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Dedicated truck facilities as a solution to capacity and safety issues on rural interstate highway corridors

Neil Ailin Burke
Iowa State University

Dedicated truck facilities as a solution to capacity and safety issues on rural interstate highway corridors

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Neil Ailin Burke

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Program of Study Committee:
Thomas Maze, Major Professor
Michael Crum
David Plazak
Omar Smadi

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Graduate College
Iowa State University

This is to certify that the master's thesis of

Neil Ailin Burke

Has met the thesis requirements of Iowa State University

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ABSTRACT

This thesis identifies the safety and operational benefits to constructing dedicated truck facilities on rural interstate corridors. The Interstate 80 corridor from the Illinois border to Altoona, Iowa is the case study corridor where crash data and commodity flows were analyzed to determine the potential benefits to constructing a dedicated truck facility. Literature was reviewed to determine the designs of other truck only facilities and the benefits that dedicated truck lanes may bring to the freight industry. The literature found truck only lanes to be most feasible when trucks constitute at least 30 percent of the vehicle mix, peak hour volumes exceed 1,800 vehicles per lane hour, and off-peak volumes exceed 1,200 vehicles per lane hour. Another study found the I-80 corridor in Iowa provided significant benefits to the operability and safety of the corridor if a dedicated truck facility is constructed along the corridor.

While most studies have considered the construction of an additional lane on the freeways and designating it for "trucks only," this thesis 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 was removed from the general-purpose lanes. Several benefit to cost analyses were calculated outside of HERS-ST to determine the feasibility of constructing dedicated truck lanes. Sensitivity analyses were conducted within the benefit to cost analyses to determine the benefits of diverting 100 percent, 75 percent, 50 percent and 25 percent of trucks to a dedicated truck facility. Through this analysis, transportation engineers and planners can understand the benefits of dedicated truck facilities on rural interstate highway corridors.

1. INTRODUCTION

A dedicated truck facility can be defined as a system of roadways to be used exclusively by trucks with three or more axles. These exclusive roadways may be tolled or free. This strategy of segregating cars from trucks improves safety, reduces congestion, improves traffic operations, and facilitates the efficient movement of commodity (1). Other studies have considered managed lanes on freeways with significant truck volumes, where trucks are restricted to travel in a specific lane. Several studies have indicated that there are inherent benefits of freight productivity, operations, and safety when combination trucks are separated from other vehicles on rural freeways. The purpose of this thesis is to determine the safety, operational, and productivity benefits to separating trucks from other vehicles, while determining if these benefits exceed the costs of constructing a separate highway for trucks. This thesis will examine the potential crash reduction for the corridor; the impacts that large vehicles may have on delays, and the economic benefits due to increased productivity in order to determine if dedicated truck lanes will improve traffic operations. A case study of truck-car crashes and motor carrier commodity flows will be conducted on the I-80 corridor between the Illinois border (Mississippi River Crossing) and the Des Moines metro area.

The Highway Economic Requirements System-State Edition (HERS-ST) software was utilized in this thesis to predict the safety and operating characteristics of separating combination unit trucks from the general-purpose lanes of a rural interstate corridor. HERS-ST is an engineering and economic analysis software that uses engineering standards to identify deficiencies on selected highway segments while using economic criteria to select the most cost effective mix of improvements. HERS-ST evaluates the implications of transportation projects and policies on the conditions, performance, and user cost levels that are associated with highway systems. The software provides cost forecasts for achieving sound economic program structures while predicting system condition and user cost levels resulting from a given level of investment (2).

While HERS-ST can be a useful planning tool in forecasting performance and maintenance needs, the software has several limitations. HERS-ST is not a network model; thus it does not consider the improvements of a parallel corridor in the project selection process of another corridor. HERS-ST is not a spatial model. Therefore, traffic volumes are assigned to specific links rather than being distributed within the model. In regards to this study, HERS-ST does not recognize a diversion of the percentage of combination truck volumes to a dedicated truck facility as an alternative to handling safety and capacity deficiencies.

A sensitivity analysis was conducted where 100, 75, 50, and 25 percent of combination unit trucks were diverted from the general-purpose lanes I-80 to a four lane simulated truck facility in HERS-ST. These truck volumes will be removed from the existing general-purpose lanes, and subsequently placed on a four lane limited access highway in HERS-ST. A benefit to cost analysis was calculated outside of HERS-ST to determine the safety and travel time benefits of separating cars and trucks on the I-80 corridor. Through the analyses that have been conducted, the researcher hoped to determine the impact from performance metrics in HERS-ST and the results of the benefit to cost analysis from constructing a dedicated facility for trucks on an interstate highway corridor.

HERS-ST is based on data taken from mixed traffic and, therefore, the system cannot estimate the safety impact that will result when the interaction between trucks and automobiles (vehicle with very difference performance profiles) are separated. To obtain estimates of the potential for crash reduction, existing crash frequencies involve interaction between heavy trucks and automobiles. These crashes are generally rear end and sideswipe crashes which result from different performance profiles of the two vehicle types. It is assumed that when trucks and automobile separated the crashes involving trucks and automobiles will proportionally drop from current level.

HERS-ST was used to obtain estimates of operating characteristics and changes in user costs if trucks are separated from other vehicles on the I-80 corridor. Crash rates for the benefit to cost analysis were developed through actual crash data that involved trucks and automobiles and assumed proportional reductions from current crash rates when the two vehicle types are separated.

In the context of this study, a truck only facility would provide the greatest benefits by allowing Longer Combination Vehicles (LCVs) to operation on the truck only lanes of the I-80 corridor between the Illinois border and Des Moines. LCVs are defined as combination unit trucks that exceed the maximum size and weight dimensions imposed by the Surface Transportation Assistance Act (STAA) of 1982. While use of the dedicated facility would be optional for combination trucks, LCV operation would be restricted to the dedicated truck facility. Motor carriers that utilized this facility would undoubtedly find increases in freight productivity with decreases in fuel consumption and wear on machinery.

This thesis is organized into five sections. The first chapter is this introduction. The next chapter is a literature review of the potential safety benefits and improvements to freight productivity from separating combination unit trucks from other traffic on an interstate corridor. The literature review was conducted by using the Transportation Research Information Services (TRIS) and other literature search engines. The search focuses on current literature to operating conflicts between cars and trucks, preliminary designs for a dedicated truck facility, toll financing, and the potential benefits to the motor carrier industry. While the majority of the literature that was reviewed in this thesis analyzed studies where truck only lanes would be constructed within the existing right of way of a freeway, this thesis has considered the acquisition of new right of way and the construction of a separate four lane freeway facility exclusively for trucks that would be constructed adjacent to the existing I-80 corridor. This complex and expensive design was chosen because of the amount of trucks that would use the facility, and the inherent safety benefits that would be attained from separating trucks from other vehicles.

The third chapter is a case study of the I-80 corridor for this thesis. The first section presents the Average Annual Daily Traffic (AADT) and combination unit counts at various points along the I-80 corridor. The I-80 corridor is also compared to other interstate corridors throughout the Midwest in terms of AADT and classification counts AADT and classification counts to understand the magnitude of daily truck traffic as compared to other routes. The second section is a truck toll cost summary for the I-70 corridor of the Kansas Turnpike between Topeka and Kansas City. This corridor allows the operation of longer combination vehicles, and the toll levels of the Kansas Turnpike were used to estimate revenue level was used in the financial analysis for the truck facility on the I-80 corridor. This analysis forecasted the potential twenty-year revenues that are possible from tolling combination trucks on the dedicated truck facility. The third section is a ten-year descriptive analysis of the crashes that occurred with trucks and other vehicles on the I-80 corridor. This section analyzed the collision types, weather conditions, and assignment of fault of all crashes involving trucks on the I-80 corridor. Crash rates and crash severity rankings were calculated for crashes involving trucks as well as other vehicles from 2002 through 2004. The fourth section is a cost estimation of capacity improvements on the I-80 corridor. The cost data was obtained from the Iowa DOT Office of Rural Pre-Design. This section considers the cost of constructing an additional travel lane in each direction as well as the construction of a separate four-lane highway for trucks. All improvement alternatives have included the replacement of all structures on the I-80 facility because they have reached the end of their useful life. The Iowa DOT plans to incorporate the reconstruction of the structures along the corridor with future capacity improvements.

The fourth chapter of the thesis introduces the HERS-ST and benefit to cost analyses. The first section explains the capabilities of HERS-ST and how it was used in the analysis. The second section of this chapter will explain the corridor scenarios that have been conducted in this study. The third section will introduce the performance metrics that will be evaluated in the run scenarios. The fourth section will discuss the run scenarios conducted in HERS-ST through the use of charts for each performance metric. The fifth section of this chapter will discuss the methods used in conducting the benefit to cost analysis. The last section of this chapter will discuss the results of the benefit to cost analyses.

The final chapter of the thesis includes a summary of the current and future operating and safety characteristics on the I-80 corridor. Several recommendations have been made regarding future capacity improvements on the I-80 corridor based on the results of the HERS-ST and benefit to cost analyses. This chapter will also provide suggestions for future research for dedicated truck facilities.

2. LITERATURE REVIEW

Methodology

The literature search for this project will focus on relevant literature that investigates the implementation of dedicated truck lanes on interstate highway corridors as well as the measures that would contribute to increased productivity and diminished fuel consumption for motor carrier companies. The review will be limited to research on mostly rural interstate highway corridors that experience significant trucking volumes. The literature review will comprise a chapter of the thesis while refining the scope and definition of the research. Due to the limited amount of scholarly research on this topic, this literature review is nearly comprehensive, and will borrow heavily from case studies and literature reviews that have been previously completed. The literature review for this thesis has been divided into the following areas:

1. **Social benefits to dedicated truck facilities on interstate highway corridors.** This section of the literature review will explain the social benefits that a dedicated truck facility would provide to highway users. While research is relatively limited on the net benefits that dedicated truck facilities will bring to society in general, there are several studies that discuss the safety benefits and the proposed design of truck only lanes. Other research has considered restricting heavy vehicles to a specific lane, as a more cost effective approach to constructing a truck only facility. This section will address the increase in auto-truck crashes in recent years. This section of the literature review will also include discussion of the potential sources of funding necessary to construct and maintain a dedicated truck facility. This section identifies the type of interstate highway corridor that could benefit from constructing a dedicated truck facility.

2. **Freight industry benefits of truck only facilities.** This section of the literature review will address the private benefits to the motor carrier industry would experience if a dedicated truck facility was constructed on an interstate highway with significant truck volumes. This section will also discuss the benefits from allowing Longer Combination Vehicles (LCVs) to operate on dedicated truck facilities.

2.1 Social benefits to dedicated truck lanes on interstate highway corridors

The following literature provides insight on the safety and operational benefits that dedicated truck lanes are expected to provide to freeway corridors. The first part of this section will discuss the operational conflicts between trucks and other vehicles. The second portion of this section explains several proposed truck only separation techniques on freeways. The final part of this section explains the estimated costs incurred in constructing a dedicated truck facility.

Operational conflicts between trucks and other vehicles

A study conducted by Samuel, Poole, and Holguin-Veras indicates that highway crashes involving trucks resulted in 5,000 deaths in 1998. Many of these crashes can be attributed to conflicts between cars and trucks, due to their different operational characteristics (3). Trowbridge, Nam, Mannering, and Carson explain that combination unit trucks are involved in roughly 20 percent of all motor vehicle crashes. While this percentage is relatively small, the crashes that do involve trucks tend to be more severe (4). Grenzeback, Reilly, Roberts, and Stowers have concluded that the sheer volume of trucks does not have a significant effect on congestion, but crashes involving trucks will impact congestion levels significantly. Congestion is affected by trucks when truck volumes exceed ten percent. Specifically, heightened delay levels are observed when crashes occur (5).

Heavy trucks and passenger vehicles have inherent operating differences on rural highways. Trucks are longer and have poorer acceleration performance than cars. Heavy trucks have a greater contribution to congestion than that of passenger vehicles. Completed research by Kostyniuk, Streff, and Zakrajsek analyzed crash data from the Fatality Analysis Reporting System (FARS) and University of Michigan Center for National Trucks Statistics database to determine the cause of fatalities in crashes involving heavy trucks and other vehicles (6). The researchers identified the following variables for each vehicle involved in a fatal crash:

- Not keeping in the lane
- Not yielding the right of way
- Speeding
- Not obeying signs, signals
- Not paying attention

Of the five driver factors listed as causes for fatal crashes in this study, 75 percent were linked to car drivers and 25 percent were linked to truck drivers. This research suggests that car drivers are three times more likely to commit unsafe actions that contribute to fatal car-truck crashes. Figure 2.1 depicts the five most frequent driver factors in fatal car-truck crashes (6, pg 8).

