75 North	91,555	56,621	148,176	112,116	21,578	47,578	181,272
4B: I-75 North	45,444	27,895	73,338	45,866	14,026	14,964	74,872
6B: I-85 South	71,888	44,422	116,310	82,375	19,106	30,765	132,247
7A: I-85 North	101,353	58,334	159,687	122,798	29,519	41,047	193,365
8: I-20 West	63,758	46,678	110,436	79,600	19,022	18,003	116,625
9: I-20 East	62,460	37,822	100,282	70,401	15,991	27,160	113,551

Source: Georgia Statewide Truck Lane Needs Identification Study.

Table B.8 Travel Speeds (Miles Per Hour) With and Without Truck-Only Lanes, *2035*

Corridor	Without TOL	With TOL		Percentage of Change in Speeds Due to TOL	
	GP	GP	TOL	Autos/Trucks on GP	Trucks on TOL
3A: I-75 South	21	42	49	100%	133%
3B: I-75 South	61	64	64	5%	5%
4A: I-75 North	27	40	52	48%	93%
4B: I-75 North	56	60	62	7%	11%
6B: I-85 South	38	48	57	26%	50%
7A: I-85 North	29	37	51	28%	76%
8: I-20 West	31	45	56	45%	81%
9: I-20 East	40	47	57	18%	43%
Average Improvement in Speeds due to TOL				**35%**	**61%**

Source: Georgia Statewide Truck Lane Needs Identification Study.

Table B.9 presents estimates for productivity enhancements due to the speed improvements for trucks on truck-only lanes observed in Table B.8, using the Reason Foundation methodology, for a set of representative candidate corridor segments. Average productivity improvements due to truck-only lanes without and with LCV operations are derived by estimating the weighted average increase in trucking industry earnings (from the results in Table B.9) by using VMTs on the corridor segments as the weighting factor. Table B.10 presents the weighted average improvements in productivity due to truck-only lanes based on this approach.

Tables B.11 and B.12 present the results from the Georgia study on travel time savings and safety benefits associated with truck-only lanes compared to the alternative without truck-only lanes. Travel time savings are estimated from model outputs for vehicle hours traveled (VHT) for the two alternatives, assuming that changes in VHT are representative of changes in average travel times. Safety performance evaluation of alternatives is conducted in terms of change in the number of fatal accidents, using crash rate data from the Georgia Department of Transportation, as a function of roadway facility type and congestion. Clearly, the method used for accident estimation in the study does not consider the incremental safety benefits associated with truck-auto separation.

Table B.9 Productivity Benefits (Increase Truck Earnings Per Ton Mile) from Truck-Only Lanes *2035**

	4A: I-75 North			7A: I-85 North			3B: 1-75 South			4B: 1-75 North			6B: I-85 South		
	Without TOL	No LCV	LCV	Without TOL	No LCV	LCV	Without TOL	No LCV	LCV	Without TOL	No LCV	LCV	Without TOL	No LCV	LCV
Speeds (mph)	27	52	52	29	51	51	61	64	64	56	62	62	38	57	57
Freight rate (per 100 mile)	500	500	875	500	500	875	500	500	875	500	500	875	500	500	875
Miles per 8-hour day shift (6 hours driving)	162	312	312	174	306	306	366	384	384	336	372	372	228	342	342
Revenue per day shift	810	1,560	2,730	870	1,530	2,678	1,830	1920	3360	1,680	1,860	3,255	1,140	1,710	2993
Variable Costs	684	684	1,086	684	684	1,086	684	684	1086	684	684	1,086	684	684	1086
Net Earnings	126	876	1,644	186	846	1,592	1,146	1,236	2,274	996	1,176	2,169	456	1,026	1,907
Earnings per ton mile	0.04	0.14	0.15	0.05	0.14	0.15	0.16	0.16	0.17	0.15	0.16	0.17	0.10	0.15	0.16
% Increase in Earnings per Ton Mile		261%	287%		159%	178%		3%	8%		7%	12%		50%	59%

Source: Cambridge Systematics, Inc. (based on The Reason Foundation approach).

*Assumptions on freight rates, and variable costs are based on The Reason Foundation study assumptions.

Table B.10 Average Productivity Improvements from Truck-Only Lanes

Corridor Segment	VMT	Percentage of Increase in Earnings Per Ton-Mile (Compared to No-Build)	
		Truck Lanes Without LCVs)	Truck Lanes With LCVs
4A: I-75 North	7.02	261%	287%
7A: I-85 North	5.31	159%	178%
3B: I-75 South	4.35	3%	8%
4B: I-75 North	6.73	7%	12%
6B: I-85 South	4.28	50%	59%
Weighted Average		**106%**	**120%**

Table B.11 Travel Time Savings (Percentage of Change in VHT) Due to Truck-Only Lanes

2035

Corridor	Without TOL				With TOL				% Savings			
	Facility	4-Mile Buffer	12-Mile Buffer	Region	Facility	4-Mile Buffer	12-Mile Buffer	Region	Facility	4-Mile Buffer	12-Mile Buffer	Region
3A: I-75 South	0.3	1.0	2.6	10.3	0.2	0.8	2.5	10.1	42%	15%	7%	2%
3B: I-75 South	0.1	N/A	N/A	38.1	0.1	N/A	N/A	38.1	0%	N/A	N/A	0%
4A: I-75 North	0.3	1.1	3.3	10.3	0.2	1.0	3.1	10.0	23%	11%	5%	2%
4B: I-75 North	0.1	N/A	N/A	38.1	0.1	N/A	N/A	38.1	8%	N/A	N/A	0%
6B: I-85 South	0.1	0.5	1.9	10.3	0.1	0.5	1.8	10.3	9%	6%	1%	0%
7A: I-85 North	0.2	1.1	3.7	10.3	0.2	1.0	3.6	10.1	11%	5%	3%	1%
8: I-20 West	0.2	0.7	2.5	10.3	0.1	0.6	2.8	10.2	20%	8%	-15%	1%
9: I-20 East	0.1	0.6	2.6	10.3	0.1	0.6	2.6	10.2	13%	2%	1%	0%
Total VHT and Average Savings	**1.2**	**4.9**	**16.5**	**137.7**	**1.0**	**4.5**	**16.4**	**137.0**	**20%**	**9%**	**1%**	**0%**

Source: Georgia Statewide Truck Lane Needs Identification Study.

Table B.12 Safety (Fatal Accident Reduction) Benefits due to Truck-only Lanes, 2035

Corridor	Estimated Annual Fatal Accidents			Percentage of Savings in Accidents
	Without TOL	With TOL	15% Additional Adjustment for TOL	
3A: I-75 South	11	7	6	46%
3B: I-75 South	10	7	6	41%
4A: I-75 North	14	9	8	45%
4B: I-75 North	10	7	6	41%
6B: I-85 South	9	6	5	43%
7A: I-85 North	10	7	6	41%
8: I-20 West	10	6	5	49%
9: I-20 East	8	5	4	47%
Total Fatal Accidents and Average % Savings	**82**	**54**	**46**	**44%**

Source: Georgia Statewide Truck Lane Needs Identification Study.

B.2 Scenario 2. Urban Corridors

The following sections present a discussion of the performance results of truck-only lanes from each of the major literature sources reviewed under this scenario.

I-710 Major Corridor Study

The I-710 Major Corridor Study was initiated in 2001 to analyze forecast traffic volumes, congestion, safety, and environmental issues along the I-710 corridor in Southern California, with the objective of developing transportation solutions to address these issues. The final set of alternative transportation solutions analyzed in the study included the following:

- **Alternative A. No Build Alternative**.
- **Alternative B. Transportation Systems Management (TSM)/Transportation Demand Management (TDM)** includes strategies such as ramp metering, empty container management strategies, arterial improvements, and increased transit service
- **Alternative C. Medium General Purpose/Medium Truck Alternative** includes adding one mixed-flow lane in each direction on select I-710 segments, adding a continuous collector-distributor system between Atlantic Blvd and I-5, adding truck bypass facilities at three freeway to freeway interchanges, and adding truck ramps at select interchanges with high truck volumes. This alternative also includes all the strategies included in Alternative B.

- **Alternative D. High General Purpose/High HOV Alternative** includes adding two mixed-flow lanes in each direction on I-710 on select segments (and one mixed-flow lane in each direction on the remaining segments), and adding an exclusive HOV facility for carpools/ buses. This alternative also includes all the strategies included in Alternative B.

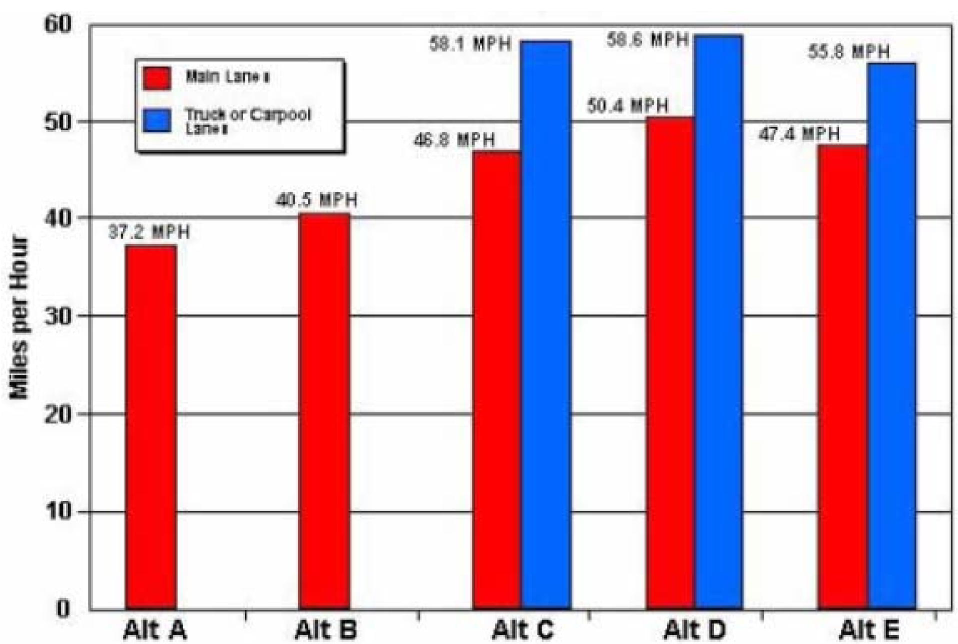
- **Alternative E. High Truck Alternative** includes construction of an exclusive truck facility (two lanes in each direction between SR 91 and SR 60, and three lanes in each direction between Ocean Blvd and SR 91); improvements (one additional lane in each direction) to select arterials with high truck volumes, and improvements to auxiliary lanes adjacent to I-710 travel lanes. This alternative also includes all the strategies included in Alternative B.

Traffic forecasts along the corridor for each of the alternatives were generated using a subarea travel demand model for the I-710 study area. These forecasts served as inputs in the estimation of key performance measures including V/Cs, speeds, travel times, and number of accidents. The following sections describe the results from the study related to travel time savings, reliability, and safety. Additional post-processing was conducted to estimate reliability (since the study did not estimate these benefits), and safety (this was done for the truck-only lane alternative since the study did not specifically account for the safety benefits of truck-auto separation).

Travel Time Savings

The study evaluated mobility performance among alternatives in terms of speeds on general purpose lanes (and speeds on truck lanes in the case of Alternative E) for each of the alternatives. These results are depicted in Figure B.1.

Figure B.1 Average Travel Speeds
Northbound Lanes, PM Peak Period, 2025



Source: I-710 Major Corridor Study.

Table B.13 presents the percent change in speeds for the build alternatives based on the speed data in Figure B.2.

Table B.13 Percent Change in Speeds Compared to No Build
Northbound Lanes, PM Peak Period, 2025

	GP Lanes	Truck/Carpool Lanes
TSM/TDM (Alternative B)	9%	N/A
Mixed-Flow Lanes (1 lane in each direction) (Alternative C – Alternative B)	17%	N/A
Mixed-flow Lanes (2 lanes in each direction) with additional HOV lanes (Alternative D – Alternative B)	27%	58%
Truck-Only Lanes (Alternative E- Alternative B)	19%	50%

Source: I-710 Major Corridor Study.

Speed improvements from Table B.13 are translated into equivalent travel time savings, and these results are presented in Table B.14.

Table B.14 Percent Travel Time Savings Compared to No Build
Northbound Lanes, PM Peak Period, 2025

	GP Lanes	Truck/Carpool Lanes
TSM/TDM (Alternative B)	8%	N/A
Mixed-Flow Lanes (1 lane in each direction) (Alternative C – Alternative B)	14%	N/A
Mixed-flow Lanes (2 lanes in each direction) with additional HOV lanes (Alternative D – Alternative B)	21%	37%
Truck-Only Lanes (Alternative E- Alternative B)	16%	33%

Source: I-710 Major Corridor Study.

Reliability Benefits

In order to estimate percentage change in reliability for each alternative compared to the no-build, a post-processing approach was undertaken. This approach involves estimating total nonrecurrent/incident-related delays for each of the alternatives (A through E), and comparing these estimates for the build alternatives against the no-build alternative to arrive at percent change in incident-related delays.

Total nonrecurrent delay per vehicle mile is estimated using IDAS post-processing factors, as a function of V/C, and number of lanes. The approach involves estimating nonrecurrent delay

per vehicle mile for various sections of the I-710 corridor based on information on V/C and number of lanes from the I-710 MCS. The nonrecurrent delay estimates per vehicle mile are then averaged out for the corridor, and multiplied by the total VMT along the corridor (from the I-710 MCS) for each of the alternatives.

IDAS post-processing factors do not consider the improvements in travel time reliability for the truck lane alternative associated with truck-auto separation. Since nonrecurrent delays are directly proportional to (and can be assumed to have a linear relationship with) the number of accidents, a 15 percent accident reduction factor as recommended by the Douglas Handbook is applied to the nonrecurrent delay estimates for the truck-only lane alternative from the I-710 study. The final estimates for percentage change in reliability for the build alternatives in the I-710 study compared to the no-build alternative are presented in Table B.15.