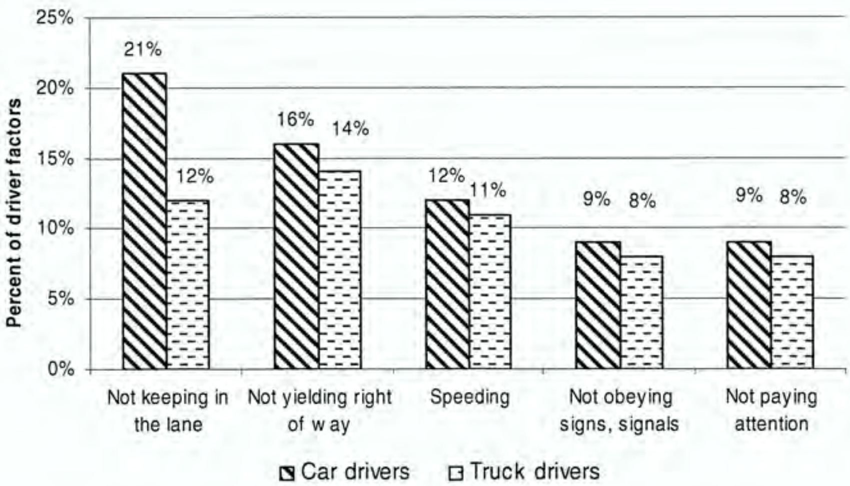

Figure 2.1. Driver factors in fatal car-truck crashes

Kostyniuk, Streff, and Zakrajsek suggest that car drivers have difficulty judging truck speed maneuverability, braking and acceleration. It is assumed that most car drivers assume that trucks are operated in the same manner as cars, and subsequently do not understand the risks associated with driving near trucks. In the case for dedicated truck lanes, the separation of cars and trucks could reduce the frequency of fatal crashes that have been caused by driver error between the two vehicle classes.

Truck only separation techniques

In 2001, the Texas Transportation Institute conducted a study that studied the reduction in crashes caused from the restriction of heavy trucks from the left lane on freeways in the Houston metro area (7). An eight-mile segment of Interstate 10 East was selected as a test segment because of its high crash rates, high truck volumes, and the availability of overhead sign structures for directing trucks. The initial analysis from the 36 week test period found a reduction in crashes from an average of 7.5 crashes per week before the study period to an average of 2.5 crash occurrences per week during the study period. The researchers found that the crash rates involving large trucks remained unchanged during the study period. Speed data for the study area was obtained from the Texas Department of Transportation's automated vehicle speed sensors. The researchers found that average speeds at some locations increased slightly, but overall the report concluded that the truck lane restriction study had no definite impact on vehicle speeds on the corridor.

Samuel, Poole, and Holguin-Veras have identified the preliminary design for dedicated truck lanes has at least one travel lane in each direction with a passing lane every few miles (3). Each direction of the designated truck facility would have a breakdown lane. Another proposed design involves a three-lane truck facility with a continuous alternating passing lane for the two directions of travel. The facility would have a concrete New Jersey barrier-separated 24 foot traveled way, with a six-foot breakdown lane in each direction. The pavement and structures for the designated truck lanes would be stronger and more durable than typical pavement currently being used on interstate highways. Similarly, design of structures and pavements for the general-purpose lanes could be designed using inexpensive, less durable materials. Rehabilitation of the general-purpose lanes would not be necessary because the truck only facility would be constructed inside the median of the existing highway.

Forkenbrock and March have identified three general designs for truck only lanes that vary in design and capital cost (8).

- Two additional lanes in each direction for heavy trucks only. The researchers did not specify which side of the highway these lanes would be constructed. These lanes would be separated from the existing lanes, which would be limited to passenger vehicles, by barriers.
- One additional lane in each direction would be limited to heavy trucks, with a breakdown lane, and an additional passing lane every few miles. When feasible, the added lane would be located within the median, with a concrete barrier separating traffic.
- The addition of one lane in each direction for a total of three lanes in each direction. The right lane in each direction would be limited to trucks, the left lane to other types of vehicles, and the middle lane could be used by both groups.

Forkenbrock and March mention that proposals can vary in terms of the configuration of entrance and exit ramps. The most cost intensive designs maximize the separation of heavy trucks and other vehicles by constructing separate entrance and exit ramps for the dedicated truck facility. Certain interchanges with low combination unit AADT may not be granted access to the dedicated truck facility (8).

According to a study completed by Samuel, Poole, and Holguin-Veras, the proposed dedicated truck lanes could have advanced entrances and exit ramps to the general-purpose lanes to allow trucks adequate space to decelerate and change lanes for an interchange (3). Another design option would involve separate entrance and exit ramps for the dedicated truck lanes. Safety would be improved with the latter design because trucks would not need to weave across general-purpose lanes in order to exit the freeway. However, separate entrance and exit ramps would require additional right of way acquisition and would make constructing the designated truck lanes inside the median difficult.

Figure 2.2 displays two designs proposed in a study completed by the Center for Urban Transportation Research at the University of South Florida regarding the feasibility of dedicated truck lanes on the Florida's Turnpike (9, pg 44).

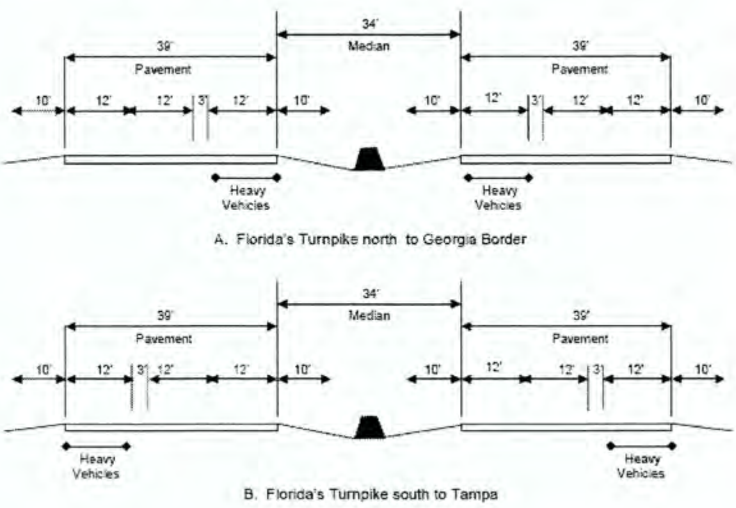

Figure 2.2 Configuration of truck only lanes on the Florida's Turnpike

This design considers the construction of truck lanes within the median of an existing interstate corridor. The design in Figure 2.2 does not offer complete separation of combination units from other vehicles because the trucks must merge into the general-purpose lanes traveled lanes to enter and exit the highway. Design A in Figure 2.2 causes safety concerns when heavy vehicles must cross several lanes to exit the freeway. Design B in Figure 2.2 causes safety concerns when the heavy vehicle lane may interfere with other vehicles that merge or diverge from the freeway. A truck only lane may decrease the number of crashes that occur in "free flowing" conditions, but there will likely be an increase in crashes in the vicinity of interchanges. While a separate truck facility is cost intensive and requires additional right of way, safety will be improved by providing full separation between combination trucks and other vehicles (9). Figure 2.3 depicts an example of a separate dedicated truck facility on an interstate highway corridor.

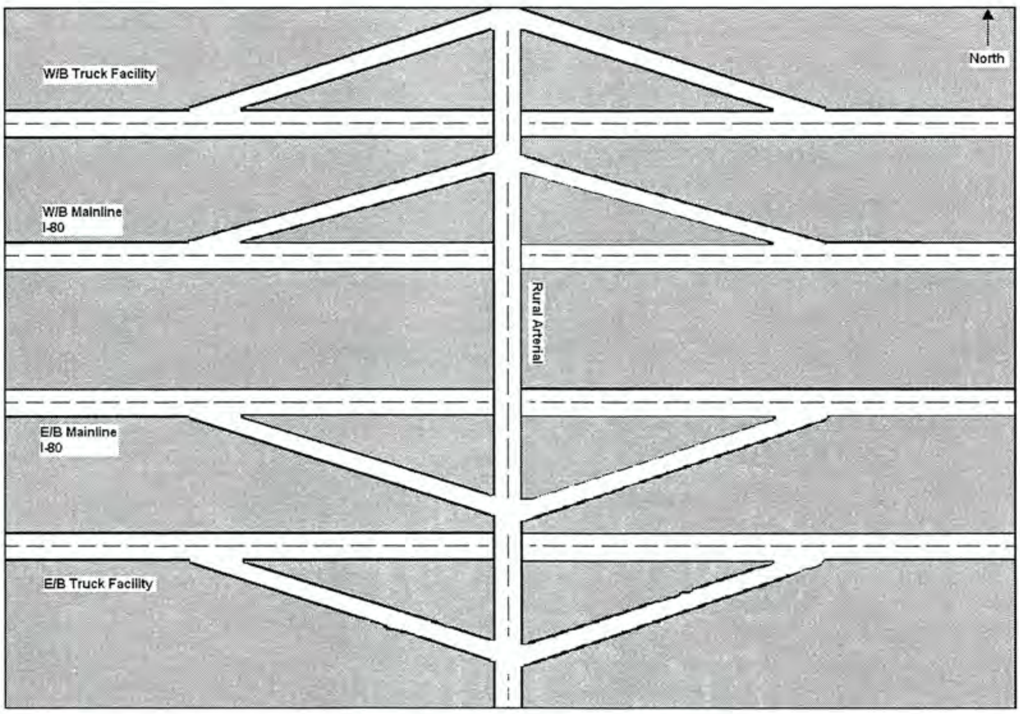

Figure 2.3 Truck only corridor interchange schematic

The design shown in Figure 2.3 allows combination trucks and LCVs to enter and exit the dedicated facility without interfering with traffic on the general-purpose lanes I-80. Separate entrance and exit ramps for the dedicated truck facility would eliminate potentially dangerous weaving maneuvers that trucks would have to execute in order to exit the freeway. The innermost lanes would handle general-purpose lanes traffic where the outermost set of lanes would function as dedicated truck facilities.

A "Managed Lanes State of the Practice" report conducted by the Texas Transportation Institute described a set of specific feasibility thresholds for the consideration of constructing dedicated truck lanes (10). The study found that the truck facilities were most cost-effective when they were constructed with barrier separation in the existing median. Truck lanes that are constructed within the median of an existing freeway typically do not require the acquisition of additional right of way. Literature cited in a study from the California Department of Transportation noted that barrier separated dedicated trucks lanes provide the greatest benefits when truck volumes exceed 30 percent of the total vehicle mix, peak hour volumes exceed 1,800 vehicles per lane-hour, and off-peak volumes exceed 1,200 vehicles per lane hour. These variables have been developed through the analysis of the Highway 60 corridor in Southern California. The values are used as threshold values to determine the need for dedicated truck lanes (10, p. 4). Poole and Samuel have justified similar parameters for constructing a dedicated truck facility with an ADT of 40,000 vehicles in each direction of a four lane limited access freeway, and 20 percent of this accounted by large trucks (11, p. 7).

Several case studies have been completed that explore the possibility of the implementation of dedicated truck lanes on urban freeway corridors (4, 12). While this thesis focuses on rural interstate corridors, several relevant case studies have been conducted on urban freeway corridors. Separation of trucks has been considered on urban freeway sections as a solution to congestion when combination unit trucks constitute a significant portion of total vehicle traffic.

Research that was completed by Trowbridge, Nam, Mannering, and Carson (4) questions the feasibility of dedicated truck lanes. The researchers argued that dedicated truck lanes will reduce the operational flexibility of the facility. Limiting vehicles to specific lanes may create additional congestion, thus limiting the operational flexibility. Additional difficulties may arise when crashes occur or maintenance needs to be conducted. Truck only lanes are viewed to the public as providing a minimal overall benefit because drivers of cars and other mid-sized vehicles will not be able to use them.

In addition to public misconception, there are several institutional, political, and policy issues related to the construction of a dedicated truck facility on an interstate corridor (1). The strategy requires extensive planning, engineering, design, and new roadway construction. There would have to be close coordination with local and state governments, acquisition of right of way, and cooperation from citizens and local businesses.

Since few truck only facilities have been constructed, there is a degree of uncertainty regarding the cost. The following literature sources provide estimates of the cost of constructing highway facilities for trucks. Poole and Samuel have estimated that constructing a truck only facility on an existing interstate highway would cost approximately $2.5 million per lane mile or $10 million per route mile for two lanes in each direction. These figures do not include the cost of potential land acquisitions. The cost would vary based on the availability of right-of-way, topography, the need for overpass reconstruction to accommodate LCV weights, and the number of new entrance and exit ramps required (11).

Fischer, Ahanotu, and Waliszeuski cite the Southern California Association of Governments proposed plan to construct a ten billion dollar network of dedicated truck lanes on Interstate Highway Corridors in the Los Angeles metro area (12). This project is important because California is one of the first states in U.S. to consider an extensive network of truck only lanes on its freeway corridors. The truck lanes would be physically separated from the general-purpose lanes, with grade separation from existing freeway ramps to minimize the weaving interactions with general-purpose traffic. Over four billion dollars in funding was allocated for the development of truck lanes on State Highway 60 in the 2001 Regional Transportation Plan. Of the 4.3 billion dollars, 70 percent of the funding will be derived from government funding, and the remaining 30 percent is derived from toll revenue. According to Fischer, Ahanotu, and Waliszeuski, the I-710 and I-15 Corridors are being studied as potential corridors for dedicated truck lanes (12).

Dedicated truck facilities would be financed through toll collection. In order to do this, federal law must be revised to allow toll collection on free interstate highways. A study by Poole and Samuel suggested that legislation must include the following requirements: "additional right of way must be granted for the construction of truck only lanes and public-private partnerships could be enhanced by allowing truck only lane projects to qualify for federal tax exempt bond status. (12, p. 24)"

While truck only facilities would be optional for motor carrier combinations that are currently allowed on the interstate system in respective states, LCV's could operate on these facilities as well (3, p. 7). Toll collection would be conducted by an automated non-stop method with the use of license plate readers or transponders. Since the truck tolls would pay the debt service on the construction of the facility, they would not be charged state or federal fuel taxes or other vehicle use taxes for the miles that they use the truck only lanes (3, p. 4). An electronic toll collection system could be used to record the miles driven and provide the information to rebate state and federal user taxes. This legislation would allow the toll facilities to be constructed by private concessionaries (3).

2.2 Freight industry benefits of truck only lanes

Previous research has suggested that dedicated truck lanes will bring additional cost savings to logistics companies by increasing the productivity and decreasing the fuel consumption of trucks (3). Allowing the operation of LCVs on dedicated truck facilities will further reduce fuel consumption as well as lessen the overall emissions output by enabling the same amounts of commodity to be hauled by fewer tractors.

Currently, the state of Iowa does not allow turnpike doubles or triple bottom trailers to operate on the interstate highway system. Turnpike doubles typically constitute two 48 foot trailers that are generally used by truckload carriers. Triple LCVs, are normally three 28 foot trailers that are commonly used by less than truckload carriers for the line haul portion of a trip (13). Figure 2.4 is a graphic found in a Reason Public Policy Report that depicts the LCVs that operate in various states throughout the United States. The graphic in Figure 2.4 was originally created in a report created by Samuel and Poole (3, p. 4).

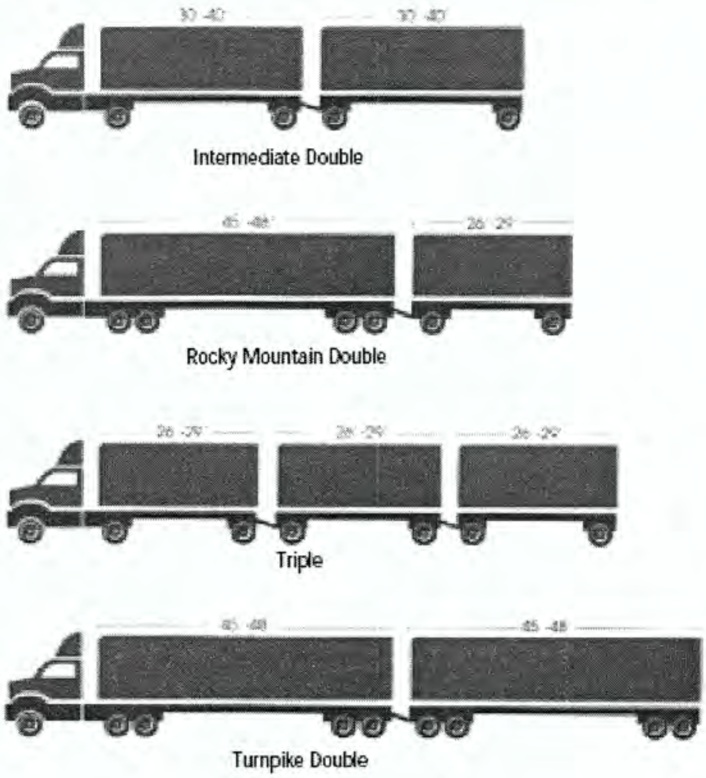

Figure 2.4 Current LCV Combinations in U.S.

A "Managed Lanes State of the Practice" report conducted by the Texas Transportation Institute explains that dedicated truck facilities would have positive impacts on diesel consumption, noise and air pollution, as well as other environmental impacts that heavy truck volumes cause (10). The study states that the creation of an uninterrupted flow condition for trucks would reduce emissions and fuel consumption as opposed to congested stop and go conditions. Conversely, the study mentions that the construction of a truck facility may shift additional, unexpected volumes from parallel roadways, thus creating additional environmental impacts for the truck facility. Additional increases to the volumes in the general purpose lanes travel lanes may occur due to latent demand from other roads that bear higher operating costs (10).

Poole and Samuel explain that the construction of an expanded LCV network (with dedicated truck lanes) will allow significant gains in productivity in the freight industry (3). Allowing trucks to carry larger loads would increase productivity, decrease price, and decrease the amount of wear and tear on the trucks themselves. LCVs can haul larger loads than a standard tractor-semi trailer can with significant transportation cost savings. While LCVs create more emissions than a standard tractor-semi trailer, the EPA has explained that hauling more freight by using multiple trailers would reduce both fuel use and emissions per capita (12, p. 7). In effect, the construction of facilities that handle LCVs will save money for the freight industry as well as decrease emissions.

Poole and Samuel have noted that the states that permit LCVs on its interstate highways are limited with many gaps between states that allow LCV operation. While most of the turnpikes in the eastern U.S. and the interstates in the Western U.S. allow some LCV configurations, a gap exists throughout much of the midwestern and the southern states. Designated truck lanes would help span the gaps from the interstate highway corridors that allow the operation of LCVs.

Poole and Samuel have analyzed five scenarios that would allow longer combination trucks to operate on the interstate highway system in the U.S. The modifications would allow greater use of LCVs and retrofitting all lanes. The five scenarios studied by Samuel and Poole are listed below.

- Uniformity: The existing "grandfather" provisions allowing LCV operation in some states would be eliminated and federal size and weight limits would be applied to the entire National Highway Network.
- NAFTA 90K: This scenario would allow the use of Canadian-style triple axle (tridem) semi trailer configurations, with a total vehicle weight of 90,000 lbs on the National Highway Network.

- NAFTA 97K: This scenario would use the tridem semi trailer configurations while allowing a maximum total vehicle weight of 97,000 lbs, which would permit fully loaded international containers to be carried on the tridem semi trailers.
- LCVs Nationwide: This scenario would end the freeze imposed by the ISTEA legislation by allowing LCV operation on nearly all of the interstate highway system in the continental United States. This scenario would require the construction of marshalling yards adjacent to interstate highway exits so the LCVs would not need to travel on local roads.
- Triples Nationwide: This scenario would allow triple trailer combinations up to 132,000 lbs on the majority of the interstate highway system. This scenario would require the construction of marshalling yards adjacent to interstate highway exits so the triples would not travel on local roads.

The study conducted by Samuel and Poole shows that savings are possible with an investment in the existing interstate highway network to allow extended LCV operation (11). Maze, Walter, Smadi, and Channaraj explain that there is little uniformity in the states that allow LCV operation. LCV operation began on the turnpikes in the East and the Midwest in the 1950's (13). The western states followed suit by allowing more extensive LCV operation in the 1970's and early 1980's. The regulation of LCV dimensions (based on size and weight) have been regulated by the respective state or turnpike authority. An example of this is the State of Nebraska that officially is an LCV state but only allows turnpike doubles to travel empty on I-80.

LCV operation in the Eastern portion of the United States is limited to turnpikes and toll roads, with the loads broken down at marshalling yards (13). The lack of uniformity in the LCV size and weight definition between states creates limitations in freight productivity when double and triple loads must be hauled separately in states that do not allow LCV operation. Table 2.1 depicts the variations in maximum truck lengths and weights between the jurisdictions that permit LCV operation.

Table 2.1 STAA Operation Policy for turnpike doubles and triples in United States

	Turnpike Doubles		*Triples*	
State	*Maximum GVW (in thousands of lbs)*	*Maximum Length (in feet)*	*Maximum GVW (in thousands of lbs)*	*Maximum Length (in feet)*
Alaska	135	90	135	110
Arizona	111	95	123.5	95
Colorado	110	95	110	95
Idaho	105.5	95	105.5	105
Montana	124	93	131.06	100
Nebraska	n/a	95	x	95
Nevada	129	95	129	95
North Dakota	105.5	103	105.5	100
Oklahoma	90	123	90	95
South Dakota	129	100	105.5	95
Utah	129	94	129	100
Wyoming	101	81	129	100
Florida Turnpike	147	106	x	x
Indiana Toll Road	127.5	106	127.4	104.5
Kansas Turnpike	120	109	110	109
Massachusetts Turnpike	127.4	114	x	x
New York Thruway	143	102	x	x
Ohio Turnpike	127.4	102	105.5	95

Table 2.1 shows that the maximum gross vehicle weights (GVW) and maximum lengths now vary considerably for turnpike doubles and triples by jurisdiction. This variation in GVW and length by jurisdiction causes difficulties for the freight logistics industries. Overall, LCV operation is limited by gaps in the network and the non-uniformity of length and weight limits by jurisdiction.

Maze, Walter, Smadi, and Channaraj identify several advantages to LCV operation in terms of freight productivity (13). While LCV combinations have a larger cost per truck mile, they are more productive on a ton-mile basis. LCVs produce distinctive savings when considering their use for a line-haul portion of a trip. Although the expansion of the LCV network may lead to increased freight productivity, consideration should be given to heightened severity for car-truck crashes, accelerated deterioration on pavements and bridges, as well as a decline in railroad hauling revenues.

Janson and Rathi explain the development of extensive analysis format to evaluate the economic feasibility of separating heavy vehicles from light vehicles on urban freeways (14). High percentages of truck traffic cause significant congestion on the freeways through the metro area. A computer program was created that evaluates existing highway characteristics along with user inputs to calculate net present values and benefit to cost ratios of dedicated heavy vehicle lane designs. Janson and Rathi identify travel time savings due to faster travel flow, vehicle operating cost savings due to faster travel flow, injury and property damage savings due to safer operating conditions, and travel delay savings due to few crashes causing blockages. The analysis takes into account the project costs such as the initial construction costs, initial right of way acquisition, and periodic resurfacing. The researchers mention that the light vehicle lanes will not need to be resurfaced as frequently with the removal of heavy vehicles from the traveled way. In summary, the researchers have found that the separation of combination trucks from automobiles lessens congestion while improving travel times and freight productivity.

Trowbridge, Nam, Mannering, and Carson have researched means for increasing freight productivity along freeway corridors in the Puget Sound (Seattle) region of Washington (4). The researchers have performed traffic simulation and estimated the economic impacts of reserved capacity strategies on freeway corridors in the region as well as evaluating the impacts to safety as a result of redistributing trucks to dedicated facilities. The results of the study determined that reserved capacity strategies would provide nearly ten million dollars in annual travel time savings for the trucking industry in the Seattle region. The researchers explain that the net benefits would not perceived as significant by individual trucking firms (2.5 minutes saved per average trip), but the 30 million dollars in annual travel time savings for single occupancy vehicles is significant.

In summary, research of the proposed design of dedicated truck lanes is relatively abundant, but little research exists on the benefits that truck only lanes will have on the freight industry. Dedicated truck lanes would be designed to handle heavy vehicles and LCVs, thereby reducing the deterioration that heavy vehicles may cause on the general-purpose lanes. Allowing LCVs to operate on a dedicated truck facility would provide additional benefits to freight productivity and allow LCV operation in states that currently do not allow their operation. Truck only lanes would separate auto and truck traffic, thus limiting the potential for severe crashes to occur due to operational differences between the two vehicle types. The argument for greater use of LCVs would be strengthened because they would not need to operate in the same lanes with passenger vehicles.

The majority of the literature concerning the design of dedicated truck lanes has the facility built in the median of the current freeway, and does not consider a separate facility where heavy vehicles will have separate entrance and exit ramps. In addition, research does not exist that establishes a set of performance metrics that determine if the economic, safety and environmental benefits will outweigh the cost of right of way acquisition and construction of a dedicated truck facility. Appendix A identifies the benefits and costs of constructing a truck only facility as found in the reviewed literature. By conducting a HERS-ST corridor analysis of the interstate highway corridor with significant truck volumes, this thesis will determine whether the construction of dedicated truck lanes will benefit the operations of the corridor and the freight corporations that utilize this highway.

3. CASE STUDY OF THE I-80 CORRIDOR IN IOWA

This chapter provides an analysis of the traffic characteristics and crash data of the corridor, and is divided into five sections. This chapter of the thesis introduces and explains the data used in the forthcoming analysis chapter. The I-80 corridor in this study can be defined from the eastern end of the urban section of the freeway east of Des Moines at milepost 142 and continuing to the Illinois Border at Milepost 306. This section of I-80 is being considered in this analysis because over thirty percent of the vehicles that travel on this corridor are trucks, and a significant portion of truck trips leave I-80 to travel on I-35 in Des Moines and I-380 in Iowa City. The urban section of I-80 through Des Moines was not considered in this analysis because of limited right of way availability and other limitations in the current alignment of the freeway. In addition, the percentages of combination trucks on the I-80 corridor decrease west of Des Moines. Figure 3.1 displays the section of the 164 mile corridor that runs from Des Moines to just west of Iowa City. Figure 3.2 shows the remainder of the corridor that runs from Iowa City to Davenport.