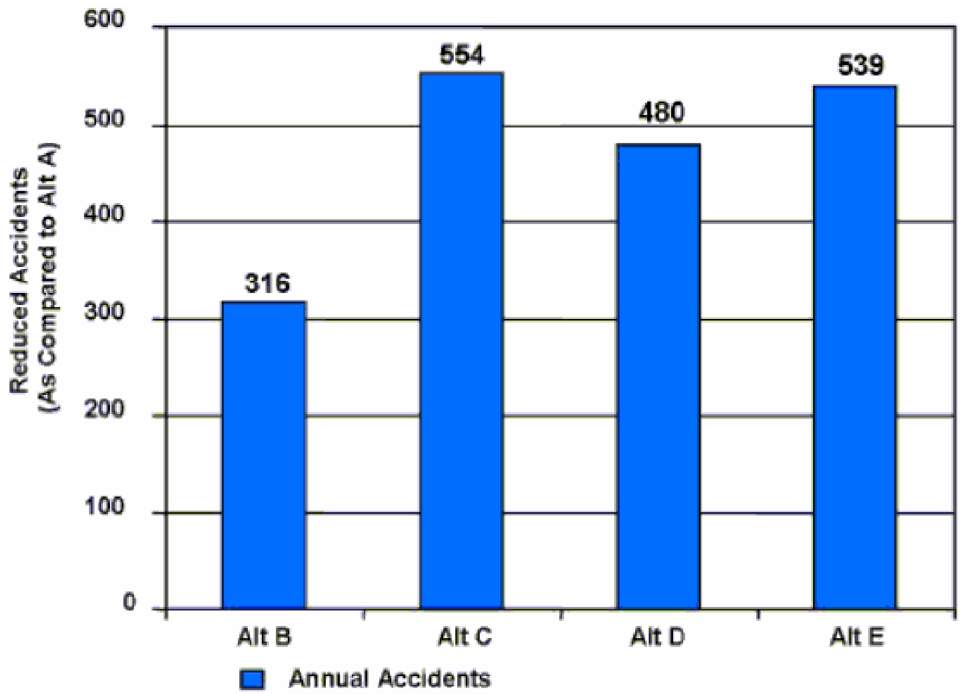
Table B.15 Percent Change in Travel Time Reliability

	Total Annual Savings in Nonrecurrent Delay	Percentage of Reliability Improvement
No Build	–	–
TSM/TDM (Alternative B)	2,375	15%
Mixed-flow Lanes (1 lane in each direction) (Alternative C – Alternative B)	7,403	47%
Mixed-flow Lanes (2 lanes in each direction) with additional HOV lanes (Alternative D – Alternative B)	9,935	63%
Truck-only Lanes (Alternative E – Alternative B)	9,308	59%

Safety Benefits

The I-710 study analyzed safety benefits among alternatives in terms of reduction in accidents under each of the build alternatives (Alternatives B through E) compared to the no-build (Alternative A). These results are presented in Figure B.2 below.

Figure B.2 Annual Accident Reduction
2025



Source: I-710 Major Corridor Study.

In order to determine percent improvements in safety relative to the no-build alternative, additional post-processing of the results from the I-710 study was conducted, using IDAS safety factors as a function of V/C, to determine annual accidents under the no-build alternative. The approach and results from the post-processing are shown in Table B.16.

Table B.16 Annual Accidents Under the No-Build Alternative
2025

V/C	1.42
Daily VMT	4,400,000
Fatality Rate (accidents per million VMT)	0.0066
Injury Rate (accidents per million VMT)	0.71
Property Damage Rate (accidents per million VMT)	0.9192
Daily Fatality Accidents	0
Daily Injury Accidents	3
Daily Property Damage Accidents	4
Total Daily Accidents	**7**
Total Annual Accidents (assuming a factor of 300)	**2,159**

Combining the results from Figure B.2 and Table B.15, Table B.17 presents the percent improvement in safety for each of the build alternatives. For Alternative E (truck-only lane alternative), an additional 15 percent reduction factor was applied to the total accidents to account for the safety benefits of truck-auto separation (as recommended by the Douglas Handbook).

Table B.17 Percent Safety Improvement
2025

	Annual Accidents	Additional Reduction Due to Truck Auto Separation	Net Annual Accidents	Percentage of Accident Reduction
Alternative A	2,159	N/A	2,159	–
Alternative B	1,843	N/A	1,843	-15%
Alternative C	1,605	N/A	1,605	-26%
Alternative D	1,679	N/A	1,679	-22%
Alternative E	1,620	243	1,377	-36%

Georgia Statewide Truck Lane Needs Identification Study

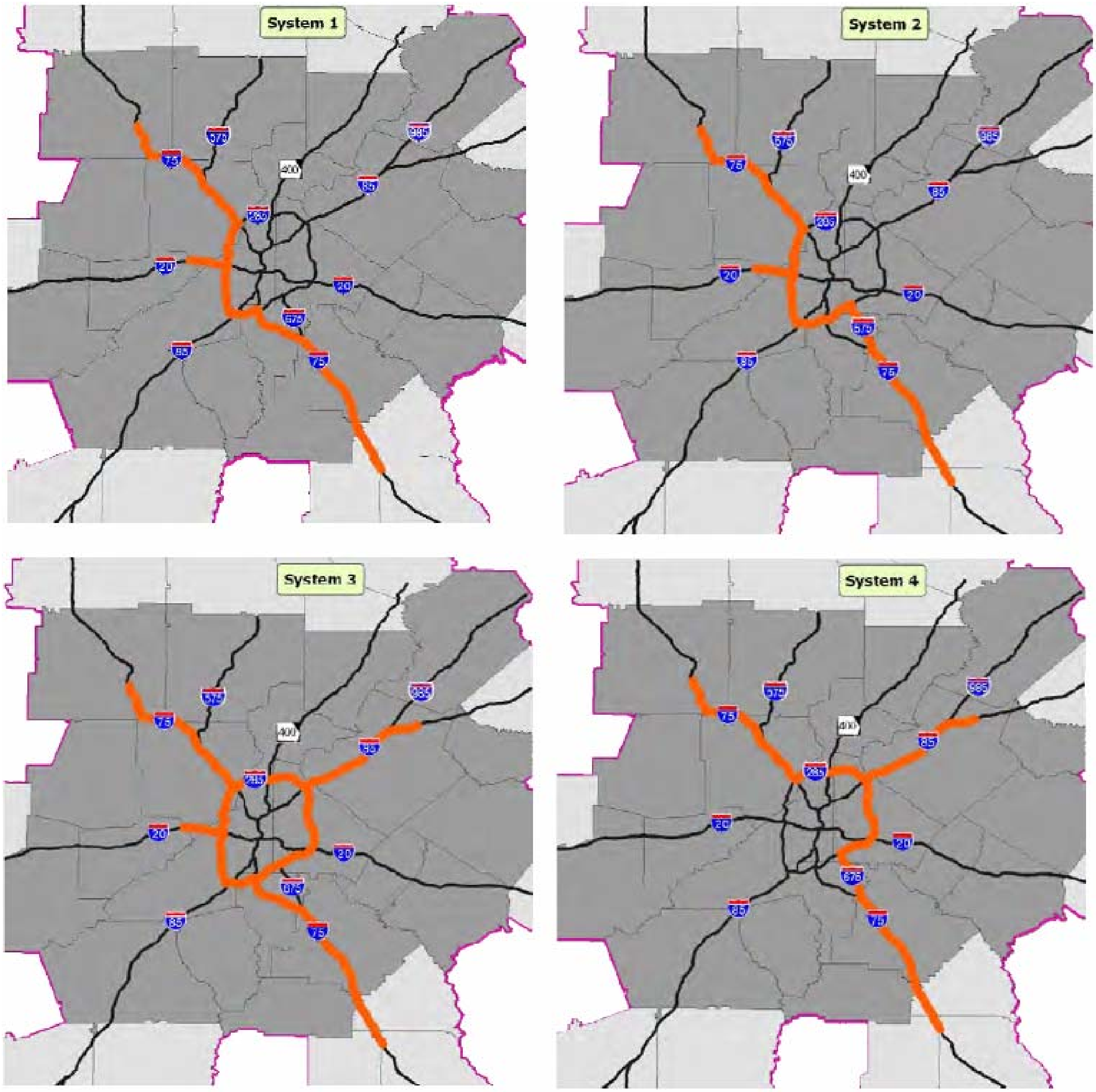
The Georgia study used a two-pronged approach in the performance evaluation and needs analysis process for truck-only lanes. The first step in the process involved the analysis of individual corridor segments and the quantification of performance benefits of truck lanes on these corridors. The results from this analysis for the long-haul corridors in the State were discussed in the long-haul corridor performance evaluation section. The second step involved the development of truck-only lane systems (combination of individual corridors), and a detailed evaluation of the performance benefits of truck-only lane systems compared to a system without truck lanes. The systems considered in the study, which fall within the Atlanta metropolitan area, are depicted in Figure B.3, and include the following:

- **System 1.** I-75/I-20W/I-285 West Wall;
- **System 2.** I-75/I-675/I-20W/I-285 West Wall;
- **System 3.** I-75/I-85N/I-20W/I-285 All; and
- **System 4.** I-75/I-85N/I-675/I-285 East Wall.

The performance measures evaluated in the study for the analysis of truck-only lanes along the abovementioned corridor systems included travel time savings, reliability, and safety benefits. As discussed earlier, the study used a combination of the Georgia Statewide model, the ARC model, and the Savannah MPO model to generate traffic forecasts on the corridor systems, and estimate travel time and reliability performance measures for each alternative. Safety

performance was analyzed using crash rates available from GDOT, in terms of number of accidents using V/C and VMT outputs from the model.

Figure B.3 Corridor Systems in Metropolitan Atlanta for Truck Lane Performance Evaluation



Source: Georgia Statewide Truck Lane Needs Identification Study.

Travel Time Savings

Travel time savings due to truck-only lanes were evaluated in terms of changes in VHT in 2035 for each of the corridor systems identified above. Analysis of change in VHT to evaluate travel time savings provides a conservative estimate for travel time savings, because part of the VHT change is contributed by increase in traffic volumes on the corridor due to increased capacity. Table B.18 summarizes these results.

Table B.18 Change in Daily VHT
2035

	System 1 I-75/ I-20W/ I-285W			System 2 I-75/ I-675/ I-20W/I-285W			System 3 I-75/ I-85N/ I-20W/I-285 All			System 4 I-75/ I-85N/ I-675/I-285 E		
	No Project	Truck-Only Lanes	Percent Change	No Project	Truck-Only Lanes	Percent Change	No Project	Truck-Only Lanes	Percent Change	No Project	Truck-Only Lanes	Percent Change
Vehicle Hours Traveled per Day (Millions)												
Facility	0.59	0.48	-19%	0.59	0.48	-19%	0.98	0.85	-14%	0.80	0.68	-15%
Corridor Buffer = 4 Miles	2.68	2.37	-11%	2.81	2.50	-11%	4.60	4.11	-11%	3.70	3.34	-10%
Corridor Buffer = 12 Miles	5.97	5.48	-8%	6.20	5.71	-8%	8.39	7.61	-9%	7.86	7.21	-8%
Region	10.66	10.11	-5%	10.66	10.12	-5%	10.66	9.82	-8%	10.66	9.93	-7%

Source: Georgia Statewide Truck Lane Needs Identification Study.

Based on the results in Table B.17, the average change in VHT due to the implementation of truck-only lanes by location is presented in Table B.19.

Table B.19 Average Change in VHT
2035

Location	Average Percentage of Change in VHT
Facility	-17%
Corridor buffer – 4 miles	-11%
Corridor buffer – 12 miles	-8%
Region	-6%

Reliability benefits

Reliability benefits in the study were evaluated in terms of change in the Buffer Index, which is the ratio of the extra time travelers must build into the trip when planning their travel (to ensure reaching their destination on time 95 percent of the time), to the average travel time. The Buffer Index was estimated as a function of the Travel Time Index (TTI, which is defined as the ratio of the congested travel time to the free flow travel time), using model outputs for congested and free flow travel times for the no-build and truck-only lane alternatives. The reliability benefits (in terms of % change in the Buffer Index) were evaluated both for trucks using the truck lanes, as well as for autos and trucks using the general purpose lanes. Table B.20 presents the reliability analysis results.

Table B.20 Percent Change in Buffer Index
2035

	System 1 I-75/ I-20W/ I-285W			System 2 I-75/ I-675/ I-20W/ I-285W			System 3 I-75/ I-85N/ I-20W/ I-285 All			System 4 I-75/ I-85N/ I-675/ I-285 E		
	No Project	Truck-Only Lanes	Percent Change	No Project	Truck-Only Lanes	Percent Change	No Project	Truck-Only Lanes	Percent Change	No Project	Truck-Only Lanes	Percent Change
Buffer Index												
Truck-Only Lanes	N/A	43%	-81%	N/A	44%	-79%	N/A	40%	-78%	N/A	45%	-80%
GP Lanes	124%	72%	-42%	124%	70%	-43%	118%	77%	-35%	124%	82%	-34%

Source: Georgia Statewide Truck Lane Needs Identification Study.

Based on the results in Table B.20, the average improvements in reliability due to truck-only lanes are generated, which are presented in Table B.21.

Table B.21 Average Improvement in Reliability Due to Truck-Only Lanes
2035

Location	Average Percentage of Change in Buffer Index
Trucks on Truck-Only Lanes	-80%
Auto/Trucks on General Purpose Lanes	-39%

Safety benefits

Safety benefits were evaluated in terms of percent reduction in injury and fatality accidents due to the implementation of truck-only lanes compared to the no-build alternative, for each of the corridor systems. These results are summarized in Table B.22 below.

Table B.22 Estimated Injury and Fatality Accidents With and Without Truck-Only Lanes
2030

	System 1 I-75/ I-20W/ I-285W			System 2 I-75/ I-675/ I-20W/ I-285W			System 3 I-75/ I-85N/ I-20W/ I-285 All			System 4 I-75/ I-85N/ I-675/ I-285 E		
	No Project	Truck-Only Lanes	Percent Change	No Project	Truck-Only Lanes	Percent Change	No Project	Truck-Only Lanes	Percent Change	No Project	Truck-Only Lanes	Percent Change
2030 Estimated Annual Crashes												
Total	7,867	7,860	0%	7,955	7,948	0%	13,564	13,553	0%	10,540	10,531	0%
Injury	1,708	1,686	-1%	1,727	1,705	-1%	2,944	2,910	-1%	2,288	2,262	-1%
Fatal	30	18	-40%	30	17	-43%	50	30	-40%	38	23	-39%
Reduction in Fatal Crashes		12			13			20			15	

Source: Georgia Statewide Truck Lane Needs Identification Study.

Since the Georgia study did not specifically account for the safety benefits of truck-only lanes accruing from truck-auto separation, a 15 percent reduction factor was applied to the total, fatality, and injury accidents estimates in Table B.22 for the truck-only lane alternative, and these results are presented in Table B.23.