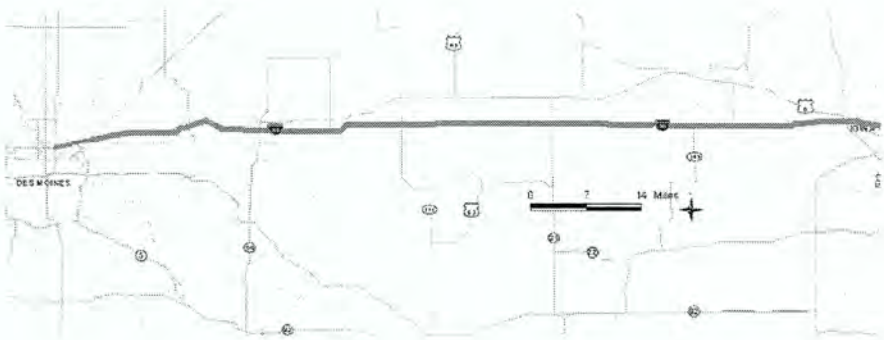

Figure 3.1 I-80 study corridor, Des Moines to Iowa City (1 of 2)

Figure 3.2 I-80 case study corridor, Iowa City to Davenport (2 of 2)

The first section of this chapter presents current Average Annual Daily Traffic (AADT) counts with classification counts for trucks. The second section contains a comparison of AADT and combination truck volumes on similar interstate corridors in the Midwest. If a truck only facility is constructed along the I-80 corridor in Iowa, it will most likely be tolled to service the debt incurred to construct the facility. The Kansas Turnpike is analyzed to determine the truck tolls on the I-70 portion between Topeka and Kansas City. This section of the Kansas Turnpike was chosen because I-70 is a trans-national trucking route and LCV operation is allowed. The Kansas Turnpike allows turnpike doubles and triple combination trailers to operate, whereas the state of Iowa does not allow turnpike double and triple combination vehicles on the interstate highways. The third section contains a descriptive analysis of commodity flows on the I-80 corridor using data obtained from the Iowa DOT and Reebie Associates. The fourth section presents a four-year analysis of all crashes involving trucks on the I-80 corridor. Through this analysis, the research illustrates that the majority of crashes involving cars and trucks can be minimized if trucks were separated from other vehicles. The final section provides an estimation of the cost of constructing a dedicated facility for trucks on I-80.

3.1 Traffic Volumes and Classification Counts

Current AADT counts and classification counts are needed to evaluate the current usage and percentage of large trucks on the I-80 corridor. The following data were obtained from the Iowa Department of Transportation Office of Transportation Data. Table 3.1 present the AADT for all vehicles on the I-80 corridor and the percentage of multi-axle trucks.

Table 3.1 I-80 Corridor AADT and percentage of multi-axle trucks, Iowa DOT Office of Transportation Data, 2004

Intersection Points	*AADT*	*% of Combination Units*	*Four Axle % of AADT*	*Five Axle % of AADT*	*Six or more Axles % of AADT*	*% of Multiple Trailers*
Altoona	36800	24%	6%	16%	1%	1%
US 63	26700	32%	8%	22%	1%	2%
Coralville	34000	26%	7%	18%	1%	1%
I 280	31500	32%	8%	22%	1%	2%
I 74	48000	20%	5%	13%	>1%	1%
Illinois Border	33500	25%	6%	17%	1%	1%

While the AADT for the corridor peaks around the corridor's larger cities, the percentage of combination vehicles fluctuates by less than thirteen percent on the selected sites throughout the corridor. The percentage of combination units decreases after the I-280 interchange near Davenport, which suggests that a significant portion of trucks may travel this route around the Quad Cities metro area as an alternative to I-80. In order to quantify the amount of combination truck traffic that travels on the I-80 corridor, a 127 mile segment of Interstate 35 between Ankeny, IA and the Iowa-Minnesota Border in Iowa was analyzed to determine the percentage of combination units that travel along this corridor. Table 3.2 depicts the averaged traffic counts for the I-80 corridor, the I-35 corridor, and the I-70 corridor from Topeka to Kansas City. The I-70 corridor in Kansas was selected because this corridor has similar traffic volumes and combination unit volumes as the I-80 corridor in Iowa.

Table 3.2 Averaged Corridor daily classification volumes for various interstate corridors

Corridor	*Length in Miles*	*Cars, buses, motorcycles, single unit trucks*	*4 Axle*	*5 Axle*	*6 Axle*	*Multiple Trailer*	*Total Combination Units*	*Total*
I-80, Altoona-Illinois Border	164	33,033	2,285	6,307	203	474	9,269	42,302
I-35, Ankeny-Minnesota Border	127	21,990	1,026	2,830	91	213	4,160	26,150
I-70, Topeka-Kansas City	35	38,564	629	3,799	172	145	4,745	43,309
I-280, Quad Cities	10	14,359	1,026	2,830	91	213	4,160	18,519

While the I-70 corridor of the Kansas Turnpike has a greater AADT, the I-80 corridor carries nearly twice the number of combination vehicles as the I-70 corridor. The I-35 corridor has a smaller total traffic count and fewer combination units than the I-70 and I-80 corridors. The I-35 and I-280 corridors were chosen because they are interstate corridors in Iowa with substantial amounts of truck traffic. The I-70 corridor was chosen because it is a major east-west trucking route and LCV operation is permitted. In summary, this corridor comparison has shown that the I-80 corridor handles more combination units than the other interstate corridors, and the long-range plans for the corridor should account for the amount of combination units that use this facility.

3.2 Kansas Turnpike truck cost summary

The I-70 corridor of the Kansas Turnpike was chosen for comparison purposes because it is a major east-west trucking route (similar to I-80) and LCV operation is allowed. The Kansas Turnpike is a tolled facility; therefore per mile costs were analyzed for combination unit trucks and were used in the forthcoming LCV sensitivity analysis of potential twenty-year revenue projections in chapter four of this thesis. The analysis of truck tolls on the Kansas Turnpike will provide a comparative route if a tolled truck only facility were to be constructed on the I-80 corridor and the tolls are used to service the debt incurred to construct the facility. Currently, the state of Iowa does not allow longer combination vehicles to operate on interstate highways. Table 3.3 depicts the tolls charged to various axle loads on the I-70 section of the Kansas Turnpike. The class description determines the number of axles on the vehicle.

Table 3.3 Tolls charged to various combination units by axle on the Kansas Turnpike

	4 Axle	*5 Axle*	*6 Axle*	*7 Axle*	*8 Axle*	*9 Axle*
Cents per mile	$0.10	$0.15	$0.20	$0.28	$0.33	$0.36
Per Axle Toll	$3.50	$5.25	$7.00	$9.75	$11.50	$12.50

The tolls shown in Table 3.3 represent the cost (in cents per mile) of traveling with various axle configurations from milepost 182 to milepost 217. The rates increase for trucks with additional axles and LCVs are charged a premium to use the Kansas Turnpike. Table 3.4 presents the AADT and percentage of combination vehicles that travel on the Kansas Turnpike from milepost 182 through 217.

Table 3.4 Combination vehicle AADT and percentage of all vehicles on I-70/The Kansas Turnpike

Class	*AADT*	*% of all vehicles*
4 Axle	629	1.4%
5 Axle	3,799	8.6%
6 Axle	172	0.4%
7 Axle	64	0.1%
8 Axle	54	0.1%
9 Axle	27	0.1%
TOTAL	*4,746*	*10.8%*

Table 3.4 shows that the majority of combination vehicles are 5 axle trucks on the I-70 corridor of the Kansas Turnpike. There are small amounts of eight and nine axle LCVs that travel on this corridor on a daily basis. Table 3.5 presents the AADT for all vehicles on the I-70 corridor of the Kansas Turnpike.

Table 3.5 AADT and percentage of all vehicles on I-70/The Kansas Turnpike

Class	*AADT*	*% of all vehicles*
Autos	38,564	87.7%
3 Axle	666	1.5%
Combination Vehicles	4,746	10.8%
All Vehicles	*43,976*	

Table 3.5 shows that combination vehicles constitute nearly eleven percent of the total AADT on the I-70 corridor between milepost 182 and milepost 217. The Kansas Turnpike has a greater amount of car traffic, and a smaller percentage of trucks than the I-80 corridor in Iowa. This may be attributed to the use of the Kansas Turnpike by commuters between Topeka and Kansas City.

3.3 Descriptive analysis of commodity flows on the I-80 corridor

The analysis of commodity flows on the I-80 corridor will help identify the types of shipments that would benefit from LCV operation if a dedicated truck facility is constructed. Transearch Freight Market data from Reebie Associates (2001) was obtained from the Iowa DOT to determine the length of haul for trucks using Interstate 80 through Iowa. Reebie Associates collects origin-destination freight data for all modes of freight throughout North America on an annual basis. Transearch is a multimodal goods movement database that is designed for public and private sector freight planning. This dataset includes tonnage and equipment volumes by commodity, transportation mode and route. The Transearch database is compiled from over 100 commercial and public sources of data representing NAFTA and domestic trade flows. Economic modeling is used to support the model to check spatial patterns and logic as well as to construct forecasts (15).

In this situation, the entire 306 mile corridor of I-80 in Iowa was analyzed to determine the most common commodities hauled and whether the trip was greater than 100 miles, over 150 miles, or more than 200 miles. The entire I-80 corridor in Iowa was used to obtain an understanding of the percentage of trucks that do not have an origin or destination in Iowa, and used this route as a bridge between two states. In this analysis, a long haul trip is constituted as a trip that is longer than 100 miles on the I-80 corridor.

Overall, 53 percent of the trucks traveled less than 100 miles on the I-80 corridor. In all, 21 percent of all trucks traveled greater than 200 miles on the I-80 corridor. Of the 21 percent, twelve percent of the combination units on the I-80 corridor were classified as bridge trips that had neither an origin nor destination within the state of Iowa. The truck trips that used I-80 were queried from the dataset, and placed into groups based upon the length of the trip on the corridor.

The specific commodity that is being hauled is important in this study because certain goods are more likely to move by LCV. These goods often include prepackaged food and home goods as well as expedited package service. Trips without an origin or destination in Iowa, or bridge trips, are also important in this analysis because these trucks would be more inclined to utilize a dedicated truck facility to travel through the state more efficiently. A truck only facility would provide minimal interaction with other vehicles while decreasing the travel times of long haul freight trips. Table 3.6 displays the breakdown of truck trips on the I-80 corridor in Iowa.

Table 3.6 Distribution of truck trips on the I-80 corridor, Reebie Transearch Data, 2001

Carrier type	*Total Corridor*	*Bridge Trips*
Truckload	38%	43%
LTL	42%	48%
Private	20%	9%

Table 3.7 displays the total trips hauled in 2001 by commodity that traveled greater than 100 miles on the I-80 corridor. Trucks that discharged a shipment, and subsequently returned to the I-80 corridor were counted as secondary trips.

Table 3.7 Trips greater than 100 miles by commodity on the I-80 corridor, Reebie Transearch Data, 2001

Commodity	*Trips*	*% of total trips*
Food Or Kindred Products	1,542,047	27.79%
Secondary Traffic	867,638	15.64%
Clay, Concrete, Glass Or Stone	479,992	8.65%
Chemicals Or Allied Products	394,062	7.10%
Petroleum Or Coal Products	378,747	6.83%
Fabricated Metal Products	251,137	4.53%
Transportation Equipment	208,380	3.76%
Rubber Or Misc. Plastics	204,907	3.69%
Farm Products	195,617	3.53%
Primary Metal Products	187,361	3.38%
Machinery	180,418	3.25%
Lumber Or Wood Products	149,873	2.70%
Pulp, Paper Or Allied Products	147,546	2.66%
Electrical Equipment	116,606	2.10%
Printed Matter	63,079	1.14%
Furniture Or Fixtures	57,289	1.03%
Apparel Or Related Products	35,418	0.64%
Misc. Manufacturing Products	32,256	0.58%
Instrum., Photo Equip, Optical Equipment	18,830	0.34%
Leather Or Leather Products	18,214	0.33%
Textile Mill Products	15,682	0.28%
Coal	2,342	0.04%
Metallic Ores	801	0.01%
Tobacco Products	519	0.01%
TOTAL	*5,548,759*	*100%*

While most of the combination trucks on the I-80 corridor are less than truckload (LTL) carriers, there are significant percentages of truckload carriers. In particular, truckload carriers would be inclined to couple multiple loads into turnpike doubles if a dedicated truck facility was constructed along the I-80 corridor and LCVs were allowed to operate on this facility. LTL carriers would find inherent cost advantages for long haul trips if units were coupled into triple combination units. Private carriers are not for hire and constitute a smaller percentage of combination trucks on the I-80 corridor. These trucks may not be as inclined to couple their loads into turnpike doubles or triples. In addition do to the nature of the haul, specific commodities that are being hauled may have inherent advantages in terms of cost savings when they are coupled as double or triple combination units.

This chart was created by sorting the Transearch database based upon the number of trips that used the I-80 corridor in Iowa and the type of commodity that was hauled in each trip. In 2001, there were a total of 5,548,759 truck trips that traveled more than 100 miles on the I-80 corridor. While the classes of commodities hauled on the I-80 corridor is fairly diverse, the 'food or kindred products' is clearly the most commonly hauled commodity, with almost 28 percent of the total commodity trips in 2001. Secondary trips, where a commodity was discharged, and the truck subsequently returned to I-80, constituted 16 percent of the total trips on the corridor. This analysis shows that it is common for trucks to discharge their loads and return to I-80.

The Reebie data analysis has shown that nearly half of all combination trucks traveled greater than 100 miles on the I-80 corridor in 2001. Twenty percent of all trips on the I-80 corridor constitute food or kindred products in 2001. If a dedicated truck facility was constructed on the I-80 corridor, the motor carrier market that hauls food and kindred products could benefit from lower operating costs by combining truckloads into turnpike doubles or triples and utilizing the dedicated truck facility. Given the commodities that are hauled on the I-80 corridor, it can be expected that bridge traffic and long haul traffic would be likely to use a truck only, toll based facility because they would experience reduced travel times as opposed to using the general-purpose lanes I-80 corridor.

3.4 I-80 corridor crash analysis

A four-year analysis of all crashes involving trucks was conducted using crash data from 2001 through 2004 to determine the severity of these crashes along with the major causes on the I-80 corridor from the Illinois border to Altoona. The crash data were obtained from the Iowa Traffic Safety Data Service (ITSDS) at the Center for Transportation Research and Education at Iowa State University. These crash data were also used to calculate the crash rates for trucks and other vehicles for the benefit to cost analysis in the forthcoming chapter. Beginning in 2001, the State of Iowa modified the forms used to report motor vehicle crashes. The crash analysis in this thesis began with 2001 to ensure uniformity in the reporting standards. Figure 3.3 depicts the annual truck crashes on the I-80 corridor and Figure 3.4 displays the number of vehicles involved in truck crashes.

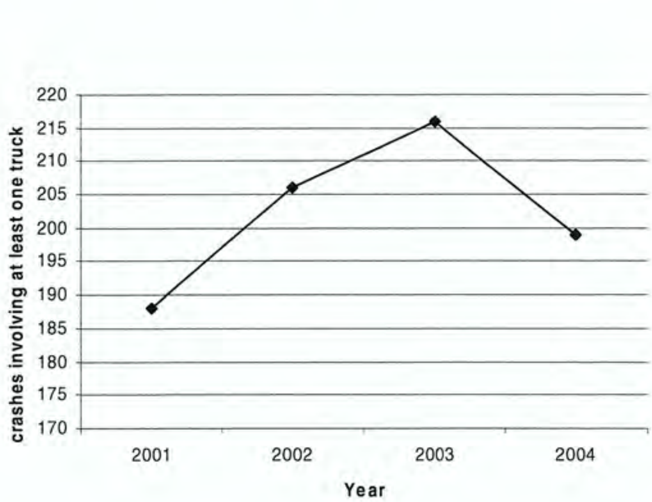

Figure 3.3 Total crashes involving trucks on the I-80 corridor, 2001-2004

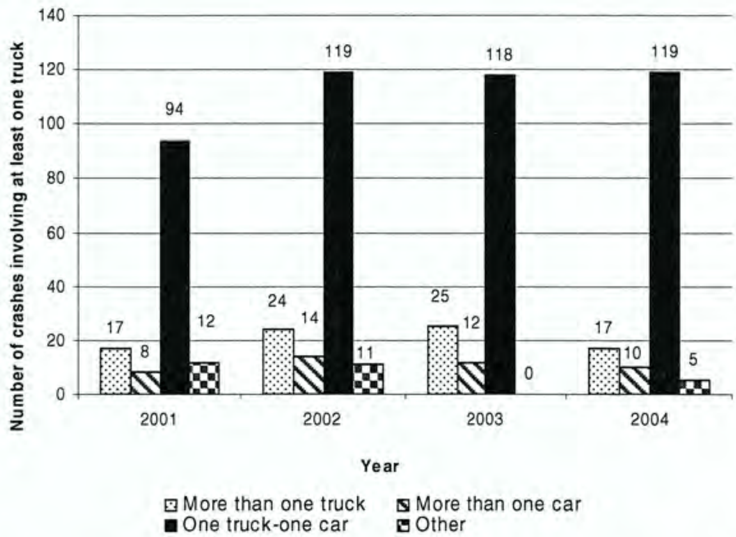

Figure 3.4 Number of vehicles in crashes involving trucks on the I-80 corridor

Figure 3.3 does not display a definitive trend to the annual crashes involving trucks. Since the occurrence of crashes is a quasi-random event, it is expected that there is an annual variation. Figure 3.4 indicates that a 'one car', 'one truck' crash is the most common collision on the I-80 corridor. There did not appear to be an overall increase or decrease in the types of crashes that occurred during this period. With the most common crash each year involving one semi-truck and one car, the separation of cars and trucks would facilitate a significant decrease in the total crashes on the I-80 corridor each year. Crashes involving a fixed object were grouped into the 'other' category. According to a report completed by the FHWA on unsafe driving acts, and total harm in car-truck collisions, the driver of the car has been found to be at fault in 70 percent of the fatal crashes involving large trucks and passenger cars (16). Figure 3.5 shows the number of injuries and fatalities that involve at least one truck on the I-80 corridor from 2001 through 2004.

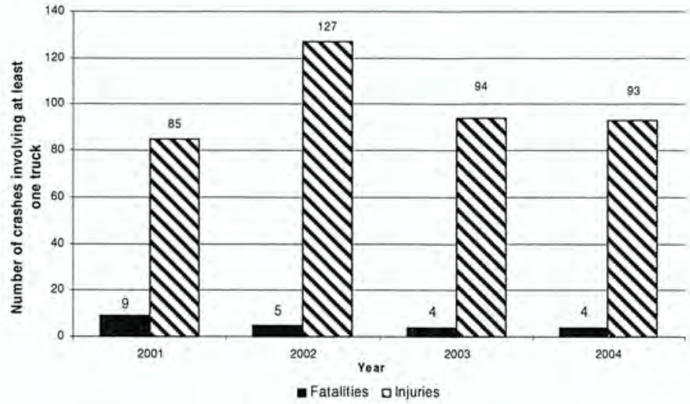

Figure 3.5 Severity of crashes involving at least one truck on the I-80 corridor

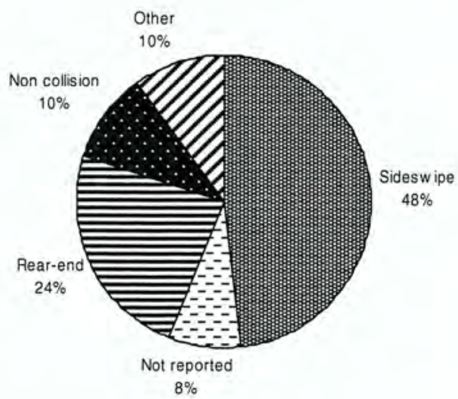

Figure 3.6 Common collision types involving trucks on the I-80 corridor, 2001-2004

Crashes that resulted in fatalities appear to be declining on the I-80 corridor from 2001 through 2004, while injury crashes are increasing throughout the period. Figure 3.6 depicts the most common collision types on the I-80 corridor. A 'non-collision' crash includes 'run off road' and 'struck a fixed object' crashes.

While sideswipe collisions is the most common crash type involving trucks, rear end collisions were relatively prevalent, suggesting an inherent speed conflict between trucks and other vehicles. A study completed by the FHWA found unsafe speed by cars to be a leading contribution to crashes involving large trucks and cars (17). When cars travel at faster speeds, there is less time to react to the movements of other vehicles, especially trucks that tend to travel at a slower speed than cars. Speed also contributes to the severity of the crash by generating additional kinetic energy. The 'other' category represents twelve collision types that constituted less than five percent each of the total crashes involving trucks on the I-80 corridor from 2001 through 2004.

To determine the vehicle types that are most likely to cause rear end and sideswipe/same direction crashes, a comparative analysis was conducted where the contributing circumstances for each vehicle involved in a crash were compared against the major cause of the crash. If the major cause matched the contributing circumstance in the crash data, then the vehicle was assumed to be at fault. This analysis only included combination unit trucks and single unit trucks, buses and motor homes were grouped in with cars. A crash was labeled 'no fault reported' if the contributing circumstances field in the crash database was labeled as unknown. Figure 3.7 shows the assignment of fault in rear end crashes.

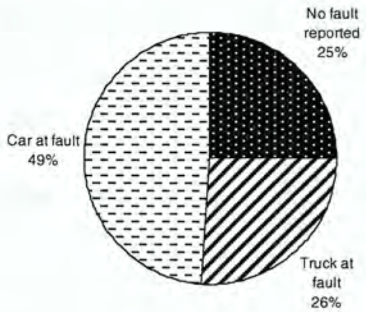

Figure 3.7 Assignment of fault in rear end crashes by vehicle type on the I-80 corridor, 2001-2004

Figure 3.8 depicts the assignment of fault in sideswipe/same direction crashes.

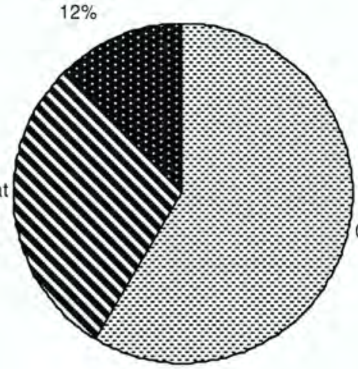

Figure 3.8 Assignment of fault in sideswipe/same direction collisions by vehicle type on the I-80 corridor, 2001-2004

Figure 3.7 explains that a higher percentage of cars were assumed to be at fault in rear end collisions between 2001 and 2004. The results displayed in Figure 3.7 cannot be considered entirely valid because the percentage of crashes where the fault could not be determined was relatively high. Figure 3.8 indicates that cars have a higher percentage of fault in sideswipe/same direction crashes that occurred on the I-80 corridor from 2001 through 2004. However, 23 percent of the sideswipe/same direction crashes did not indicate fault in the crash database. While a significant percentage of crashes in each chart could not ascertain fault from the information given in the crash database, assumptions can be made regarding the causation of rear end crashes and sideswipe/same direction crashes. Rear end collisions may be caused by trucks requiring a longer stopping distance and they usually operate at lower speeds. Cars may be more likely to have fault in sideswipe/same direction crashes because of the car driver's inability to choose an appropriate gap when changing lanes. It can be assumed that separating trucks from other vehicles would reduce the amount of crashes, but it is not possible to determine the reduction in crashes from the diversion of trucks to a dedicated truck facility. To determine the effect that weather may have on crashes involving trucks on the I-80 corridor, Figure 3.9 depicts the surface condition of the pavement for crashes involving at least one truck.

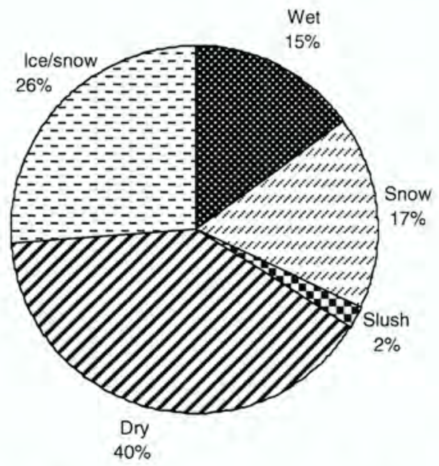

Figure 3.9 Pavement surface conditions for crashes involving at least one truck on the I-80 corridor

Figure 3.9 suggests that the surface condition of the pavement may be a heightened factor in crashes involving trucks, with sixty percent of all crashes occurring during conditions where some form of precipitation was present on the roadway. While precipitation is variable throughout the year in Iowa, it can be deduced from this data that surface conditions may cause more crashes that involve at least one truck.

Crash rates were calculated on the I-80 corridor to determine the relative involvement of trucks in crashes along the I-80 corridor on an annual basis. Crash data were utilized on the I-80 corridor from 2002 through 2004. Crash rates were calculated for all vehicles, semi-trucks, and vehicles other than trucks. A comparative analysis of the crash rate of all vehicles and trucks was conducted from the Geographic Information and Management System (GIMS), which is operated and maintained by the Iowa DOT. Trucks were defined in GIMS as the following units:

- Four axle single trailer
- Five axle single trailer
- Six axle single trailer
- Five axle multiple trailer
- Six axle multiple trailer
- Seven axle multiple trailer

The equation below was used to calculate the crash rate per 100 million vehicle miles traveled over a three year period.

$$CrashRate = \frac{Totalcrashes}{AADT(Miles) * 3 * 365} * 100{,}000{,}000$$

Table 3.8 displays the crash rates according to the vehicles involved in the crashes on the I-80 corridor.

Table 3.8 I-80 corridor crash rates for various vehicle types, 2002-2004

	all crashes	*crashes involving trucks*	*crashes not involving trucks*
VMT	5,531,185	1,527,161	4,004,025
total crashes	3571	621	2950
crash rate	59	37.1	67.3

While trucks comprise 28 percent of the total vehicle miles traveled (VMT) on the I-80 corridor, they are involved in 17 percent of the total crashes on the corridor between 2002 and 2004. The data in Table 3.8 suggests that trucks have much lower crash rate than other vehicle types from 2002 through 2004. The crash rates shown in Table 3.8 were utilized in calculating the crash costs for trucks and other vehicles in the benefit to cost analysis in chapter four.

A modified crash severity ranking was calculated for each of the groups to place more weight on serious injuries and fatalities. The modified crash rankings range from property damage only [1] to fatality [5]. This ranking methodology places a greater weight on serious injuries and fatalities. Table 3.9 depicts the modified crash rankings for all vehicles crashes and trucks crashes as well as the likelihood of each groupings involvement in a major injury or fatality crash.