Table B.23 Safety Benefits of Truck-Only Lanes
2030

	No Build	Truck-Only Lanes	15% Reduction	Safety Benefits (Percentage of Reduction due to Truck-only Lanes)
Fatality Accidents				
System 1	30	18	15	49%
System 2	30	17	14	52%
System 3	50	30	26	49%
System 4	38	23	20	49%
Average				**50%**
Injury Accidents				
System 1	1,708	1,686	1,433	16%
System 2	1,727	1,705	1,449	16%
System 3	2,944	2,910	2,474	16%
System 4	2,288	2,262	1,923	16%
Average				**16%**
Total Accidents				
System 1	7,867	7,860	6,681	15%
System 2	7,955	7,948	6,756	15%
System 3	13,564	13,553	11,520	15%
System 4	10,540	10,531	8,951	15%
Average				**15%**

Puget Sound Region Freight Action Strategy (FAST) Corridor Analysis

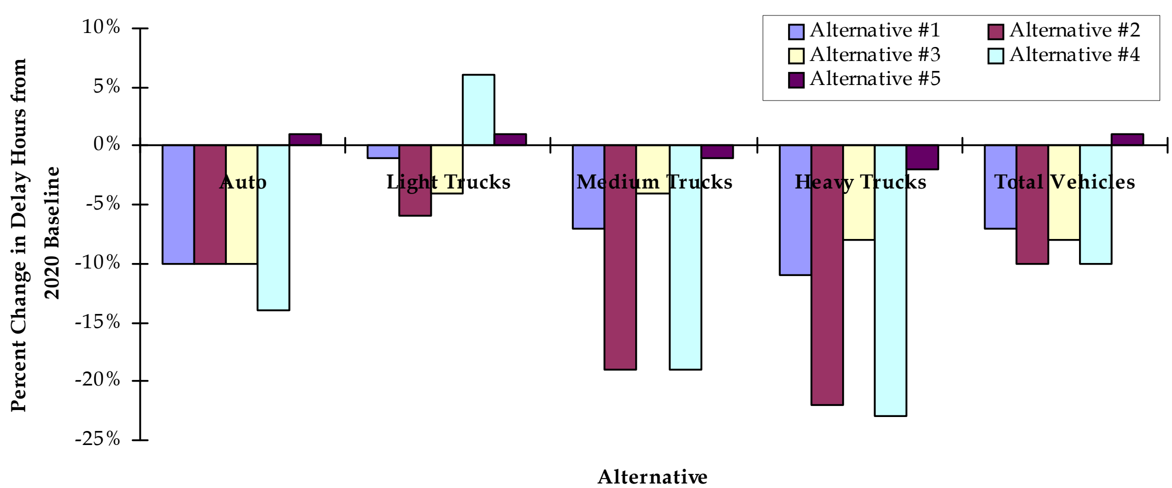
The FAST corridor analysis project in the Puget Sound region involved the development and application of a regional truck model (the FAST truck model) to evaluate the benefits associated with various transportation investments impacting goods movement in the four-county Puget Sound region. The analysis involved conducting model runs for a set of alternatives and comparing model outputs for a set of performance measures against the future no-build (baseline) alternative. The following alternatives were considered in the analysis:

- **Alternative 1.** '*Operational*' improvements of facilities, such as upgrading arterials to freeways, interchange improvements, and capacity improvements for trucks;

- **Alternative 2.** "*Infrastructure*' related – mainly adding general purpose lanes and truck lanes along the larger corridor network;
- **Alternatives 3.** Adding truck-only lanes along the I-405 corridor;
- **Alternative 4.** Adding truck-only lanes along the I-5 corridor; and
- **Alternative 5.** Changes in land use patterns for the 2020 future no-build scenario, and associated impacts.

The primary performance measures evaluated in the study for the abovementioned alternatives included travel time savings in terms of change in VHT, and change in delays (congested travel time – free flow travel time). Figure B.4 presents the VHT results from the alternatives analysis.

Figure B.4 Percentage Change in Vehicle Hours Traveled (VHT) from 2020 Future Baseline



Source: PSRC FAST Corridor Study.

Based on the results in Figure B.4, Table B.24 summarizes the percentage change in VHT for the truck-only lane alternatives (Alternatives 3 and 4) compared to the no-build alternative by vehicle class and total vehicles. Assuming the total VMTs to be relatively the same along the I-5 and I-405 corridors, average travel time savings from truck-only lanes are estimated to be around nine percent compared to the no-build alternative.

Table B.24 Change in VHT, Truck-Only Lanes Against No-Build
2020

	Autos	Light-Heavy	Medium-Heavy	Heavy-Heavy	Total Vehicles
Truck-only Lanes (Alternative 3)	-10%	-4%	-10%	-8%	-8%
Truck-only Lanes (Alternative 4)	-14%	6%	-19%	-23%	-10%

Source: PSRC FAST Corridor Study.

I-15 Comprehensive Corridor Study

The I-15 study was sponsored by the Southern California Association of Governments (SCAG), the California Department of Transportation (Caltrans), and the San Bernardino Associated Governments (SANBAG) with the primary objectives of analyzing right-of-way needs along the corridor, assess the feasibility and costs of implementing truck lanes, and perform a comprehensive evaluation of transportation needs along the corridor to feed the development of a long range improvement plan and implementation strategy for the corridor. The study conducted an initial screening evaluation of a comprehensive list of alternatives, which were narrowed down to a final set of five alternatives for detailed screening and alternative selection process. The final set of alternatives selected for detailed evaluation included the following:

- **Strategy A – No-Build.** This represents the future baseline alternative against which the performance of the other alternatives is assessed, and includes all the transportation projects currently under construction or planned and committed for implementation prior to 2030 (the planning horizon year of the study).

- **Strategy B – TSM/TDM.** This includes operational strategies aimed at improving transit service, goods movement, and automobile travel along the corridor, in addition to reducing the environmental impacts of transportation operations. Specific strategies include ramp metering, truck emission reduction programs, improved transit service, and expanded corridor ITS applications.

- **Strategy C – HOV Lanes.** This includes one HOV lane in each direction along the entire stretch of the corridor in the study area between SR 60 in Riverside County and D Street in Victorville. In addition to serving vehicles with two or more occupants (either 2+ or 3+ occupants per vehicle depending on demand), the HOV lanes would serve Express Bus Service as well to ensure maximum utilization of the lanes.

- **Strategy D – Full Corridor Dedicated Truck Lanes.** This includes two truck lanes (physically separated from the GP lanes) in each direction for the entire stretch of the corridor between SR 60 and D Street.

- **Strategy E – Reversible Managed Lanes.** This includes construction of two (or possibly three) managed lanes (physically separated from the GP lanes) along the corridor between

SR 210 and U.S. 395, serving typically peak trips with flows along the lanes reversible to reflect the directional variations in peak travel demand by time of day and day of week along the corridor.

Traffic (truck and auto) volume forecasts and mobility performance measure (V/C) for each of the alternatives were generated using the 2004 SCAG Regional Transportation Plan (RTP) model. Table B.25 shows the forecast (2030) truck and auto volumes along the corridor by segment (the study analyzed travel demand along the corridor for seven segments) under each of the alternatives. Assuming that the average trip lengths under the various alternatives remain the same for this comparative analysis, Table B.26 presents the percent change in VMT for alternatives relative to the no-build. As mentioned earlier, the SCAG RTP model was used to generate V/C statistics for each of the alternatives, which are presented for the PM peak period in Table B.27. The following sections present the performance benefits results for the study.

Travel Time Savings

The V/C results in Table B.27 are translated into equivalent speeds (shown in Table B.28) for each alternative using volume-delay function (VDF) for freeways, using the following function:

$$Speed = 65/(1+[1.16*(V/C)^{4.33}])$$

Table B.25 Daily Auto and Truck Volumes Along I-15 by Segment and Alternative
2030

Segment	No Build			TSM/TDM			HOV Lanes			Truck Lanes			Managed Lanes		
	Autos	Trucks	Truck %	Autos	Trucks	Truck %	Autos	Trucks	Truck %	Autos	Trucks	Truck %	Autos	Trucks	Truck %
1	103,133	34,749	25%	103,473	34,777	25%	108,985	34,835	24%	110,093	35,237	24%	113,332	34,755	23%
2	98,240	42,047	30%	98,704	42,004	30%	103,340	42,167	29%	105,404	43,079	29%	108,787	42,013	28%
3	101,608	48,330	32%	100,414	48,268	32%	102,100	48,464	32%	105,329	48,664	32%	98,301	48,120	33%
4	142,320	49,575	26%	141,585	49,547	26%	142,922	49,920	26%	147,598	50,161	25%	142,574	49,663	26%
5	96,515	39,559	29%	96,333	39,532	29%	100,713	39,885	28%	104,212	40,316	28%	99,034	39,681	29%
6	163,796	27,704	14%	163,500	27,521	14%	175,326	30,172	15%	173,552	32,319	16%	173,871	27,717	14%
7	223,860	42,250	16%	224,995	42,422	16%	245,335	46,071	16%	244,013	56,828	19%	234,762	42,477	15%

Source: I-15 Comprehensive Corridor Study.

Note:
Segment 1 – Mojave River Crossing to Bear Valley Road;
Segment 2 – Bear Valley Road to U.S. 395;
Segment 3 – U.S. 395 to SR 138;
Segment 4 – SR 138 to I-215;
Segment 5 – I-215 to I-210;
Segment 6 – I-210 to I-10; and
Segment 7 – I-10 to SR 60.

Table B.26 Percent Change in Daily Auto VMT Compared to No Build
2030

Segment	No Build	TSM/TDM	HOV Lanes	Truck Lanes	Managed Lanes
1	–	0%	6%	7%	10%
2	–	0%	5%	7%	11%
3	–	-1%	0%	4%	-3%
4	–	-1%	0%	4%	0%
5	–	0%	4%	8%	3%
6	–	0%	7%	6%	6%
7	–	1%	10%	9%	5%

Table B.27 V/C, Comparison Across Alternatives
PM Peak Period, Northbound, 2030

MEASURE	SEGMENT	EXISTING CONDITION	FUTURE ALTERNATIVE				
			A No Build	B TSM/TDM	C HOV Lanes	D Truck Lanes	E Managed Lanes
PM Peak Period Demand V/C Ratios Northbound (General Purpose Lanes)	1	0.39	0.79	0.79	0.69	0.62	0.60
	2	0.57	0.81	0.81	0.73	0.58	0.63
	3	0.41	0.92	0.91	0.80	0.75	0.69
	4	0.74	**1.39**	**1.38**	**1.20**	**1.17**	**1.01**
	5	0.61	0.78	0.78	0.68	0.56	0.55
	6	0.80	0.92	0.92	0.81	0.78	0.76
	7	0.86	**1.12**	**1.12**	**1.09**	**1.09**	0.91
PM Peak Period Demand V/C Ratios Northbound (HOV, Truck, or Managed Lanes)	1	na	na	na	0.40	0.32	not applicable
	2	na	na	na	0.35	0.44	not applicable
	3	na	na	na	0.59	0.47	0.46
	4	na	na	na	0.78	0.53	0.81
	5	na	na	na	0.52	0.55	0.56
	6	na	na	na	0.66	0.50	not applicable
	7	na	na	na	0.66	0.44	not applicable

Source: I-15 Comprehensive Corridor Study.

Table B.28 PM Peak-Period Speeds
Northbound, 2030

Segment	No Build	TSM/TDM	HOV Lanes	Truck Lanes	Managed Lanes
1	46	46	53	57	58
2	44	44	50	59	56
3	36	37	45	49	53
4	11	11	18	20	29
5	47	47	53	59	60
6	36	36	44	47	48
7	22	22	24	24	37
Average	**35**	**35**	**41**	**45**	**49**
% Speed Improvement	**–**	**0%**	**19%**	**30%**	**41%**

Table B.29 translates the speed improvements in Table B.28 into percent reduction in travel time savings for alternatives compared to the no-build alternative.

Table B.29 Average Travel Time Savings Relative to No Build
Northbound, 2030

	Percentage of Savings
TSM/TDM	0%
HOV Lanes	16%
Truck Lanes	23%
Managed Lanes	29%

Reliability Benefits

Reliability benefits are estimated in terms of reduction in incident-related delay for the build alternatives relative to the no-build alternative using IDAS post-processing factors for delay per VMT as a function of congestion (V/C) and number of lanes. Table B.30 shows the delay per VMT estimated along the corridor by segment for each of the alternatives derived from IDAS. For the truck-only lane alternative, the delay per VMT was reduced by an additional factor of 15 percent to account for the reliability benefits of truck-auto separation.

Table B.30 Incident-Related Delay Per VMT, PM Peak Period
*Northbound, 2030**

Segment	No Build	TSM/TDM	HOV Lanes	Truck Lanes		Managed Lanes
				IDAS	Net after 15% Additional Reduction	
1	1.31E-07	1.31E-07	1.72E-08	1.72E-08	1.46E-08	1.72E-08
2	1.31E-07	1.31E-07	1.31E-07	1.72E-08	1.46E-08	1.72E-08
3	6.30E-07	6.30E-07	1.31E-07	1.31E-07	1.11E-07	1.72E-08
4	6.75E-06	6.75E-06	2.28E-06	2.28E-06	1.94E-06	6.30E-07
5	1.31E-07	1.31E-07	1.72E-08	1.72E-08	1.46E-08	1.72E-08
6	6.30E-07	6.30E-07	1.31E-07	1.31E-07	1.11E-07	1.31E-07
7	2.28E-06	2.28E-06	6.30E-07	6.30E-07	5.36E-07	6.30E-07

* Note that for the truck lane alternative, an additional 15 percent reduction in incident-related delay was applied as recommended by the Douglas Handbook to account for safety benefits resulting from truck-auto separation.

Using the percent change in daily auto VMT estimates from Table B.26 and the delay per VMT estimates from Table B.30, the percent change in incident related delay for the build alternatives relative to the no-build are calculated, which are presented in Table B.31 below.

Table B.31 Percent Change in Incident Related Delay, PM Peak Period
Northbound, 2030

Segment	No Build	TSM/TDM	HOV Lanes	Truck Lanes	Managed Lanes
1	–	0%	-86%	-88%	-86%
2	–	0%	5%	-88%	-85%
3	–	-1%	-79%	-82%	-97%
4	–	-1%	-66%	-70%	-91%
5	–	0%	-86%	-88%	-87%
6	–	0%	-78%	-81%	-78%
7	–	1%	-70%	-74%	-71%
Average	**–**	**0%**	**-66%**	**-82%**	**-85%**

Safety benefits

Safety benefit comparisons between alternatives are conducted by estimating total accidents (fatality, injury and property damage) per million VMT as a function of V/C along the corridor (by segment) using the IDAS software, and estimating percentage change in total accidents using the percent change in VMT estimates between alternatives. For the truck-only lane alternative, an additional 15 percent reduction factor is applied to the total accidents estimate to account for the safety benefits of truck-auto separation. Table B.32 presents these results.

Table B.32 Percent Change in Total Accidents Compared to No-Build, PM Peak Period
Northbound, 2030

Segment	No Build	TSM/TDM	HOV Lanes	Truck Lanes		Managed Lanes
				From IDAS	After 15% Reduction Factor Adjustment	
1	–	0%	-8%	-21%	-33%	-4%
2	–	0%	-8%	-20%	-32%	-3%
3	–	-1%	0%	-12%	-25%	-15%
4	–	-1%	0%	-12%	-25%	0%
5	–	0%	-9%	-20%	-32%	-10%
6	–	0%	7%	-10%	-24%	6%
7	–	1%	10%	-7%	-21%	-19%
Average	**–**	**0%**	**-1%**	**-15%**	**-27%**	**-6%**

B.3 New Jersey Turnpike Safety Performance Analysis

The Douglas Handbook[2] presents a discussion of the safety benefits that resulted from implementing the dual-dual roadway sections on the NJ Turnpike. The accident rate history on the NJ Turnpike presented in the handbook supports the notion that the dual-dual roadway system enhances safety. Based on an analysis of historic trends in total accident rates along the Turnpike for the 10-year period from 1994 to 2003, it is found that in each of the 10 years, the accident rates on the dual-dual roadway sections were 28 percent to 40 percent less than on the segments of the Turnpike without separated roadways. Figures B.5, B.6, and B.7 show a

[2] Douglas, J. G., *Handbook for Planning Truck Facilities on Urban Highways*, August 2004.

comparison in total, injury, and fatal accident rates, respectively, between the dual-dual and nondual-dual roadway sections of the New Jersey Turnpike.