Table 3.9 I-80 corridor modified crash severity rankings for truck crashes and all crashes, 2002-2004

	all crashes	*crashes involving trucks*
modified crash severity ranking	1.46	1.58
weighted major injury	14%	21%
weighted fatality	4%	7%

It is evident that crashes involving trucks are more likely to cause injuries and fatalities with a higher crash severity ranking than the other groups. From 2002 through 2004, 21 percent of the crash severity rankings were based upon major injury crashes for combination trucks, whereas the crash severity rankings for major injury crashes involving all vehicles constituted only 14 percent. Similarly, the weighted fatality rankings constituted seven percent of all truck crashes on the I-80 corridor between 2002 through 2004, and the weighted fatality rankings made up only four percent of the severity of all crashes during this time.

The crash data presented in this chapter has illustrated the magnitude of conflicts between cars and trucks on the I-80 corridor. The descriptive analysis of crashes involving trucks on the I-80 corridor found the most common crashes to involve one car and one truck. Driver error appears to be the key contributing factor to accident causation on the I-80 corridor and adverse weather conditions will increase the chances of a crash occurrence. Separating truck and car traffic along the I-80 corridor may reduce the occurrences of crashes involving driver error due to the inherently different operating characteristics of these vehicles.

3.5 Cost estimation of capacity improvements to the I-80 corridor

An approximate cost of capacity improvements on a rural interstate cross section was necessary to conduct an economic analysis for this study. Cost summaries for roadway improvements were obtained from the Office of Rural Pre-Design at the Iowa DOT. This section will include a comparison the costs of widening the I-80 corridor against the construction of a truck only facility with future intentions to construct additional travel lanes for the general-purpose lanes as needed. While data were readily available for constructing additional lanes on a freeway facility, cost data did not exist for the construction of a dedicated truck facility. Therefore, the cost data for constructing a new four-lane limited access highway and a new four lane freeway facilities were used.

While the Iowa DOT has not considered a design for a dedicated truck facility along the I-80 corridor, the agency has considered several capacity and reconstruction layouts for the corridor between Davenport and Des Moines. This thesis has considered one alternative from the Iowa DOT Office of Rural Pre-Design. While the Iowa DOT has created these designs with the intent of adding additional lanes to the existing traveled way, the researcher has made modifications to allow the construction and operation of a dedicated truck facility on this corridor. Figure 3.10 displays the Iowa DOT Alternative 1, which proposes a conversion from a four lane freeway to a six lane facility, with the option to expand to eight lanes.

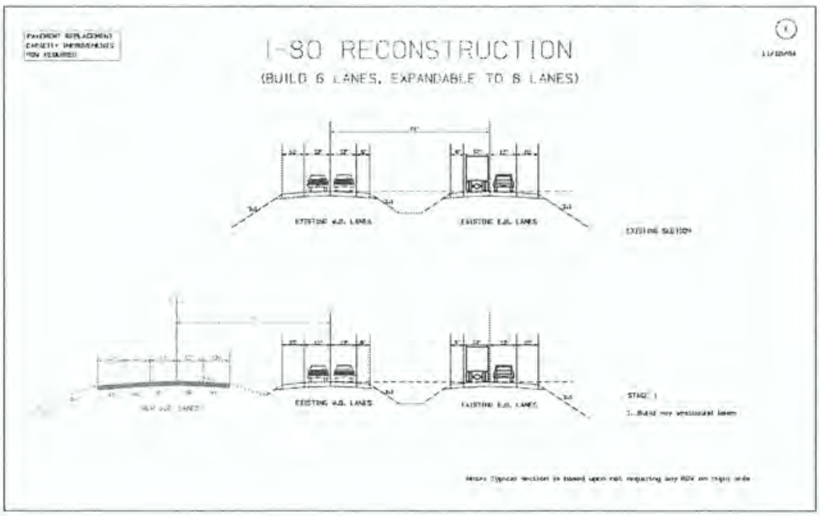

Figure 3.10 I-80 Reconstruction Alternative 1, Stage 1

Alternative 1 would allow four lanes of traffic to operate at all times while the new westbound lanes are being constructed. This design will minimize cost because right of way acquisition will only be conducted on the south side of the cross section. The old travel lanes could be retrofitted to become the dedicated truck facility. Figure 3.11 shows the subsequent stages of the Alternative 1 widening project.

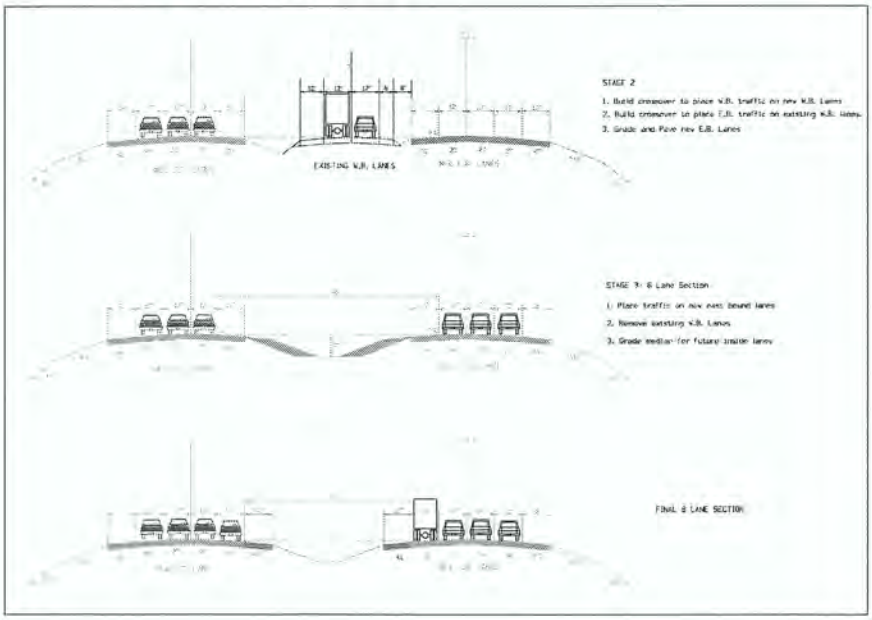

Figure 3.11 I-80 Reconstruction, Stages 2 and 3

Stage 2 of the reconstruction involves the transitioning of westbound traffic onto the new three-lane section, while eastbound traffic is diverted to the former westbound lanes. In stage 3, the former westbound lanes are removed and the median is regraded.

To generate accurate cost data regarding the reconstruction and implementation of a dedicated truck facility, an inventory of the bridges in this corridor was necessary. Within the selected corridor on I-80 from milepost 142 through milepost 306 there are a total of 182 structures, which are located above or below the existing traveled way and ramp segments. The majority of the structures in this corridor were constructed at least 40 years ago, and they are approaching the end of their constructed lifespan. The Iowa DOT is planning to replace the structures along the I-80 corridor when capacity improvements are being conducted.

In this study, approximate cost estimations were computed using typical bridge reconstruction costs provided by the Iowa DOT Office of Bridges and Structures. Currently, the overhead bridges are estimated to be 220 feet long throughout the corridor.

Constructing two additional lanes in each direction and providing the appropriate shoulder widths will require overhead bridges that are at least 300 feet in length. The additional 120 feet was added to the calculation, and the Iowa DOT assumes overhead bridge replacement costs to be $60/ft^2$. General-purpose lanes bridges will require an additional 24 feet to account for two additional lanes of traffic. The Iowa DOT assumes a bridge widening cost of $100/ft^2$ for general-purpose lanes bridges, and constructing a new bridge deck is estimated to cost $60/ft^2$. Table 3.10 displays the bridge replacement costs by structure type.

Table 3.10 Bridge replacement costs by structure type

Structure Type	*Number of structures*	*Replacement cost by type*
Prestressed concrete	108	$63,526,137
Continuous steel	41	$36,809,532
Concrete continuous	33	$2,822,532
TOTAL	*182*	*$103,158,201*

The majority of the bridges included in the I-80 corridor were constructed as pre-stressed concrete structures. Continuous steel structures are constructed with the beams running through the piers and are spliced between the piers. The Iowa DOT has figured the replacement of all of the bridges in the I-80 corridor along with any improvements to capacity. The total cost of replacing all of the structures along the I-80 corridor would be 103,158,201 dollars. This figure also accounts for widening the structures to accommodate an additional lane of traffic in each direction. Table 3.11 shows the bridge replacement cost by location type for the I-80 corridor.

Table 3.11 Bridge reconstruction costs by location type

	Number of structures	*Replacement cost by type*
Ramp Structure	5	$4,408,445
Overhead Structure	59	$28,922,021
General purpose lanes Structure	88	$67,017,444
Single Structure	30	$2,810,292
TOTAL	*182*	*$103,158,201*

The figures displayed in Table 3.11 include the cost of widening the structures to accommodate an additional lane of traffic in each direction. Reconstructing the bridges on the I-80 corridor is inevitable because the structures are reaching the end of their useful life and capacity improvements to the corridor will necessitate wider structures.

Cost data were obtained from the Iowa DOT Office of Rural Pre-Design for several re-construction alternatives as well as the consideration for a separate highway facility specifically for trucks. In this analysis, the reconstruction costs for a four lane facility assumed that a dedicated truck facility will be constructed on the I-80 corridor. Conversely, the six lane freeway reconstruction is an alternative to constructing a dedicated truck facility. Table 3.12 depicts the cost for the capacity improvement alternatives considered in this thesis. Table 3.13 displays the total cost for the I-80 corridor for the capacity improvements listed above. The length of the corridor is 164 miles and there are 41 interchanges on this section of I-80.

Table 3.12 Improvement cost for alternatives on the I-80 corridor

Improvement	*Six lane freeway*	*Four lane freeway*
Reconstruction cost per mile	$5,400,000	$4,400,000
Reconstruction cost per interchange	$2,500,000	$2,400,000

Table 3.13 Calculated improvement costs for alternatives on the I-80 corridor

Improvement	*Six lane freeway*	*Four lane freeway*
Reconstruction cost for 164 miles	$885,600,000	$721,600,000
Reconstruction cost for 41 interchanges	$102,500,000	$98,400,000
Reconstruction cost for 158 bridges	$103,158,201	$69,973,729
TOTAL	*$1,091,258,201*	*$889,973,729*

The cost of reconstructing the I-80 corridor as a four-lane freeway has been included in the total construction cost of the dedicated truck facility shown in Table 3.14. The four-lane freeway reconstruction cost includes reconstructing the bridges and interchanges to accommodate six-lanes of traffic if future AADT warrants capacity improvements.

The number of crashes involving trucks and cars would be minimized and traffic flow would improve for all vehicles if a separate truck only roadway were constructed. If constructed, a dedicated truck way would be built to the north or south of the existing I-80 corridor. Analyses that have been run in HERS-ST have determined that the volume of trucks on the I-80 corridor would warrant the construction of a four-lane dedicated truck facility, as opposed to a two-lane roadway. Therefore, a four lane limited access facility for trucks and LCVs has been considered in this analysis. Table 3.14 displays the approximate cost of constructing a four-lane rural roadway on a new alignment with two 26-foot wide general-purpose lanes with a 68-foot wide median, and six foot and eight foot granular shoulders. Bridge construction costs for constructing a four lane limited access facility were used.

Table 3.14 Cost of constructing a four-lane limited access highway on new alignment

	Per Mile	*164 mile corridor total*
Grading	$1,000,000	$164,000,000
Paving	$1,600,000	$262,400,000
Land Acquisition	$630,000	$103,320,000
Diamond Interchanges	-	$54,600,000
Bridges	-	$69,973,729
TOTAL	*$3,230,000*	*$654,293,729*
CORRIDOR TOTAL (with four lane reconstruction)	-	*$1,544,267,458*

The total cost of constructing a new four-lane facility specifically for trucks would be 654,293,729 dollars, and the cost of reconstructing the general-purpose lanes I-80 would be 889,973,729 dollars, which brings the total cost to 1,544,267,458 dollars. While constructing a four lane limited access highway for combination trucks is significantly more expensive than a two-lane alignment, this design would accommodate expected future truck volumes without creating capacity issues. In summary, a tradeoff exists in providing added capacity and safety conditions by constructing a separate facility for trucks as opposed to a cost effective design where a dedicated truck facility is not constructed and I-80 is reconstructed as a six-lane freeway.

4. HERS-ST AND BENEFIT TO COST ANALYSES OF THE I-80 CORRIDOR

This chapter will explain how HERS-ST was used in the analysis of the I-80 corridor, and present the results of the analysis. The benefit to cost analysis will be calculated outside of HERS-ST using Microsoft Excel because of the complexity of the analysis and because HERS-ST does not recognize truck only facilities as an improvement alternative. HERS-ST was used to quantify the benefits of separating combination trucks from other vehicles on the I-80 corridor. The reviewed literature was used in making assumptions and the crash data from the previous chapter was used to calculate the crash costs in the benefit to cost analysis.

This chapter is divided into seven sections. The first section explains the applications and capabilities of HERS-ST. The second section of this chapter explains the corridor run scenarios that have been conducted in this study. The second section introduces the performance metrics that will be evaluated in the run scenarios. The third section discusses the run scenarios conducted in HERS-ST through the use of charts for each performance metric. The fourth section of this chapter discusses the methods used in conducting the benefit to cost ratio analysis. The fifth section of this chapter discusses the results of the benefit to cost ratio analysis. The sixth section of this chapter is a sensitivity analysis that measures the benefits of truckload and LTL carriers that couple their loads into turnpike doubles and triples. The last section of this chapter is an analysis of potential user cost savings from using the dedicated truck facility.

4.1 I-80 corridor run scenarios in HERS-ST

A corridor run scenario has been conducted for the I-80 corridor in HERS-ST. The corridor is the entire I-80 section in this study from the Mississippi River crossing at Milepost 306 to Milepost 142, east of Des Moines. Conducting a run analysis on the entire corridor will help to identify the benefits to safety and operations if trucks and cars were separated for the entire distance from the Illinois border to the Des Moines metro area.

Because truck only facilities are not a recognized improvement in HERS-ST, a percentage of the combination truck volume was removed from the general purpose lanes I-80 corridor, and placed in a dataset that represents a dedicated truck facility in HERS-ST. The truck only lane dataset was given two lanes in each direction with a speed limit of 70 miles per hour. The peak capacity, AADT, future AADT, and percentage of Combination Truck fields were re-calculated to reflect the level of truck traffic anticipated on the facility. The same modifications were applied to the existing traveled way, where cars and other vehicles travel.

Additional modifications were needed to emphasize the nature of this analysis in HERS-ST. While most analyses consider pavement deficiency thresholds based on the International Roughness Index (IRI) and Present Serviceability Rating (PSR) data to program pavement improvements, HERS-ST was used in this thesis to predict future safety and operational conditions on the I-80 corridor. Therefore, the IRI and PSR deficiency levels were set to zero and the volume to capacity ratio thresholds were increased to place the emphasis on capacity improvements as a response to delay and crashes on the I-80 corridor.

Since the trucks that travel on the I-80 corridor through Iowa cannot be forced to use the dedicated truck facility, a series of run scenarios with varying percentages of truck traffic on the general purpose lanes I-80 corridor were conducted. Since there are no other dedicated truck facilities of this magnitude anywhere else in the United States, predictions cannot be made regarding the percentages of trucks that divert to the facility. An assumption can be made where the combination trucks that travel greater than 100 miles on I-80 in Iowa would divert to the dedicated truck facility, then this would represent 47 percent of the total truck AADT. The following assumptions were created as run analyses in HERS-ST to measure the safety and operational characteristics of various percentages of the total combination trucks on the I-80 corridor utilizing the truck only facility.

- 100 percent of all trucks use the dedicated facility and 0 percent of trucks use the general-purpose lanes
- 75 percent of all trucks use the dedicated facility and 25 percent of trucks use the general-purpose lanes
- 50 percent of all trucks use the dedicated facility; 50 percent of trucks use the general-purpose lanes

- 25 percent of all trucks the use dedicated facility; 75 percent of trucks use the general-purpose lanes

The scenarios shown above were run separately for the general-purpose lanes and the truck only segments in HERS-ST. The full engineering needs analysis was used for the above scenarios in HERS-ST. A full engineering analysis disregards the benefit to cost ratio when selecting projects, and instead identifies all deficiencies on a highway system and calculates the funds necessary to correct any deficiency. In this study, HERS-ST reported deficiencies and improvement costs in four, five year funding periods over a 20 year planning horizon. In total, eight run scenarios were executed in HERS-ST for this analysis. Of these eight run scenarios, four scenarios were dedicated to the general-purpose lanes I-80 corridor segments and four run scenarios were executed to represent combination trucks traveling on a truck only limited access facility. To provide additional comparison, a full engineering needs analysis was run where the I-80 corridor was gradually reconstructed as a six lane freeway.

4.2 Discussion of HERS-ST Analyses

A series of graphs have been generated from the performance metrics measured in HERS-ST to determine the benefits of diverting various percentages of trucks to a dedicated truck facility on the I-80 corridor. These graphs have been generated by the HERS-ST analysis model. The following graphs will display the four truck volume diversion scenarios across the funding periods of five years in length. Each performance metric that has been selected in the analysis has graphs to depict the performance of the general purpose lanes corridor and the simulated truck facility. The percentages shown at the bottom of each graph represent the amount of trucks that have diverted to the dedicated truck facility.

The first series of graphs will display the lane miles for mainline I-80 and truck only facilities. Lane mileage is useful in determining when HERS-ST has programmed additional capacity improvements to a corridor. An initial sensitivity analysis of a simulated truck facility on the I-80 corridor was executed with one travel lane in each direction. HERS-ST programmed a second travel lane in each direction by doubling the lane miles in the first funding period. Because HER-ST suggested that truck only facility be immediately improved to a four-lane cross section, in future analyses the truck only facility was assumed to be a four-lane facility from the initial period.

A lane mile can be defined as the summation of the distance measurements of each traveled lane on a multi-lane facility. Analyzing the lane mileage by funding period is useful in this thesis because this indicates when HERS-ST has programmed capacity improvements as a response to increased traffic volumes and congestion. Figure 4.1 depicts the lane miles for the general-purpose lanes throughout the twenty year analysis period.

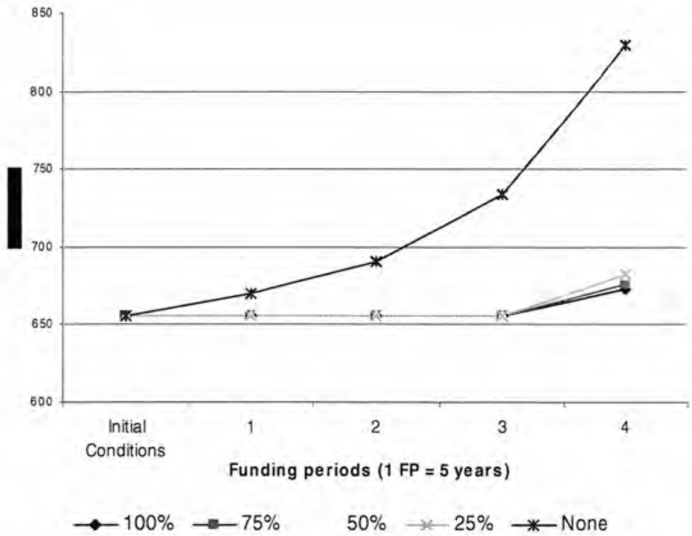

Figure 4.1 Lane mileage for general-purpose lanes with various percentages of diversions to a truck only facility for a twenty year HERS-ST analysis period

In Figure 4.1, the general-purpose lanes begins as a four lane freeway and additional lane miles have not been programmed until the third funding period (fifteen years) after the beginning of the HERS-ST analysis. The scenario that does not consider a dedicated truck facility indicates that continual capacity improvements will be required throughout the duration of the HERS-ST analysis on the general purpose lanes I-80 corridor because all combination unit trucks will be traveling on the general-purpose lanes. Following the fourth funding period in HERS-ST, 145 miles of the 164 mile corridor are reconstructed as a six lane freeway. Figure 4.1 shows that diverting combination trucks to a truck facility will not necessitate capacity improvements until the end of the third funding period (fifteen years) in

HERS-ST. Figure 4.2 shows the lane miles for the simulated dedicated truck facility with various percentages of diversions from the general-purpose lanes I-80 corridor.

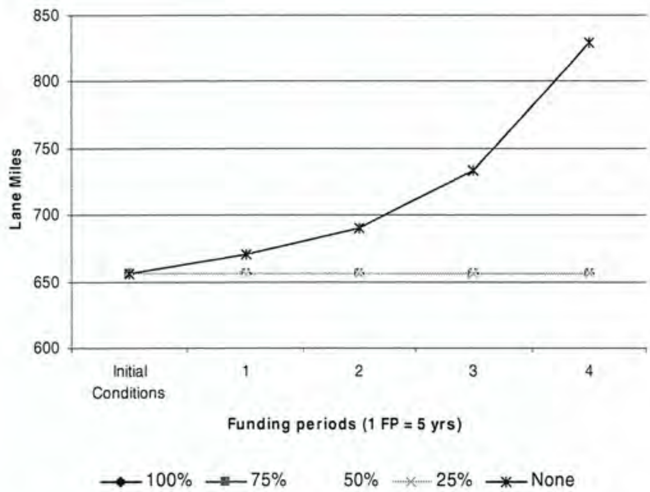

Figure 4.2 Lane mileage for the simulated truck only facility with various percentages of diversions from the general-purpose lanes for a twenty year HERS-ST analysis period

It is evident from Figure 4.2 that capacity improvements would not be required for the truck only facility throughout the twenty year HERS-ST analysis.

The following tables present the crash totals from the HERS-ST analysis for various percentage diversions of trucks to the simulated truck facility. Table 4.1 compares the annual number of crashes, injuries and fatalities as estimated by the HERS-ST analysis for the mainline I-80 corridor.

Table 4.1 Estimated average annual crash totals for the mainline I-80 corridor as estimated through the HERS-ST analysis

	100%	*75%*	*50%*	*25%*	*Six lane reconstruction*
Crashes	314	364	386	423	461
Injuries	106	123	130	143	156
Fatalities	4	4	5	5	6

It is evident from Table 4.1 that the number of crashes increases with smaller diversions of trucks to the dedicated truck facility. A reduction in all crashes can be observed on the simulated truck facility when smaller percentages of trucks travel on the simulated truck facility. The previous tables show that fewer crashes are possible when percentages of trucks are diverted from the mainline I-80 to a dedicated truck facility.

Table 4.2 presents the total delay for the general-purpose lanes in hours for a twenty year HERS-ST analysis for several diversion scenarios to a dedicated truck facility.

Table 4.2 Total delay (in hours) for the general purpose lanes on the I-80 corridor throughout a twenty year HERS-ST analysis

100% diversion	*75% diversion*	*50% diversion*	*25% diversion*	*Six lane reconstruction*
131,686,000	191,658,000	810,602,000	981,442,000	1,461,368,000

It is evident from Table 4.2 that the scenarios that consider a larger diversion of combination units to a dedicated truck facility experience fewer hours of delay per vehicle over the twenty year HERS-ST analysis. The six lane reconstruction scenario has the highest level of delay in the HERS-ST analysis because all combination unit trucks are traveling with other vehicles on the general-purpose lanes.

Average speed data was reviewed in HERS-ST, and the analysis indicated that there would be no reduction. The speed limit was set to 70 mph in the parameter file and average speeds were reported above the posted limit in every funding period in the HERS-ST analysis. Since severe crashes that affect the average speed of all vehicles is relatively uncommon on a rural interstate corridor, the delay levels have not affected the average speed in the HERS-ST analysis.

The HERS-ST analysis provided an estimation of future operating conditions if a dedicated truck facility was constructed on the I-80 corridor in Iowa. When combination trucks were removed from the mainline of I-80, the total crashes decreased modestly. Total delay was reduced substantially when trucks were removed from the general-purpose lanes. It was evident from the HERS-ST analysis of the simulated truck facility that one travel lane could not effectively handle any of the diversion analyses due to the large number of trucks that travel the I-80 corridor. While the scenario that did not consider a dedicated truck facility recommended a six lane freeway for most of the I-80 corridor, the truck only facility scenarios required an alignment that included a four-lane general purpose roadway and a four lane truck facility. Because a dedicated truck facility does not exist of this magnitude, these forecasts have a high degree of uncertainty. The situation where trucks are separated from other vehicles produces an unknown set of operating characteristics that HERS-ST cannot be expected to accurately forecast.

4.3 Dedicated truck facility benefit to cost analysis

A twenty year benefit to cost analysis was calculated in Microsoft Excel from 2006 through 2027. The HERS-ST analysis offered an estimation of the safety and operating characteristics of a rural interstate highway with a truck only facility, but the benefit to cost analysis will determine the economic validity of constructing a highway for trucks. Additional guidance on the methods utilized in computing the benefit to cost analyses can be referenced in Appendix B. An annual traffic growth rate of two percent was used combination trucks and a growth rate of one percent was used for other vehicles for all scenarios because it is anticipated that truck traffic along the corridor would double in thirty years. The traffic growth rates were obtained from the Iowa DOT, Office of Systems Planning. The percentages are derived from recent growth rate calculations for combination truck traffic on the I-80 corridor in Eastern Iowa. In the benefit to cost analysis, separate crash costs and travel costs were calculated for the following scenarios:

- 100 percent of combination trucks divert to a truck only facility
- 75 percent of combination trucks divert to a truck only facility
- 50 percent of combination trucks divert to a truck only facility
- 25 percent of combination trucks divert to a truck only facility

Within the benefit to cost analysis for the general-purpose lanes I-80 corridor, car and combination unit AADT counts were calculated for each truck diversion in the sensitivity analysis. From the AADT counts for each vehicle class, travel costs were calculated from vehicle miles traveled (VMT) and vehicle hours traveled (VHT) by using the following equations:

$$\text{VMT} = \text{AADT} * \text{Corridor length in miles} * 365$$

$$VehicleHoursTraveled = AADT * \frac{CorridorLength}{AverageSpeed} * 365$$

In both facility scenarios, the VMT and VHT were used to calculate crash costs and travel costs. The crash costs represented property damage, injury, and fatality crashes multiplied by a respective crash rate for each severity ranking. Table 4.3 displays the cost of crashes by severity that is obtained from the Iowa DOT Office of Traffic and Safety.