Figure B.5 New Jersey Turnpike: Comparison of Total Crash Rates

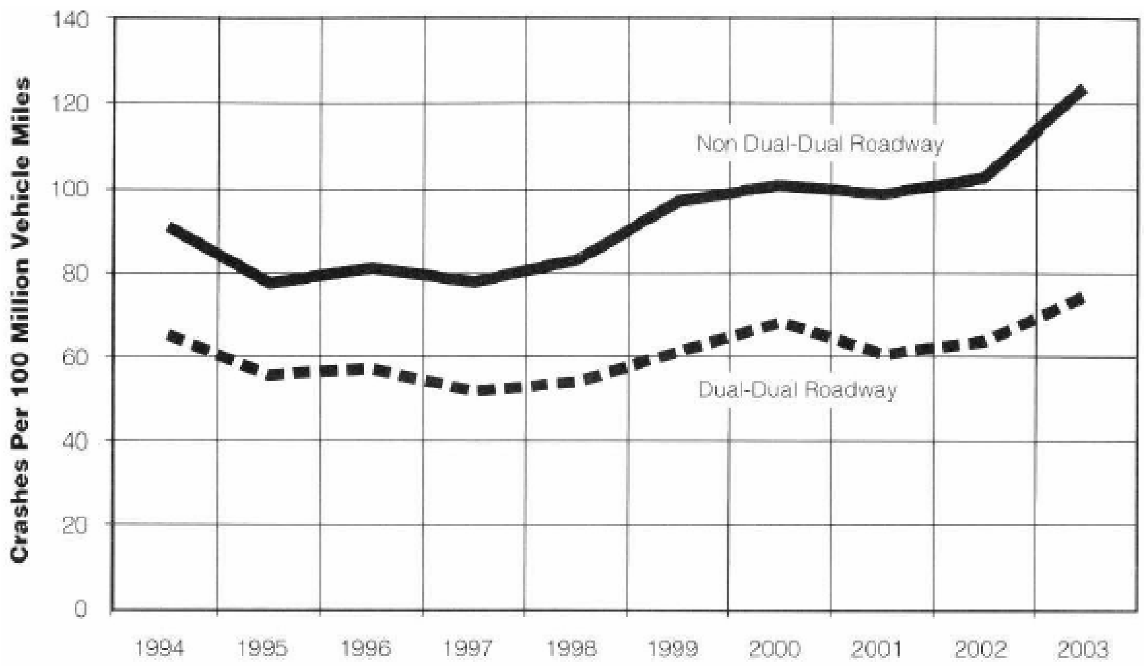


Figure B.6 New Jersey Turnpike: Comparison of Injury Crash Rates

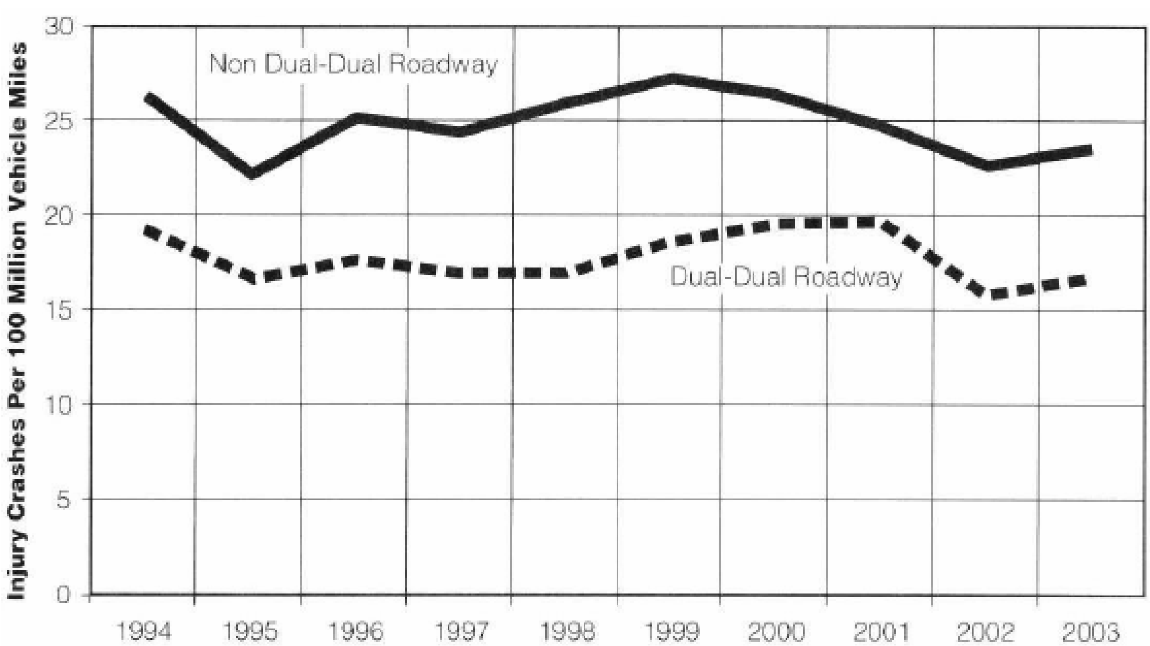
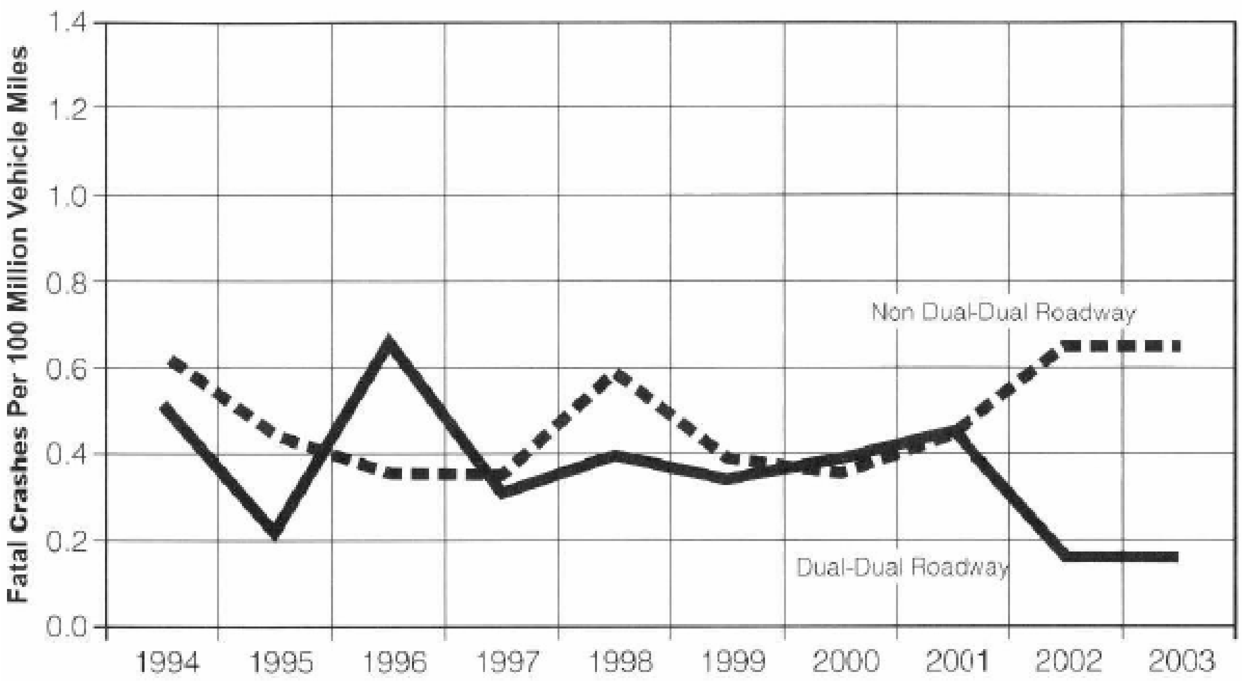


Figure B.7 New Jersey Turnpike: Comparison of Fatal Crash Rates



Some key insights based on the historic crash trends depicted in Figures B.5. B.6, and B.7 include the following:

- Total crash rates on the dual-dual sections of the Turnpike were at least 28 percent lower than the total crash rates on the nondual-dual sections in the 1994 through 2003 time period. The lower crash rates on the dual-dual sections can be attributed to higher capacity as well as more homogeneity in vehicular traffic compared to the nondual-dual sections.

- Injury crash rates on the dual-dual sections were observed to be 20 to 34 percent lower than the injury crash rates on the nondual-dual sections in the 1994 through 2003 time period.

- No consistent pattern was observed in differences in fatal crash rates between the dual-dual and nondual-dual sections of the Turnpike in the 1994 through 2003 time period. Based on this trend, the Douglas Handbook states that "it is not possible to safely conclude that there will likely be any changes in the rates of fatal crashes due to constructing truck lanes."

More detailed evaluation of the incident reports and corresponding roadway conditions is needed to determine how much of the difference in total and injury crash rates between the dual-dual and nondual-dual sections of the Turnpike is attributable to the separation of vehicles and how much is attributable to other factors such as higher number of lanes and lower congestion levels along the dual-dual sections. Nonetheless, the data clearly indicate that accident rates have been consistently lower in the areas with dual-dual roadway sections. The handbook also reports that an 18 percent reduction in total accident rate was observed for the time period immediately after the construction of the dual-dual roadway sections, and notes that "the crash rate reduction benefit attributable to the separated roadways should be placed

closer to the 18 percent reduction observed after the initial opening of the dual-dual roadways," as the impacts of increased capacity on safety benefits are not expected to be realized immediately after the construction of the dual-dual roadways (in other words, most of these benefits can be attributed to the separation of autos from trucks). Based on this assessment, the handbook recommends applying a 15 percent safety benefit (reduction in accidents) due to truck-only lanes attributable to truck-auto separation.

B.4 Simulation Analysis of the Safety Benefits of Truck-only Lanes

A study conducted at The University of Tennessee at Knoxville analyzed the performance benefits of implementing exclusive truck lanes against a no-build ("current situation") alternative. The study also looked at other kinds of truck management strategies such as different types of truck restrictions (restricting trucks to the left-most lane only, and restricting trucks to two left most lanes). However, only the results of the safety performance evaluation of the exclusive truck lane alternative compared against the "current situation" alternative are discussed in this section. The "current situation" alternative (Alternative A) involves truck restrictions on the two right lanes (on general purpose lanes with three lanes in each direction), while the truck-only lane alternative (Alternative B) includes one exclusive truck lane in each direction, which is barrier separated from the general purpose lanes, which have two lanes in each direction.

The approach used to analyze safety benefits involved simulating the alternatives in a VISSIM microsimulation environment, using number of lane changes as the performance metric for safety analysis (under the assumption that higher the number of lane changes, higher the propensity for accidents, and lower the safety performance). The study evaluated the alternatives under two different traffic scenarios – a 2008 scenario with current traffic conditions, and a 2020 scenario with projected 2020 traffic conditions. The results of the safety performance (in terms of number of lane changes) comparisons for the 2020 traffic scenarios are presented in Table 3.49.

Table 3.49 Lane Change Rate (Lane Changes per Hour) Comparisons, Current Situation vs. Truck Lane Alternative

Vehicle Class	Current Situation Lane Change Rate (lcph)	Truck-Only Lane Lane Change Rate (lcph)	Percent Change
Car	198,969	119,334	-40.02%
SU Truck	3,500	675	-80.71%
Tractor-Trailer	33,283	4,254	-87.22%

Source: *Simulating Truck Lane Management Approaches to Improve Efficiency and Safety of Highways in Knoxville, Tennessee*, Master's Thesis, Adebola Adebisi Adelakun, December 2008, The University of Tennessee, Knoxville.

The number of lane changes under the Alternative B depends on the number of trucks diverting to the exclusive truck lanes. In this case, a significant number of trucks diverted to the truck-only lanes (because of the absence of tolls), which caused a notable drop in the number of lane changes for trucks compared to Alternative A. Also, since the cars and trucks (those that did not divert to the truck-only lanes) on the general purpose lanes are restricted to only two lanes in the exclusive truck lane alternative, this also results in a notable reduction in the number of lane changes for cars. Since the number of lanes under the two alternatives are the same (Alternative A has three general purpose lanes in each direction with truck restrictions on the two right lanes, while Alternative B has two general purpose lanes and one exclusive truck lane in each direction), analyzing the number of lane changes under the two alternatives can give insights into the safety benefits resulting from separating trucks and autos. The best approach to evaluating the net improvement in safety is by comparing the total number of lane changes under the two alternatives. Alternative B results in 124,263 lane changes per hour, which is a 47.3 percent reduction compared to Alternative A. Since the relationship between accident rates and lane change rates may vary based on the composition of traffic (relative magnitude of trucks and autos), it would be difficult to quantify the exact safety improvement (in terms of accident reduction) associated with a 47.3 percent reduction in lane change rates. However, the results from this study provide useful insights into the expected range of safety benefits that can be attributed to truck-auto separation compared to mixed-flow facilities.

As discussed in the Interim Report, there is a lack of real world data on accident rates on truck-only lane facilities, which can be compared against the accident rates on mixed-flow facilities with similar capacity and traffic flow conditions. The data from the New Jersey Turnpike does provide some useful insights into safety improvements associated with the implementation of the dual-dual roadway sections; however, some of the safety improvements result from increased capacity, which make it difficult to assess the safety benefits resulting just from separating autos from the mixed-flow traffic. The lack of real world applications of truck-only lanes has also meant that there is a dearth of analytical tools that can be calibrated/validated to predict the safety benefits resulting from separating trucks and autos. Applications of simulation approaches, like the study conducted at the University of Tennessee at Knoxville, appear promising and robust in assessing the safety benefits of truck-auto separation.

B.5 Impact of Tolls on Utilization and Performance of Truck-only Lanes

The ability of truck-only lanes to generate significant congestion reduction benefits depends on the number of truck trips that can be diverted from the general purpose lanes in the peak periods (given that trucks have a notable contribution to congestion in the peak periods). The diversion potential and resulting utilization rates (fraction of total truck traffic along the corridor utilizing the truck lanes) of truck lanes depend on many factors, including the level of congestion on the general purpose lanes (higher the congestion on the general purpose lanes, higher the propensity for trucks to divert to truck lanes to avoid congestion), the truck trip O-D distribution patterns in the region and the physical configurational characteristics of truck lanes to serve these distribution patterns (such as access/egress points), and perhaps most importantly, the application of tolls on truck-only lanes and the value of time characteristics of truck trips along the corridor (for example, port truck trips typically have a higher value of time

than nonport truck trips, and consequently, the truck diversion under tolls might vary depending on what share of the total trucks are port trucks).

This section discusses the sensitivities of tolls on the diversion potential and utilization of truck lanes, which in turn directly impact the performance of truck lanes, based on the I-710 Major Corridor Study in Southern California. The I-710 MCS serves as an ideal example to analyze these sensitivities because of the following aspects:

- The I-710 corridor is expected to experience significant congestion in the future throughout the day (AM peak, mid-day, and PM peak);
- The corridor is forecast to experience high truck traffic volumes in the future, a large share of which would be generated by the Ports of Los Angeles and Long Beach; thus, utilization of truck lanes is not an issue as long as significant diversion can be achieved; and
- The study provides relationships between changes in tolls and diversion to truck-only lanes, which can be used to understand how tolls impact the performance of truck-only lanes based on the truck and auto volume characteristics on the general purpose lanes, as well as assess the revenue potential of various toll scenarios.

The I-710 MCS analyzed three scenarios as part of the toll sensitivity analysis, which included the following:

- **Scenario 1.** No toll;
- **Scenario 2.** Tolls of 0.07 cent per mile; and
- **Scenario 3.** Tolls of 0.15 cent per mile.

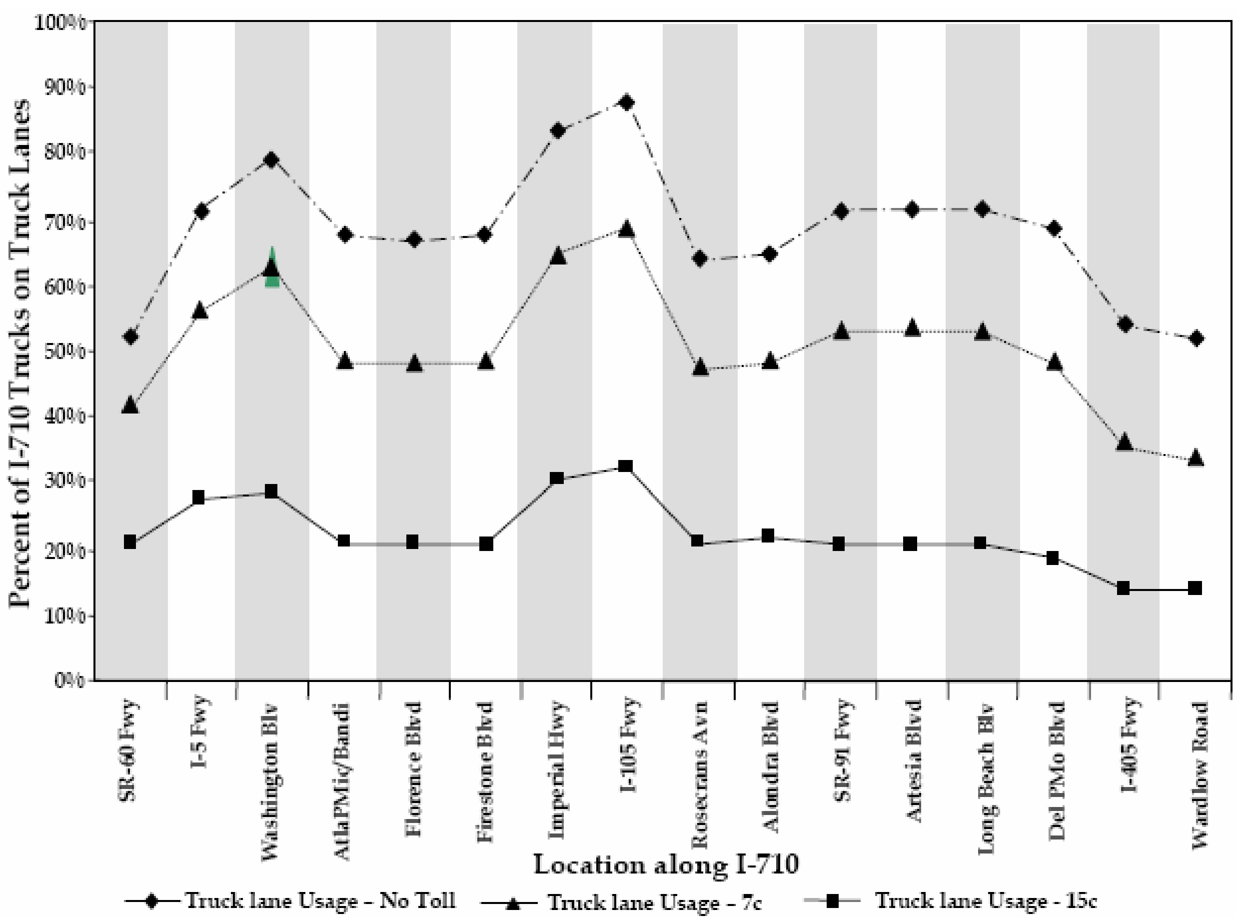
Truck value of time data for use in the toll analysis were developed using a truck value of time probability distribution developed using stated-preference surveys conducted by the University of California Berkeley. Using this distribution, trucks were divided into two truck classes, and five value of time categories, for the estimation of truck diversion by truck class and value of time category. The logit probability distribution resulted in a mean value of time of $30 per hour and a median of $18 per hour, indicating that the distribution was skewed more towards trucks with lower values of time. Since a large share of the trucks on the corridor are port trucks which would potentially have higher values of time, and since the study does not explicitly account for the value of reliability improvements for trucks from using the truck lanes, the diversion estimates from the study provide a lower bound estimate of expected diversions under the various toll scenarios.

The results of potential diversion of trucks to truck lanes under the three scenarios are depicted in Figure B.8. As expected, the highest diversion occurs under scenario 1, in the range of 50 percent to 90 percent of total truck traffic along the corridor. With the application of tolls of $0.07 per mile, the estimated diversion drops to between 30 percent and 70 percent. Under scenario 3 (tolls of $0.15 per mile), the diversion further drops to between 10 percent and 30 percent along the corridor. However, as stated earlier, these diversion estimates are likely to be under-reported due to the higher value of time of port trucks, and the lack of consideration of value of reliability benefits in the diversion analysis. The study estimates that the tolls

resulting in the highest revenue potential lie somewhere between $0.07 per mile and $0.15 per mile. The difference between peak period and daily diversion estimates were observed to be minimal due to high congestion levels along the corridor throughout the day.

Clearly, the application of tolls has an impact on the congestion reduction performance of truck lanes along the I-710 corridor. Along the I-710 corridor, trucks are predicted to account for, on an average, close to 17 percent of total traffic volumes in 2025. Considering the larger size of trucks compared to passenger cars, the contribution of trucks to congestion along the corridor is predicted to be even higher (close to 34 percent for a PCE factor of 2.5). This information can be used to analyze the relative impacts of the various toll scenarios on congestion on the I-710 general purpose lanes. For example, a 20 percent reduction in truck volumes on general purpose lanes between two toll scenarios would potentially result in around 7 percent reduction in congestion.

Figure B.8 Impacts of Tolls on Truck Lane Utilization Along the I-710 Corridor



Source: I-710 Major Corridor Study.

In deciding on the application of tolls on truck lanes, it is not only important to analyze the revenue potential of tolls to recover the costs of developing truck lanes, but also on the impacts of tolls on congestion on the general purpose lanes and the effective utilization of truck lanes. Tolls resulting in low truck diversion from general purpose to truck lanes would not contribute to an effective investment strategy, due to substantial under-utilized capacity on the truck lanes, as well as marginal reduction in congestion on the general purpose lanes. The diversion potential of tolled truck lanes is also important because some share of the freed-up capacity could potentially be filled up by autos diverting to the general purpose lanes from arterials, as well as some trips outside the region that now use the corridor due to the increased capacity.

Some of the key factors that would impact the decisions related to the application of tolls on truck lanes include, but may not be limited to, the following:

- Revenue potential of tolls and what share of the costs of developing truck lanes can be recovered through tolls: The revenue potential of tolls is tied to the diversion potential of tolled truck lanes for a given toll scenario, which is in turn dependent on the congestion and reliability benefits of truck lanes and the value of time distribution of truck traffic along the corridor.

- Magnitude of truck and auto traffic volumes, congestion along the corridor, and contribution of truck traffic to corridor congestion.

- Truck traffic with high sensitivity to travel time and reliability benefits. This factor would be inherently dependent on the value of time and reliability distributions of truck traffic. Typically, urban corridors with significant port truck traffic volumes such as the I-710 would have favorable conditions for application of tolls, as large share of the port truck traffic would be willing to pay tolls to achieve improved travel times and reliability.

- Variable tolling: Variable tolling might be a potent approach to maximize the truck diversion, utilization, and revenue potential of truck lanes along corridors with varying congestion, and truck and auto volume characteristics by time of day.

Appendix C.

Benefits Monetization Factors and Unit Costs

C. Benefits Monetization Factors and Unit Costs

C.1 Benefits Monetization Factors

Value of Time

Value of time (VOT) for trucks and autos are key data inputs for the monetization of travel time savings and reliability benefits (for the public and private sector) of truck-only lanes. Task 6 (Tolling and Privatization) of the project conducted detailed research on truck VOT estimates from available data sources, which provides the basis for the selection of truck VOT for the benefit-cost analysis. The sections below summarize the auto and truck value of time estimates that are used in the current analysis.

Truck Value of Time

As discussed in the Tolling and Privatization chapter in the Interim Report, a trucker's value of time is a function of many factors, which include, but may not be limited to, the type of trucking business operation (for example, for-hire and private carriers), truck trip length characteristics (short-haul versus long-haul trips), the type of truck (medium heavy-duty versus heavy heavy-duty trucks), and the type of delivery schedule (not fixed delivery schedule and penalty on late delivery). Several methods have been employed to measure a trucker's value of time, including the following:

- **Revenue or net operating profit method.** This method estimates truck value of time in terms of the net increase in profit resulting from reduction in travel times;

- **Cost-saving method.** This method estimates truck value of time in terms of the cost savings to truck operators per unit of time;

- **Cost-of-time method.** This method calculates the cost of providing time savings for a specific project; and

- **Willingness-to-pay method.** This method measures the "market" or "perceived" value of time for trucks based on observed or stated choices under tradeoff situations involving time and money.

Due to variations in the approaches to estimating truck value of time and the differences in value of time as a function of trucking company and truck type characteristics, average truck value of time estimates are used for the monetization of performance benefits, based on the extent of availability of truck value of time data from various sources. Also, since the truck VOT data available from sources may correspond to different years, the data is indexed to 2008 in estimating the average truck VOT, using historical trends in Consumer Price Index (CPI).

Table C.1 presents truck VOT estimates from different sources reviewed as part of this study. Assuming most of the trucks operating on truck-only lanes to be heavy heavy-duty trucks, the average truck value of time used for the benefit-cost analysis from Table C.1 is estimated to be around $39 per hour. The value of time for Longer Combination Vehicles (LCV) is expected to be higher than that of standard trucks because of increased payloads per trip. According to the Reason Foundation, variable costs for LCVs are approximately 1.6 times the variable costs of standard trucks. The variable costs do not increase at the same rate as the increase in payload because of increased productivity associated with LCVs (higher payloads per trip). Thus, if an hour saved corresponded to around $39 in savings for standard trucks, an hour saved for LCVs would amount to around $62 in savings for LCVs.

Table C.1 Truck Value of Time Estimates

Source	Trucking Characteristics	Value of Time (Dollars Per Hour)	Year	Value of Time (Indexed to 2008)
Kawamura, K., Commercial vehicle value of time and perceived benefit of congestion pricing (Doctoral dissertation, University of California at Berkeley, 1999)	For-hire Carriers	28.0	1999	36.2
	Private Carriers	17.6		22.7
Truck-Only Toll Facilities: Potential for Implementation in the Atlanta Region/ Atlanta TOT Facilities Study, State Road and Tollway Authority, July 2005	Light Heavy-Duty Trucks	18.0	2005	19.8
	Heavy Heavy-Duty Trucks	35.0		38.6
Puget Sound Regional Council (PSRC), Value of Time for Travel Forecasting and Benefits Analysis, Technical Memorandum, March 2008	Light Heavy-Duty Trucks	40.0	2008	40.0
	Medium Heavy-Duty Trucks	45.0		45.0
	Heavy Heavy-Duty Trucks	50.0		50.0
Robert W. Poole, Jr., Miami Toll Truckway: Preliminary Feasibility Study, Reason Foundation Policy Study 365, November 2007	Heavy Heavy-Duty Trucks	25.0	2007	26.0
Smalkoski, Brian, and Levinson, D. (2005), Value of Time for Commercial Vehicle Operators; Journal of the Transportation Research Forum 44:1 89-102.	Heavy Heavy-Duty Trucks	49.4	2005	54.5
I-710 Major Corridor Study Final Report, Los Angeles (LA) Metro, March 2005	Heavy Heavy-Duty Trucks	30.0	2005	33.1
The Value of Travel-Time: Estimates of the Hourly Value of Time for Vehicles in Oregon 2005	Light Heavy-Duty Trucks	20.4	2005	22.5
	Heavy Heavy-Duty Trucks	29.5		32.5
Average Value of Time (Light Heavy-Duty Trucks)		**26.3**		
Average Value of Time (Medium Heavy-Duty Trucks)		**Data insufficient to compute average**		
Average Value of Time (Heavy Heavy-Duty Trucks)		**38.7**		

Auto Value of Time

Auto value of time is a key data input for the monetization of public-sector benefits (travel time savings and reliability improvements for autos on the general purpose lanes) of truck-only lanes. The commonly adopted approach to estimating auto value of time is based on the observation by Small and Verhoef[1], according to which value of time for autos (for commuting to work) can be approximated as 50 percent of the gross average wage rate in a region. Small and Verhoef observe that this is a reasonable assumption given that there are variations in auto value of time (between 20 percent and 10 percent of wage rate) depending on the region, as well as differences in income levels within a population. In 1997, the U.S. Department of Transportation (DOT) established guidelines[2] for the valuation of travel times for economic analyses, which required adoption of the following assumptions for the estimation of value of time for personal travel:

- Fifty percent of the wage rate for all local personal travel (by surface modes); and
- Seventy percent of the wage rate for all intercity personal travel (by surface modes).

Empirical studies conducted by Brownstone and Small[3] on values of travel time savings for passenger vehicles for two California roadway pricing projects (I-15 High-Occupancy Toll lanes in San Diego, and SR 91 in Orange County) revealed values of time ranging between 50 percent to 90 percent of average wage rates in these areas. The PSRC travel demand model[4], until recently, was also assuming auto value of time to be 50 percent of average regional wage rates for applications in roadway pricing impact analyses.

Based on the discussion above on the assumptions related to the estimation of auto value of time from various sources, it is proposed that auto value of time of 75 percent of the national weighted average wage rate be applied for the current benefits analysis. National weighted average wage rate calculated using the 2007 Occupational Employment Statistics (OES) published by the Bureau of Labor Statistics (BLS), is estimated to be around $20.3 per hour (indexed to 2008 dollars), resulting in auto value of time of around $15.2 per hour.

Value of Travel Time Reliability

In the current analysis, travel time reliability for autos and trucks is measured in terms of savings in non-recurrent (incident-related) delays. Due to the probabilistic nature of incidents, autos and trucks typically associate a higher cost to non-recurrent delays (such as due to incidents) compared to predictable (recurrent delays) such as due to peak hour congestion. There have been a few studies that have attempted to quantify the value of time that takes into

[1] Small, K., and E. T. Verhoef, *The Economics of Urban Transportation*, October 2007.

[2] U.S. Department of Transportation, *Departmental Guidance for the Valuation of Travel Time in Economic Analysis*, 2997 (http://ostpxweb.dot.gov/policy/Data/VOT97guid.pdf).

[3] Brownstone, D., and K. Small, *Valuing Time and Reliability: Assessing the Evidence from Road Pricing Demonstrations*, Transportation Research A, Volume 39, pp. 279-293, 2005.

[4] Puget Sound Regional Council, Value *of Time for Travel Forecasting and Benefits Analysis*, Technical Memorandum, March 2008.

account non-recurrent delay such as Cohen et al.[5], which presents the results from a couple of models (model 1 and model 2). According to model 1, the value of incident-related delay was observed to be equal to the value of time under uncongested conditions, while model 2 predicted the value of incident-related delays to range between 2 to 6 times the value of time under uncongested conditions. Since the VOT estimates used in the current analysis take into account the affect of congestion (recurrent delay), the factor to be applied to these estimates to arrive at the value of incident-related delays are expected to be lower than the factors predicted by Cohen et al. (average factor from models 1 and 2 of around 2.5). In a study conducted by Levinson et al.[6], a factor of 1.35 was applied to the value of time to account for the value of travel time reliability benefits. Based on the above results, a factor of 1.5 is used to adjust the VOT estimates to arrive at the value of incident-related delay for the quantification of reliability benefits.

Monetization Factors for Accidents

Monetization factors for accidents were derived using detailed accident cost data published by the Federal Highway Administration (FHWA) in October 2005[7]. Table C.2 summarizes these estimates for fatality, injury and property damage only (PDO) accidents, after indexing the costs to 2008 dollars.

Table C.2 Accident Costs, 2008

Type of Accident	Cost
Fatality	4,365,164
Injury	131,642
PDO	8,226

Source: Federal Highway Administration, *Crash Cost Estimates by Maximum Police-Reported Injury Severity Within Selected Crash Geometries*, Publication No. FHWA-HRT-05-051, October 2005.

[5] Cohen, Harry and Southworth, Frank, *On the Measurement and Valuation of Travel Time Variability due to Incidents on Freeways*, Journal of Transportation and Statistics, December 1999

[6] Levinson, David and Zhang, Lei, *Travel Time Variability after a Shock: The Case of the Twin Cities Ramp Metering Shut Off,* First International Symposium on Transportation Network Reliability, Kyoto, Japan, July 30 – August 1, 2001

[7] Federal Highway Administration, *Crash Cost Estimates by Maximum Police-Reported Injury Severity Within Selected Crash Geometries*, Publication No. FHWA-HRT-05-051, October 2005.

C.2 Unit Costs

Urban Corridors

Construction Costs (Lanes)

Middleton et al.[8] provides a detailed discussion on the construction costs associated with at-grade truck-only lane facilities as a function of the number of lanes, and how these costs compare against the construction costs of mixed-flow facilities. The study provides two separate set of estimates of construction cost comparisons between truck-only lane and mixed-flow facilities, one in which the total number of lanes in the truck-only lane and mixed-flow facilities are the same, and other with different number of lanes in the two facilities. Analysts in the study used planning cost estimates available from the Texas DOT for the costing analysis for truck-only and mixed-flow lanes.

Tables C.3 and C.4 summarize these estimates, in which the construction costs are provided in terms of costs per mile. Estimates in these tables can serve as useful inputs for truck-only lane facility planning, particularly in the case of new facility development, where there is a choice between building a mixed-flow facility versus a separated facility (facility having separate truck lanes). The column titled "Difference" in Tables C.3 and C.4 provides the incremental costs of building separated facilities compared to mixed-flow facilities. "Cost Mixed" and "Cost Separated" columns provide the total construction cost per mile for mixed-flow and separated facilities, respectively. The "Separated Scenario" column indicates the number of general purpose and truck-only lanes in the separated facilities.

Table C.3 Initial Construction Cost Per Mile Comparisons Between Truck-Only Lane and Mixed-Flow Facilities With Equal Number of Lanes

Number of Lanes (Bidirectional)	Cost Mixed	Separated Scenario	Cost Separated	Difference
4	10,699,845	2+2	16,964,429	6,264,584
5	16,018,968	2+3[a]	19,767,232	3,748,264
6	16,518,089	2+4	21,699,845	5,181,756
7	19,069,090	2+5	27,018,968	7,949,878
8	Unavailable	2+6	27,518,089	N/A
9	Unavailable	2+7	30,069,090	N/A

Source: Middleton, D., S. Venglar, C. Quiroga, D. Lord, and D. Jasek, *Strategies for Separating Trucks from Passenger Vehicles: Final Report*, September 2006.c.

[a] 2+3 implies two truck lanes and three mixed-flow lanes (bidirectional).

[8] Middleton, D., S. Venglar, C. Quiroga, D. Lord, and D. Jasek, *Strategies for Separating Trucks from Passenger Vehicles: Final Report*, September 2006.

Table C.4 Initial Construction Cost Per Mile Comparisons Between Truck-Only Lane and Mixed-Flow Facilities With Different Number of Lanes

Number of Lanes (Bidirectional)	Cost Mixed	Separated Scenario	Cost Separated	Difference	Separated Scenario	Cost Separated	Difference
4	10,699,845	2+3[a]	19,767,232	9,067,387	2+4	21,699,845	11,000,000
5	16,018,968	2+4	21,699,845	5,680,877	2+5	27,018,968	11,000,000
6	16,518,089	2+5	27,018,968	10,500,879	2+6	27,518,089	11,000,000
7	19,069,090	2+6	27,518,089	8,448,999	2+7	30,069,090	11,000,000

Source: Middleton, D., S. Venglar, C. Quiroga, D. Lord, and D. Jasek, *Strategies for Separating Trucks from Passenger Vehicles: Final Report,* September 2006.c.

[a] 2+3 implies two truck lanes and three mixed-flow lanes (bidirectional).

It is inferred from the estimates in Tables C.3 and C.4 that the construction cost for a two-lane at-grade truck-only lane facility (two bidirectional exclusive truck-only lanes) is approximately $11 million per mile ($5.5 million per lane mile). Table C.3 data also indicates that average unit construction cost for mixed-flow facilities is approximately $2.8 million per lane-mile. The increased construction costs for truck-only lanes relative to mixed-flow lanes may be attributed to the following aspects:

- Increased costs of pavement on truck-only lanes;
- Increased geometric costs of truck-only lanes to accommodate truck operations at higher speeds.

The construction costs associated with elevated and underground truck-only lane facilities will be higher compared to at-grade facilities. Analysis of elevated and underground truckways in the Miami Truckway preliminary feasibility study[9] assumes capital costs of elevated truck-only facilities to be around $45 million per mile, and around $180 million to $220 million per mile for underground truckways. The elevated facilities consist of two 12-foot travel lanes, 3-foot inner shoulders, an 8-foot outer breakdown lane, a central Jersey Barrier, and outside sound walls. Thus, the total width of the elevated truck-only lane cross-section is 50 feet.

Construction Costs (Interchanges)

The construction costs associated with interchanges are derived using cost assumptions in the Highway Economic Requirements System (HERS) software. According to HERS, for an interchange with 0.5 centerline miles of ramps, four structures, rolling terrain, and 10 culverts, the total cost of construction is around $80 million per interchange. For the current analysis,

[9] Poole, Jr., R. W., *Miami Toll Truckway: Preliminary Feasibility Study,* Reason Foundation, Policy Study 365, November 2007.

these assumptions are assumed to be applicable for the interchanges under the truck-only lane and additional mixed flow lanes alternatives.

Right-of-Way (ROW) Acquisition Costs

ROW acquisition costs associated with the development of highway facilities are a function of several variables, including land ownership, and the type of land use (for example, residential, commercial, industrial, farm). ROW acquisition costs are typically derived using data on urban and rural land values in terms of dollars per unit area. According to research conducted by Woudsma et al.[10], urban land values used for transportation facilities typically range between $100 to $200 per square meter (in 2000 Canadian dollars). Converting these to U.S. dollars (and indexing to 2008) results in average urban land values of between $85 to $170 per square meter, which are equivalent to an average land value of around $500,000 per acre.

- For two 12 feet truck-only lanes in each direction (accompanied by 10 feet outer shoulder and 5 feet inner shoulder – implying total ROW of close to 20 feet per lane), the ROW acquisition costs per lane mile at average land values of $500,000 per acre are estimated to be around $1.2 million per lane mile.

- For two mixed flow lanes in each direction (accompanied by 10 feet outer shoulder and 5 feet inner shoulder – implying total ROW of close to 20 feet per lane), the ROW acquisition costs per lane mile at average land values of $500,000 per acre are estimated to be around $1.2 million per lane mile.

Operations and Maintenance (O&M) Costs

As discussed in the Interim Report of the project, there is inadequate data on O&M costs associated with truck-only lane facilities (largely due to the lack of real-world truck-only lane applications in the U.S.). However, the annual O & M cost assumptions for exclusive truck-only toll facilities used in the Georgia DOT Statewide Truck Lane Needs Identification Study (Georgia DOT study) are used in the current analysis for the estimation of O&M costs for additional mixed-flow and truck-only lane alternatives. According to the Georgia DOT study, annual O&M costs equal 0.5 percent of total project capital cost in the base year, which increase annually at a 3.0 percent rate of inflation.

Table C.5 presents the unit costs associated with the build alternatives (additional mixed-flow and truck-only lanes) for urban corridors.

[10] Woudsma, C., T. Litman, and G. Weisbrod, *A Report on the Estimation of Unit Values of Land Occupied by Transportation Infrastructures in Canada*, Transport Canada, 2006.

Table C.5 Units Costs for Benefits-Costs Analysis, Urban Corridors

Unit Costs	Mixed-Flow Lanes	Truck-Only Lanes (Without LCV Operations)
ROW Acquisition (Dollars per Lane Mile)	$1,200,000	$1,200,000
Construction (Dollars per Lane Mile)	$2,800,000	$5,500,000
Construction (Dollars per Interchange)	$80,000,000	$80,000,000
O&M	Base year cost equivalent to 0.5% of total capital cost incremented at 3.0% annual rate of inflation	Base year cost equivalent to 0.5% of total capital cost incremented at 3.0% annual rate of inflation

Long Haul Corridors

Construction Costs (Lanes)

This section presents a discussion of unit construction costs associated with truck-only lanes along long-haul corridors. For truck-only lanes without LCV operations, the construction costs are expected to be similar to the costs presented under the urban corridors scenario. For truck-only lanes with LCV operations, additional construction costs for truck lanes with LCV operations include incremental costs for improvements in geometrics (to support LCV operations) and costs associated with staging areas for assembly/disassembly of LCVs. (according to the Western Uniformity Scenario Analysis[11], increased LCV operations did not have a significant impact on pavement costs, since the increase in Equivalent Single Axle Loads (ESALs) from LCV operations were accompanied by a decrease in vehicle miles traveled (VMT), thus minimizing the level of incremental load on the pavement due to LCV operations).

The Uniformity Study analyzed the impacts of expanded LCV operations on roadway geometric improvement costs, and found that the costs associated with improvements to mainline curves, intersections and interchanges to support LCV operations were between 49 percent and 90 percent higher than the geometric improvement costs under the base case scenario (existing operations), implying an average of close to 70 percent in incremental geometric improvement costs under LCV operations. Assuming that geometric improvement costs (discounted to the net present value) are equivalent to around 10 percent of total construction costs, the total construction costs under LCV operations are estimated to be around 7 percent higher than the total costs under non-LCV operations.

[11] Western Uniformity Scenario Analysis: A Regional Truck Size and Weight Scenario, requested by the Western Governors' Association, U.S. DOT, April 2004.

Construction Costs (Staging Areas)

Staging area costs for LCV operations are a function of location (urban or rural area), and capacity of the staging area (in terms of number of trucks that can be accommodated/processed at any given time). According to the U.S. DOT's Comprehensive Truck Size and Weight Study[12] completed in August 2000, average unit costs for developing staging areas in rural areas (with a capacity to accommodate six trucks) are around $825,000 (indexed to 2008 dollars) per staging area, while unit costs for urban area staging areas (to accommodate 20 trucks) are estimated to be around $4.5 million (indexed to 2008 dollars) per staging area. These unit cost estimates are used for estimating the total costs associated with the truck-only lanes with LCV operations alternative.

Construction Costs (Interchanges)

The interchange construction costs for the long-haul corridor scenario are expected to be similar to the costs under the urban corridor scenario for the additional mixed-flow lanes and truck-only lanes without LCVs alternatives. The construction costs under LCV operations are expected to be a higher compared to standard truck operations due to geometric considerations (for example, higher turning radius resulting in lower curvatures, and grades). As discussed under the lane-mile construction costs above, assuming that incremental costs associated with geometric elements are 70 percent higher under LCV operations, and these costs account for 10 percent of the total construction costs, the interchange construction costs under LCV operations are incremented by a factor of 7.0 percent compared to the truck-only lane alternative without LCV operations.

ROW Acquisition Costs

Average ROW costs for long-haul corridors are derived using assumptions used in the ROW cost estimation for the Trans-Texas Corridor (TTC) in Texas, as well as rural ROW cost data assumptions in the Washington Commerce Corridor Feasibility Study[13] (Washington Study). ROW costs for the TTC were estimated based on land value assumptions in the range of $20,000 to $65,000 per acre (average land value of $42,500 per acre). According to the Washington Study, default rural ROW cost assumptions are $1.00 per square foot ($43,560 per acre) for farmland, and $2.00 per square foot ($87,120 per acre) for all other rural. Assuming an equal distribution between farmland and other rural land uses results in average rural ROW costs of around $65,000 per acre. Based on the assumptions used in the TTC and the Washington Study, average rural ROW costs for the current analysis are estimated to be $53,750 per acre. For two 12-feet truck only lanes (or two 12 feet mixed flow lanes) in each direction (accompanied by 10 feet outer shoulder and 5 feet inner shoulder – implying total ROW of 20 feet per lane), the ROW acquisition costs per lane mile at average land values of $53,750 per acre are estimated to be around $130,000 per lane mile. ROW acquisition costs are not expected to vary significantly between LCV and non-LCV operations.

[12] http://www.fhwa.dot.gov/reports/tswstudy/tswfinal.htm.

[13] http://www.wsdot.wa.gov/NR/rdonlyres/E4016606-A9D0-44DD-91AD-7CB4A62EF821/0/WCC_Chapter5.pdf.

Operations and Maintenance (O&M) Costs

As discussed in the urban corridors scenario, the O&M costs for additional mixed-flow and truck lane (without LCV operations) alternatives along long-haul corridors are derived from the assumptions used in the Georgia DOT study, according to which, annual O&M costs equal 0.5 percent of total project capital cost in the base year, and increase annually at a 3.0 percent rate of inflation. For the truck lanes with LCVs alternative, the O&M costs are increased by a factor of 10 percent to account for the higher costs associated with LCV operations (such as enforcement, and staging area operations). The incremental costs associated with pavement maintenance under LCV operations are not expected to be significant compared to standard truck operations on truck-only lanes (due to a net decrease in total truck volumes under LCV operations due to an increase in payloads).

Table C.6 provides a summary of the various unit costs considered in the benefits-costs analysis for the long-haul corridor scenario.

Table C.6 Units Costs for Benefits-Costs Analysis, Long-Haul Corridors

Unit Costs	Additional Mixed-Flow Lanes	Truck-Only Lanes (Without LCV Operations)	Truck-Only Lanes (With LCV Operations)
ROW Acquisition (per lane mile)	$130,000	$130,000	$130,000
Construction (per lane mile)	$2,800,000	$5,500,000	$5,885,000
Construction (per interchange)	$80,000,000	$80,000,000	$85,600,000
Construction (per staging area – rural location)	n/a	n/a	$2,750,000
Construction (per staging area – urban location)	n/a[1]	n/a	$4,500,000
O&M	0.5% of total project capital cost in the base year, and annual growth at rate of inflation of 3.0%	0.5% of total project capital cost in the base year, and annual growth at rate of inflation of 3.0%	0.55% (10% higher than non-LCV alternative) of total project capital cost in the base year, and annual growth at rate of inflation of 3.0%

[1] n/a – not applicable.

Appendix D.

Net Present Value Calculations for Benefit-Cost Analysis

D. Net Present Value Calculations for Benefit-Cost Analysis

D.1 Key Assumptions in NPV Analysis

For the purpose of the benefit-cost (B-C) analysis, it is assumed that the corridors (long haul and urban) are operational beginning in 2008, and benefits are accrued for a study time horizon up to 2030. Key economic assumptions for the Net Present Value (NPV) analysis are presented in Table D.1. The discount rate is assumed to be 7.0 percent, as recommended by the Office of Management and Budget (OMB) for projects providing societal benefits. Average annual growth rate in truck and auto traffic for the NPV analysis is assumed to be 3.3 percent and 1.8 percent, respectively, based on truck and auto vehicle-miles traveled (VMT) growth estimates from the Federal Highway Administration's (FHWA) Freight Analysis Framework (FAF)[1]. Annual rate of inflation for freight rates and operating costs is assumed to be 3.0 percent based on historic trends in Consumer Price Index (CPI). Table D.1 summarizes the key assumptions used in the NPV analysis.

Table D.1 Key Assumptions in NPV Analysis

Study Time Period	2008 to 2030
Annual Growth Rate (Autos)	1.8% (based on FHWA FAF VMT growth estimates)
Annual Growth Rate (Trucks)	3.3% (based on FHWA FAF VMT growth estimates)
Annual Rate of Inflation	3.0% (based on historic trends in CPI)
Discount Rate	7.0% (based on OMB recommendations)

The sections below present a detailed discussion of the key assumptions and methodologies used for the NPV analysis under the long-haul and urban corridor scenarios.

[1] http://www.ops.fhwa.dot.gov/freight/presentations/lambert_nasto.htm, Slide 7.

Long-Haul Corridor Scenario

The following sections discuss the key assumptions and methodologies used for the estimation of the NPV of the various performance measures as well as the costs associated with each of the alternatives within this corridor scenario.

Productivity Benefits Calculations

The following are assumptions used in the productivity benefits analysis:

- Average payloads for standard trucks and Longer Combination Vehicles (LCV) are assumed to be 45,000 pounds (20 metric tons) and 78,750 pounds (35 metric tons assuming equal split between Turnpike Doubles and Triple Shorts), respectively;

- Consistent with the Reason Foundation assumptions, the freight rates for standard truck and LCV operations are assumed to be $570 per 100-mile shipment and $997 per 100-mile shipment, respectively (indexed to 2008 dollars); and

- Consistent with the Reason Foundation assumptions, average variable costs for standard trucks and LCVs are assumed to be $97.5 per hour and $155 per hour, respectively (indexed to 2008 dollars).

The productivity benefits are estimated for each year using the Reason Foundation approach (wherein productivity benefits are estimated in terms of increased earnings for the trucking industry), starting from 2008 through 2030, and discounted to the current year (2008) to estimate the total NPV of productivity benefits. For the future years (2009 through 2030), the inputs in the productivity benefits analysis that would change include the speeds (due to growth in auto and truck traffic volumes), and the freight rates and variable costs (due to inflation). These changes would impact the total incremental earnings per truck for each year.

Travel Time Savings Calculations

The monetary NPV of travel time savings associated with the additional mixed-flow lanes and truck lane alternatives relative to the no-build are estimated based on the VOT assumptions for autos, standard trucks, and LCVs discussed in Appendix C; and assumptions related to auto and truck traffic growth, rate of inflation, and NPV discount rates presented in Table C.1. To summarize, the following statistics were estimated for the no-build and the build (additional mixed-flow lanes and truck-only lanes without and with LCV operations) alternatives as part of the NPV analysis of travel time savings benefits:

- **No-Build Alternative.** Daily Vehicle-Hours Traveled (VHT) for autos and trucks for each year in the 2008 through 2030 time period are estimated based on average daily speeds estimated from volume-capacity (V/C) (using volume-delay functions), and the assumption that auto and truck trips traverse the entire stretch of the corridor (400 miles).

- **Additional Mixed-Flow Lane Alternative:**
  - Daily VHT for autos and trucks for each year in the 2008 through 2030 time period are estimated based on average daily speeds estimated from V/C (using volume-delay functions), and the assumption that auto and truck trips traverse the entire stretch of the corridor (400 miles).
  - The daily auto and truck VHTs are compared against the corresponding estimates for the no-build alternative to estimate annual auto and truck travel time savings under this alternative.
  - These annual auto and truck travel time savings are monetized using auto and truck value of time estimates (presented in Appendix C) (VOTs for future years are estimated based on an inflation rate of 3.0 percent), and discounted to the current year (2008) to arrive at the monetary NPV of total travel time savings under this alternative compared to the no-build alternative.
- **Truck-Only Lanes Without LCV Operations:**
  - Daily VHT for autos and trucks (truck VHTs represent the total VHT for truck travel on the general purpose and truck-only lanes) for each year in the 2008 through 2030 time period are estimated based on average speeds on the general purpose and truck-only lanes from V/C, and the assumption that auto and truck trips on the general purpose and truck-only lanes traverse the entire stretch of the corridor;
  - The daily auto and truck VHTs are compared against the corresponding estimates for the no-build alternative to estimate annual auto and truck travel time savings under this alternative; and
  - These annual auto and truck travel time savings are monetized using auto and truck value of time estimates (VOTs for future years are estimated based on an inflation rate of 3.0 percent), and discounted to the current year (2008) to arrive at the monetary NPV of total travel time savings under this alternative compared to the no-build alternative.
- **Truck-Only Lanes With LCV Operations:**
  - Daily VHT for autos and trucks (VHTs for standard trucks on general purpose lanes and LCVs on truck-only lanes are estimated separately) for each year in the 2008 through 2030 time period are estimated based on average speeds on the general purpose and truck-only lanes from V/C, and the assumption that auto and truck trips on the general purpose and truck-only lanes traverse the entire stretch of the corridor.
  - For autos, annual travel time savings are estimated by comparing the daily auto VHTs under this alternative with the corresponding estimate in the no-build alternative. These travel time savings are monetized using auto VOT for each year in the 2008 through 2030 time period.

- For trucks, since the VOT for LCVs are different from the VOT for standard trucks, the VHTs for standard trucks and LCVs are monetized first to estimate total annual monetized truck VHTs for the 2008 through 2030 time period under this alternative. The total monetized truck VHTs are compared against monetized annual truck VHTs under the no-build alternative to estimate the total annual monetized truck travel time savings for the 2008 through 2030 time period.

- Monetary value of total (auto + truck) travel time savings are estimated for each year (2008 through 2030 time period) by adding the truck travel time savings with the auto travel time savings generated in the previous two steps, and discounted to the current year to estimate the monetary NPV of total travel time savings under this alternative compared to the no-build alternative.

Safety Benefit Calculations

Safety benefits are quantified in terms of the NPV of monetary savings in total accidents (fatality, injury, and property damage only (PDO)) for the 2008 to 2030 time period for each of the alternatives compared to the no-build alternative. Total accidents for each of the alternatives are estimated using inputs on auto and truck VMTs, level of congestion (V/C) on the general purpose and truck-only lanes, and accident rates (for fatality, injury, and PDO accidents in terms of accidents per million VMT) as a function of V/C from the ITS Deployment Analysis System (IDAS) User Manual[2]. Additionally, as discussed in the performance evaluation task, for the truck-only lane alternatives, the total accidents on the general purpose lanes estimated using IDAS inputs are reduced by an additional factor of 15 percent, as recommended by the Douglas Handbook[3], to account for the safety benefits of truck-auto separation. The monetary value of savings in accidents is derived using accident cost factors presented in Appendix C. These factors are inflated for the future years using a rate of inflation of 3.0 percent.

In summary, the following accident statistics were estimated for the no-build, additional mixed-flow lane, and the truck-only lane alternatives to arrive at the relative safety benefits of mixed-flow and truck-only lanes compared to the no-build alternative:

- **No-Build Alternative.** Annual fatality, injury, and PDO accidents for each of the years in the 2008 through 2030 time period on the mixed-flow lanes are estimated using auto and truck VMT estimates and IDAS accident rates (which are a function of V/C). These accidents include total auto and truck accidents.

- **Additional Mixed-Flow Lane Alternative.** Annual fatality, injury, and PDO accidents for each of the years in the 2008 through 2030 time period on the mixed-flow lanes are estimated using auto and truck VMT estimates and IDAS accident rates (which are a function of V/C). These accidents include total auto and truck accidents.

[2] http://idas.camsys.com/userManual/App_b.pdf.

[3] Douglas, J. G., *Handbook for Planning Truck Facilities on Urban Highways*, August 2004.

- **Truck-Only Lane Alternative Without LCV Operations.** Annual fatality, injury, and PDO accidents for each of the years in the 2008 through 2030 time period are estimated on the general purpose and truck-only lanes using auto and truck VMT (truck VMT on the general purpose and truck-only lanes), and IDAS accident rates. The total accidents on the general purpose lanes are then adjusted using a 15 percent reduction factor (based on the Douglas Handbook recommendation), and they are combined with the truck accidents on the truck-only lanes to arrive at the total fatality, injury, and PDO accidents under this alternative.

- **Truck-Only Lane Alternative with LCV Operations.** The accident statistics under this alternative are similar to the statistics estimated for the truck-only lane alternative without LCV operations. Since IDAS truck accident rates correspond to standard trucks (primarily tractor-semitrailers in the case of long-haul corridors), accident rates for LCVs were estimated based on the relative differences in fatality, injury, and PDO accident rates between tractor-semitrailers and LCVs (Turnpike Doubles) reported in TRB Special Report 225[4] (TRB 225). According to TRB 225, the fatality, injury, and PDO accident rates for Turnpike Doubles are 10 percent higher than the corresponding rates for tractor-semitrailers under similar operating conditions, and these factors are used to adjust the IDAS truck accident rates to arrive at the rates for LCVs.

The annual fatality, injury, and PDO accident statistics for the mixed-flow and truck-only lane alternatives are compared against the no-build alternative to estimate the annual savings in fatality, injury, and PDO accidents for each year in the 2008 through 2030 time period under the build alternatives compared to the no-build. These savings are monetized to dollar values based on the accident monetization factors presented in Appendix C, and discounted to the base year to arrive at the NPV of total monetized savings in accidents.

Cost Calculations

The cost estimates for the build alternatives under this corridor scenario are developed using the unit costs presented in Appendix C, and the configurational characteristics of the representative baseline (generic) corridor defined for the B-C analysis. Due to some uncertainties in the cost estimates for the build alternatives, the B-C analysis is based on a range of costs. The range of costs was developed by first estimating a baseline total cost for each alternative, and varying the costs across the baseline (lower and upper limit costs with the baseline as the mean), using a maximum variance of ±20 percent relative to the baseline. The following section quantifies the various baseline cost components for each of the build alternatives.

- **Additional Mixed-Flow Lane Alternative.** The various baseline cost components associated with this alternative include the following:

  - Right-of-Way (ROW) Acquisition Costs. Total ROW acquisition costs for two additional mixed-flow lanes in each direction over a corridor length of 400 miles (at $130,000 per lane mile) equal $208 million (in 2008 dollars).

[4] TRB Special Report 225, *Truck Weight Limits: Issues and Options*, 1990.

- Construction Costs (Lanes). Total costs to construct 400 miles of additional mixed-flow lanes (two lanes in each direction at unit cost of $2.8 million per lane mile) equal $4.5 billion (in 2008 dollars).

- Construction Costs (Interchanges). Assuming that there is an interchange every 50 miles along the corridor (nine interchanges along the 400-mile corridor, counting the interchanges at the origin and destination nodes), total interchange construction costs (at unit cost of $80 million per interchange) equal $720 million (in 2008 dollars).

- Operations and Maintenance (O&M) Costs. Based on the total capital costs estimated above, and the O&M cost estimation approach presented in Appendix C, total NPV of O&M costs for the 2008 to 2030 time period are estimated to be around $420 million (in 2008 dollars).

- **Truck-Only Lanes Without LCV Operations.** The various baseline cost components associated with this alternative include the following:

  - ROW Acquisition Costs. Assuming that the truck-only lanes (two bidirectional lanes) are built on either side of the existing general purpose lanes over a corridor length of 400 miles, the total ROW acquisition costs at a unit cost of $130,000 per lane mile are estimated to be $208 million (in 2008 dollars);

  - Construction Costs (Lanes). At unit construction costs of $5.5 million per lane mile, the total construction cost to build two bidirectional truck-only lanes over the corridor length of 400 miles is estimated to be $8.8 billion (in 2008 dollars);

  - Construction Costs (Interchanges). Assuming that there is an interchange every 50 miles along the corridor (nine interchanges along the 400-mile corridor, counting the interchanges at the origin and destination nodes), total interchange construction costs (at unit cost of $80 million per interchange) equal $720 million (in 2008 dollars); and

  - O&M Costs. Based on the total capital costs estimated above, and the O&M cost estimation approach presented in Appendix C, total NPV of O&M costs for the 2008 to 2030 time period are estimated to be around $760 million (in 2008 dollars).

- **Truck-Only Lanes With LCV Operations.** The various baseline cost components associated with this alternative include the following:

  - ROW Acquisition Costs. Since the unit costs for ROW acquisition are not expected to change significantly under LCV operations, at a unit cost of $130,000 per lane mile, the total ROW acquisition costs under this alternative are estimated to be around $208 million (in 2008 dollars).

  - Construction Costs (Lanes). At unit construction costs of $5.885 million per lane mile, the total construction cost to build two bidirectional truck-only lanes over the corridor length of 400 miles is estimated to be around $9.4 billion (in 2008 dollars).

- Construction Costs (Interchanges). Assuming that there is an interchange every 50 miles along the corridor (nine interchanges along the 400-mile corridor, counting the interchanges at the origin and destination nodes), total interchange construction costs (at unit cost of around $86 million per interchange) equal around $770 million (in 2008 dollars).

- Construction Costs (Staging Areas). The costs associated with staging areas for LCV operations include construction costs, and costs for operations and maintenance of these facilities. Assuming two staging areas are developed at the end nodes of the corridor (in urban areas), and one staging area is developed along the corridor (in a rural location), the total staging area capital costs under this alternative equal around $11.8 million. The number of staging areas required under this alternative would be a direct function of the number of LCVs using the truck-only lanes. However, for the purpose of the current analysis, it is assumed that the three staging areas would be sufficient to support LCV operations on the truck-only lanes under the various diversion rate scenarios considered as part of the sensitivity analysis.

- O&M Costs. Based on the total capital costs estimated above, and the O&M cost estimation approach presented in Appendix C, total NPV of O&M costs for the 2008 through 2030 time period are estimated to be around $812 million (in 2008 dollars).

Based on the above cost estimates, Table D.2 presents the baseline cost components for each of the alternatives.

Table D.2 Baseline Cost Components for Long Haul Corridor Alternatives
In Billion of Dollars

Cost Components	Additional Mixed-Flow Lanes	Truck-Only Lanes	
		Without LCV Operations	With LCV Operations
ROW Acquisition	0.2	0.2	0.2
Construction (lanes)	4.5	8.8	9.4
Construction (interchanges)	0.7	0.7	0.8
Construction (staging areas – rural locations)	–	–	0.003
Construction (staging areas – urban locations)	–	–	0.009
Operations and Maintenance	0.4	0.8	0.8
Total Cost	**5.8**	**10.5**	**11.2**

As mentioned above, to account for the uncertainty in costs in the sensitivity analysis, the total costs for each alternative (in Table D.2) are varied to arrive at a representative range of cost

estimates for the B-C analysis. Table D.3 presents the range of cost estimates used for the B-C analysis for the build alternatives under the long-haul corridor scenario.

Table D.3 Range of Costs Considered for the Long-Haul Corridor B-C Analysis
In Billion of Dollars (Indexed to 2008)

Alternative	Lower Limit for Cost (20% Below Baseline)	Baseline Cost	Upper Limit for Cost (20% Above Baseline)
Additional Mixed-Flow Lanes	4.7	5.8	7.0
Truck-Only Lanes Without LCV Operations	8.4	10.5	12.6
Truck-Only Lanes With LCV Operations	9.0	11.2	13.5

Urban Corridors Scenario

The following sections discuss the key assumptions and methodologies used for the estimation of the NPV of the various performance measures as well as the costs associated with each of the alternatives within this corridor scenario.

Travel Time Savings Calculations

The estimation of the NPV of travel time savings associated with the build alternatives (additional mixed-flow lanes and truck-only lanes) relative to the no-build alternative was based on estimating average daily V/C ratios and associated speeds on general purpose lanes and truck-only lanes, under various diversion rate scenarios governing the utilization of the truck-only lanes. The estimates do not take into account time-of-day variation in traffic volumes by vehicle class. The approach is summarized below.

- **No-Build Alternative:**
  - Annual auto and truck VHT estimates were generated for each year in the 2008 through 2030 time period, based on average daily speed (estimated from average daily V/C generated from auto and truck volumes and total capacity), assuming that auto and truck volumes on the corridor traverse the entire 20-mile stretch.
- **Additional Mixed-flow Lane Alternative:**
  - Annual auto and truck VHT estimates were generated for each year in the 2008 through 2030 time period, based on average daily speed (estimates from average daily V/C generated from auto and truck volumes and total capacity), assuming that auto and truck volumes on the corridor traverse the entire 20-mile stretch;

- Annual auto and truck travel time savings were generated by comparing the annual auto and truck VHT in this alternative with the corresponding estimates in the no-build alternative;

- The savings in auto and truck travel times were monetized to equivalent dollar values based on auto and truck VOT estimates presented in Appendix C; and

- The monetized travel time savings for each year were discounted to the current year (2008), and aggregated to estimate the total NPV of travel time savings under this alternative compared to the no-build alternative.

- **Truck-Only Lane Alternative:**

  - Annual VHTs for autos and trucks (truck VHTs represent the total VHT for truck travel on the general purpose and truck-only lanes) for each year in the 2008 through 2030 time period are estimated based on average speeds on the general purpose and truck-only lanes from V/C estimates, and the assumption that auto and truck trips on the general purpose and truck-only lanes traverse the entire 20-mile stretch of the corridor;

  - Annual auto and truck travel time savings were generated by comparing the annual auto and truck VHT in this alternative with the corresponding estimates in the no-build alternative;

  - The savings in auto and truck travel times were monetized to equivalent dollar values based on auto and truck VOT estimates; and

  - The monetized travel time savings for each year were discounted to the current year (2008), and aggregated to estimate the total NPV of travel time savings under this alternative compared to the no-build alternative.

Reliability Benefits Calculations

Reliability benefits are quantified in terms of the monetized savings in incident-related delay. Techniques and specific performance metrics for predicting and measuring reliability are still very much under development. One approach to assessing the value of reliability benefits has been to assume that the value of time for incident-related delays is significantly higher than that of recurrent delay because of the stochastic (probabilistic) nature of incident-related delay. For trucking, it is possible to plan for recurrent delay, and to incorporate these plans into cost structures; whereas, unpredictable incident occurrences can have highly variable (and sometimes very significant) cost implications. In this project, incident-related delay was calculated as a function of V/C and configuration of the highway, and was valued at 1.5 times the recurrent delay VOT estimates to arrive at the value of incident-related delay for the quantification of reliability benefits.

There have been a few studies that have attempted to quantify the value of time that takes into account nonrecurrent delay, such as Cohen et al,[5], which presents the results from a couple of models (Models 1 and 2). According to Model 1, the value of incident-related delay was observed to be equal to the value of time under uncongested conditions, while Model 2 predicted the value of incident-related delays to range between two to six times the value of time under uncongested conditions. Since the VOT estimates presented in Appendix C take into account the effect of congestion (recurrent delay), the factor to be applied to these estimates to arrive at the value of incident-related delays is expected to be lower than the factors predicted by Cohen et al. (average factor from Models 1 and 2 of around 2.5). In a study conducted by Levinson et al.,[6] a factor of 1.35 was applied to the value of time to account for the value of travel time reliability benefits. Based on the above results, a factor of 1.5 is applied to the VOT estimates to arrive at the value of incident-related delay for the quantification of reliability benefits. Incident-related delay estimates are developed using IDAS factors (incident-related delay per VMT) as a function of V/C and number of lanes. For the truck-only lane alternative, the incident-related delays are reduced by an additional factor of 15 percent to account for the reduction in incidents (and associated delays) due to truck-auto separation.

The estimation of the NPV of travel time reliability benefits associated with the build alternatives relative to the no-build alternative was based on the following approach:

- **No-Build Alternative:**
  - Annual incident-related delays for autos and trucks for each year in the 2008 through 2030 time period are estimated using IDAS factors (function of V/C), and annual auto and truck VMTs (VMTs are estimated based on the assumption that autos and trucks traverse the entire 20-mile stretch of the corridor).
- **Additional Mixed-flow Lane Alternative:**
  - Annual incident-related delays for autos and trucks for each year in the 2008 through 2030 time period are estimated using IDAS factors (function of V/C), and annual auto and truck VMTs (VMTs are estimated based on the assumption that autos and trucks traverse the entire 20-mile stretch of the corridor);
  - The reduction in V/C under this alternative (from the addition of mixed-flow lanes) results in a reduction in annual incident-related delays for autos and trucks (due to reduction in accidents from congestion reduction). Annual savings in incident-related delays for autos and trucks are estimated by comparing the delays under this alternative with corresponding estimates in the no-build alternative.

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[5] Cohen, H., and F. Southworth, *On the Measurement and Valuation of Travel Time Variability due to Incidents on Freeways*, Journal of Transportation and Statistics, December 1999.

[6] Levinson, D., and L. Zhang, *Travel Time Variability after a Shock: The Case of the Twin Cities Ramp Metering Shut Off*, First International Symposium on Transportation Network Reliability, Kyoto, Japan, July 30 through August 1, 2001.

  - The incident-related delay savings for autos and trucks are monetized for each year (2008 through 2030) using the value of time associated with incident-related delay for autos and trucks, and discounted to the current year (2008) to estimate total NPV of incident-related delay savings (reliability benefits) under this alternative

- **Truck-Only Lane Alternative**
  - Annual incident-related delays for autos and trucks on the general purpose lanes are estimated for each year in the 2008 through 2030 time period from IDAS factors and annual auto and truck VMTs on the general purpose lanes. Since these delay estimates from IDAS account for congestion impacts alone, they are adjusted by a 15 percent reduction factor, as recommended by the Douglas Handbook, to account for the additional reduction in delays due to truck-auto separation.
  - Annual incident-related delays for trucks on truck-only lanes are estimated for each year in the 2008 through 2030 time period from IDAS factors (function of V/C and number of lanes for the truck-only lanes) and annual truck VMTs on the truck-only lanes.
  - The incident-related delay estimates from the above two steps are combined to arrive at the total annual incident-related delays for autos and trucks for each year in the 2008 through 2030 time period.
  - Annual incident-related delay savings for autos and trucks are estimated by comparing the incident-related delays under this alternative with corresponding estimates in the no-build alternative.
  - Annual savings in delays are monetized to equivalent dollar values using the value of time associated with incident-related delays, and discounted to the current year (2008) to arrive at the total NPV of incident-related delay savings under this alternative compared to the no-build alternative.

Safety Benefits Calculations

The estimation of NPV of safety benefits associated with the build alternatives relative to the no-build alternative was developed based on the following approach:

- **No-Build Alternative**
  - IDAS accident rates (accidents per million VMT) by accident type (fatality, injury, and PDO) as a function of V/C are applied to annual auto and truck VMTs to estimate annual auto and truck accidents (which are combined to get total accidents) by accident type for each year in the 2008 through 2030 time period.

- **Additional Mixed-flow Lane Alternative**
  - Similar to the no-build alternative, IDAS accident rates are applied to annual auto and truck VMTs to estimate annual auto and truck accidents (which were combined to get total accidents) by accident type for each year in the 2008 through 2030 time period. Due to a reduction in congestion from the additional mixed-flow lanes, there is a reduction in

the IDAS accident rates (and consequently, a reduction in total accidents) under this alternative.

- Annual savings in accidents (by accident type) are estimated by comparing the total accidents by type under this alternative with corresponding estimates in the no-build alternative.

- Annual savings in accidents are monetized to equivalent dollar values based on accident monetization factors presented in Appendix C, and discounted to the current year to get the total NPV of monetized savings in accidents under this alternative.

• **Truck-only Lane Alternative**

  - Annual accidents (by accident type) for autos and trucks on the general purpose lanes are estimated for each year in the 2008 through 2030 time period using IDAS accident rates and annual auto and truck VMTs on the general purpose lanes.

  - Annual auto and truck accident estimates are combined to get total accidents (by accident type) on the general purpose lanes, and they are adjusted by a 15 percent reduction factor to account for the additional reduction in accidents due to truck-auto separation (which is not accounted for by IDAS).

  - Annual accidents (by accident type) on truck-only lanes are estimated for each year in the 2008 through 2030 time period using IDAS accident rates and annual truck VMT on the truck-only lanes.

  - The accident estimates from the previous two steps are combined to get the total annual accidents (by accident type) by year. These estimates are compared against corresponding estimates from the no-build alternative to estimate the annual savings in accidents (by accident type) under this alternative.

  - Annual savings in accidents are monetized to equivalent dollar values based on monetization factors by accident type presented in Appendix C, and discounted to the current year to estimate the total NPV of monetized savings in accidents under this alternative.

Cost Calculations

As mentioned under the long-haul corridor scenario, to account for the uncertainties in some of the cost estimates, a range of costs are used for the B-C analysis (derived by applying a ±20% variation to the baseline cost estimate). The following section quantifies the various baseline cost components for each of the build alternatives under the urban corridor scenario.

• **Additional Mixed-Flow Lane Alternative.** The various baseline cost components associated with this alternative include the following:

- Right-of-Way (ROW) Acquisition Costs. Total ROW acquisition costs for two additional mixed-flow lanes in each direction over a corridor length of 20 miles (at $1.2 million per lane mile) equal $96 million (in 2008 dollars).

- Construction Costs (Lanes). Total costs to construct 20 miles of additional mixed-flow lanes (two lanes in each direction at unit cost of $2.8 million per lane mile) equal $224 million (in 2008 dollars).

- Construction Costs (Interchanges). Assuming that there is an interchange every 5 miles along the corridor (five interchanges along the 20-mile corridor, counting the interchanges at the origin and destination nodes), total interchange construction costs (at unit cost of $80 million per interchange) equal $400 million (in 2008 dollars).

- Operations and Maintenance (O&M) Costs. Based on the total capital costs estimated above, and the O&M cost estimation approach presented in Appendix C, total NPV of O&M costs for the 2008 to 2030 time period are estimated to be around $56 million (in 2008 dollars).

• **Truck-Only Lane Alternative.** The various baseline cost components associated with this alternative include the following:

- ROW Acquisition Costs. Assuming that the truck-only lanes (two bidirectional lanes) are built on either side of the existing general purpose lanes over a corridor length of 20 miles, the total ROW acquisition costs at a unit cost of $1.2 million per lane mile are estimated to be $96 million (in 2008 dollars);

- Construction Costs (Lanes). At unit construction costs of $5.5 million per lane mile, the total construction cost to build two bidirectional truck-only lanes over the corridor length of 20 miles is estimated to be $440 million (in 2008 dollars);

- Construction Costs (Interchanges). Assuming that there is an interchange every 5 miles along the corridor (five interchanges along the 20-mile corridor, counting the interchanges at the origin and destination nodes), total interchange construction costs (at unit cost of $80 million per interchange) equal $400 million (in 2008 dollars); and

- O&M Costs. Based on the total capital costs estimated above, and the O&M cost estimation approach presented in Appendix C, total NPV of O&M costs for the 2008 to 2030 time period are estimated to be around $73 million (in 2008 dollars).

Based on the above calculations, Table D.4 presents the baseline cost estimates for the urban corridor alternatives.

Table D.4 Baseline Cost Components for Urban Corridor Alternatives
In Billion Dollars

Cost Components	Mixed-Flow Lanes	Truck-Only Lanes
ROW Acquisition	0.1	0.1
Construction (lanes)	0.2	0.4
Construction (interchanges)	0.4	0.4
O&M	0.1	0.1
Total Cost	**0.8**	**1.0**

Similar to the long-haul corridor scenario, to account for the uncertainty in costs in the sensitivity analysis, the total costs for each alternative (in Table D.4) are varied to arrive at a representative range of cost estimates for the B-C analysis. Table D.5 presents the range of cost estimates used for the B-C analysis for the build alternatives under the urban corridor scenario.

Table D.5 Range of Costs Considered for the Urban Corridor B-C Analysis
In Billion Dollars (Indexed to 2008)

Alternative	Lower Limit for Cost (20% Below Baseline)	Baseline Cost	Upper Limit for Cost (20% Above Baseline)
Mixed-Flow Lanes	0.6	0.8	1.0
Truck-Only Lanes	0.8	1.0	1.2