Table 4.3 Crash cost by severity, Iowa DOT

Fatal Crash Cost	$1,200,000
Injury Crash Cost	$48,000
PDO Crash Cost	$6,500

The HERS-ST crash rates were not used in the benefit to cost analysis because the Safety Performance Functions used in HERS-ST assume mixed traffic and cannot forecast crashes frequencies accurately for conditions (truck only lanes) that HERS-ST was not calibrated to model. Instead, actual crash experience on I-80, along with the assumption that separating trucks from automobiles will reduce or eliminate crashes involving the interaction of trucks and automobiles, are use to project crash rates under vehicle separation scenarios.

Crash rates by severity were calculated for crashes that involved a car and a truck using actual crash data for the three year period from 2002 through 2004. Each type of crash was reduced by 25 percent for each truck diversion. Hence, the 75 percent truck diversion would have 50 percent fewer car-truck crashes than the 25 percent diversion scenario. The total amount of crashes for each severity level was divided by the VMT per year. Then, the total number of crashes in each category was recalculated and an overall crash rate was developed. A linear approach was utilized in reducing crashes due to the uncertainty in the crash relationships when trucks have been separated from other vehicles. The equation that was used to calculate the severity rates for each scenario is shown below.

$$CrashRate = \left(\frac{VMT * 100{,}000{,}000}{Crashes * 3 * 365} \right)$$

For each severity, the number of occurrences was entered as ‘crashes.’ Because the nature of crash occurrences is unknown when percentages of trucks divert to a dedicated facility, the number of crashes involving both cars and trucks was incrementally reduced by 25 percent for each diversion. Table 4.4 depicts the modified crash rates for each percentage of diverted combination units to the truck only facility.

Table 4.4 Modified crash rates for all vehicles based on several truck diversion scenarios

Facility Type	*Property Damage Only*	*Injury*	*Fatal*
No truck lanes	33.10	11.81	0.48
25% truck diversion	31.39	11.01	0.45
50% truck diversion	29.67	10.20	0.41
75% truck diversion	27.95	9.40	0.36
100% truck diversion	26.24	8.60	0.33

Table 4.4 shows that all crash rates have reduced with a diversion to a dedicated truck facility. Due to the fact that there are few truck only highways in existence in North America, there is a high degree of uncertainty in the crash relationships within vehicle types once cars and trucks have been separated. A linear method of reducing all crashes was used to estimate the crash rates. This involved incrementally reducing the number of crashes involving at least one combination unit truck by 25 percent for each scenario.

The crash costs in the benefit to cost analysis were discounted with a rate of four percent and summed to create a total throughout the four diversion scenarios within each analysis. The discount rate of four percent was used because it was the default value for HERS-ST and is a rate that is based on a national average (2). Table 4.5 depicts the calculation of the crash cost for the benefit to cost analysis.

Table 4.5 Crash cost calculation for several truck diversion scenarios

	General-purpose lanes present worth	*Dedicated truck facility present worth*	*Total*
Existing I-80	$436,572,110	-	$436,572,110
25% Truck Diversion	$379,004,397	$9,906,807	$388,911,204
50% Truck Diversion	$361,069,638	$14,100,380	$375,170,019
75% Truck Diversion	$343,134,879	$18,293,953	$361,428,833
100% Truck Diversion	$318,643,665	$22,487,527	$341,131,191

The VMT and crash rates from Table 4.3 were used to calculate the fatal, injury, and PDO rates for each truck diversion scenario and the existing conditions. The crash cost was calculated by multiplying the severity rates by 'the crash cost by severity values for Iowa' that are shown in Table 4.4. Both present worth fields in Table 4.5 have an annual discount rate of four percent over twenty years. The total crash cost was obtained from the summation of present worth values for the general-purpose lanes and the dedicated truck facility.

Travel costs were computed separately for the general purpose lanes and the truck only facility to determine the benefits of diverting various percentages of combination units to truck lanes on the I-80 corridor. Table 4.6 shows the unit values that were used in computing the travel costs for cars and combination trucks. These values were obtained from the parameter settings in HERS-ST to ensure uniformity in the results of the benefit to cost analysis and the HERS-ST analysis.

Table 4.6 Unit values for computing travel cost for cars and combination units

Car Operating Cost/mile	0.28
Truck Operating Cost/mile	$1.40
Car Time cost/hour	$12.42
Truck time cost/hour	$20.08
Car Occupancy	1.45
Truck Occupancy	1.08
Social Discount Rate	4%

These values were used in an equation to determine the travel cost for cars and trucks for different percentages of combination units diverted to the dedicated truck facility. The travel costs for cars and combination trucks were obtained from the equation below.

Travel Cost = car VHT (car occupancy)(car time cost/hr) + Truck VHT (truck occupancy) (truck time cost) + car VMT (car operating cost/mi) + truck VMT (truck operating cost/mi)

For the benefit to cost analysis, the travel costs were discounted with a rate of four percent and summed to create a total throughout the four diversion scenarios within the analysis. Table 4.7 shows the calculation of the travel cost for the benefit to cost analysis.

Table 4.7 Travel cost calculation for several truck diversions

	Mainline I-80 present worth	*Dedicated truck facility present worth*	*Total*
Existing I-80	$27,206,883,100	-	$27,206,883,100
25% Truck Diversion	$23,515,358,466	$3,177,590,450	$26,692,948,916
50% Truck Diversion	$19,569,482,974	$6,733,180,900	$26,302,663,874
75% Truck Diversion	$15,524,491,095	$10,099,771,350	$25,624,262,445
100% Truck Diversion	$11,097,141,416	$13,478,656,050	$24,575,797,466

The values shown in Table 4.7 were multiplied by the VMT and VHT to obtain the travel time cost. The discounted travel time cost field has applied a four percent discount rate over twenty years. The total travel time cost was obtained by summing the twenty year present travel cost values for mainline I-80 and the dedicated truck facility.

In addition to crash and travel cost calculations, assumptions were made concerning the percentage of trucks that would couple into turnpike double and triple units before using the truck only facility on the I-80 corridor. In this case, the target market for LCV operation would be the less then truck carriers (LTL) and truckload carriers (TL) that travel on the I-80 corridor. LTL carriers often carry 'food and kindred' products in addition to expedited parcel services, and these commodities can easily be consolidated as triple combination units. If a dedicated truck facility was constructed on the I-80 corridor, truckload carriers would be inclined to couple into turnpike doubles.

4.4 Results of benefit to cost analysis

This section will explain the results of benefit to cost analyses for the general-purpose lanes when percentages of combination trucks are removed. The benefit to cost analysis that was computed for the general-purpose lanes involved the comparison of total user costs of the corridor conditions where the planned six-lane cross section is built (null option) versus those conditions where a percentage of combination trucks have been diverted to a dedicated truck facility and the general-purpose lanes are reconstructed with a four-lane cross section. The benefit to cost analysis considers marginal facility cost differences and road user costs for the scenarios that consider a truck only facility as well as the six lane improvement option. The total user costs are a summation of the total crash and travel costs for each scenario. The benefits for each scenario are calculated by subtracting the total user cost of the scenario from the total user cost of the planned six-lane cross section.

The construction cost data were obtained from the Iowa DOT office of pre-design. The total costs represent the construction of a new four lane limited access facility (dedicated truck facility) and the reconstruction of all structures on I-80 with the amount of reserved right of way to expand the general-purpose lanes sections to three lanes in each direction. The Iowa DOT has intended to reconstruct the structures along the I-80 corridor because they have reached the end of their useful life, and they intend to incorporate capacity improvements with the improvements to the structures to lessen the potential delay caused by multiple construction projects staged at different times. The added cost of reconstructing the structures on the I-80 corridor to handle an additional travel lane has been factored into the total improvement cost.

A twenty year maintenance and operating cost was obtained from the Iowa DOT office of Maintenance. It was estimated that the Iowa DOT would spend 73,983,597 dollars maintaining both facilities over a twenty year period. This cost was discounted over twenty years at four percent. The maintenance and operating cost includes snow removal, line painting, crack sealing, and sign maintenance. The maintenance and operating cost was added to the capital cost to produce a total cost of 1,618,266,746 dollars for the construction of four general-purpose lanes (with right-of-way to expand to six-lanes) and a four-lane truck only roadway. The cost of constructing marshalling yards to couple trucks into LCVs was not included in the capital cost. An incremental benefit to cost analysis is used to calculate the economic feasibility of new configuration where the costs to reconstruct the I-80 corridor to a six-lane cross section was compared to the cost of constructing a four-lane general-purpose faculty plus a dedicated truck facility. The result of the benefit to cost analysis conducted for the corridor improvements when several percentages of combination units divert to the truck only facility is shown in Table 4.8.

Table 4.8 Benefit to cost Analysis for the I-80 corridor when percentages of combination trucks divert to a dedicated truck facility

	Travel Costs	*Crash Costs*	*Total User Costs*	*Benefit*	Cost	B/C
six lane reconstruction	$27,206,883,100	$436,572,110	$27,643,455,210		$1,137,734,941	
25% truck diversion	$26,679,473,823	$356,567,365	$27,036,041,187	$607,414,022	$1,618,266,746	1.26
50% truck diversion	$26,627,802,217	$334,243,381	$26,962,045,598	$681,409,612	$1,618,266,746	1.42
75% truck diversion	$26,599,064,996	$315,696,334	$26,914,761,330	$728,693,880	$1,618,266,746	1.52
100% truck diversion	$25,863,239,951	$254,430,872	$26,117,670,822	$1,525,784,388	$1,618,266,746	3.18

It is evident from Table 4.8 that each of the truck diversion scenarios results in benefits that exceed the cost of the improvement. The six lane reconstruction is viewed as the null option for comparison to all other scenarios. Travel cost savings comprise the largest portion of the benefits from reduced delay. The 100 percent diversion of combination units to the dedicated truck facility produced the highest benefit to cost ratio because crashes between cars and trucks were non-existent. While the 100 percent truck diversion results in the greatest benefits, transportation policy must be changed to effectively "force" all combination trucks to use the dedicated truck facility. The cost of 1,618,266,746 dollars represents an approximate cost of reconstructing the structures and building the truck only highway along the 164 mile corridor of I-80. Table 4.9 shows the benefit to cost ratio of the various diversions if the cost of all improvements was increased to 1,700,000,000 dollars. This number was chosen because it was determined to be the breakeven point where the 25 percent truck diversion would have a benefit to cost ratio that was greater than 1.0. This sensitivity cost analysis provides a margin of error if the capital cost of constructing the facility is more than 1,618,266,746 dollars.

Table 4.9 Sensitivity cost analysis for the construction of a dedicated truck facility

	Travel Costs	*Crash Costs*	*Total User Costs*	*Benefit*	*Cost*	*B/C*
six lane reconstruction	$27,206,883,100	$436,572,110	$27,643,455,210		$1,137,734,941	
25% truck diversion	$26,679,473,823	$356,567,365	$27,036,041,187	$607,414,022	$1,700,000,000	1.08
50% truck diversion	$26,627,802,217	$334,243,381	$26,962,045,598	$681,409,612	$1,700,000,000	1.21
75% truck diversion	$26,599,064,996	$315,696,334	$26,914,761,330	$728,693,880	$1,700,000,000	1.30
100% truck diversion	$25,863,239,951	$254,430,872	$26,117,670,822	$1,525,784,388	$1,700,000,000	2.71

This sensitivity cost analysis shows that benefit to cost ratios above 1.0 are possible with an increased capital cost. The next section of this chapter will include a sensitivity analysis where LCV operation is compared against the base operating conditions.

4.5 LCV Sensitivity Analysis

A sensitivity analysis was conducted within the dedicated truck facility benefit to cost analysis to compare the potential benefits of coupling LTL and truckload into turnpike doubles and triples. The baseline percentages that were used in the benefit to cost analysis was based on the assumption if LCV operation was allowed on a dedicated truck facility then five percent of the truckload carriers would couple their loads into turnpike doubles and five percent of LTL carriers would couple into triples. Additional scenarios were created to determine the additional travel and crash savings possible from LCV allowance on the dedicated truck facility. The following benefit to cost analyses was executed as sensitivity analyses:

- *Scenario one*: Five percent of truckload carriers will couple into turnpike doubles and five percent of LTL carriers will couple into triples.
- *Scenario two*: Ten percent of truckload carriers will couple into turnpike doubles and ten percent of LTL carriers will couple into triples
- *Scenario three*: Fifteen percent of truckload carriers will couple into turnpike doubles and fifteen percent of LTL carriers will couple into triples

Table 4.10 presents the results of the benefit to cost analysis for scenario one.

Table 4.10 Benefit to cost analysis for scenario one

	Travel Costs	*Crash Costs*	*Total User Costs*	*Benefit*	*Cost*	*B/C*
Six lane Reconstruction	$27,206,883,100	$436,572,110	$27,643,455,210		$1,137,734,941	
25% Truck Diversion	$26,692,948,916	$388,911,204	$27,781,860,120	$561,595,090	$1,618,266,746	1.17
50% Truck Diversion	$26,302,663,874	$391,184,666	$26,693,848,540	$949,606,670	$1,618,266,746	1.98
75% Truck Diversion	$25,624,262,445	$361,428,833	$25,985,691,278	$1,657,763,932	$1,618,266,746	3.45
100% Truck Diversion	$24,575,797,466	$341,131,191	$24,916,928,657	$2,726,526,553	$1,618,266,746	5.67

By coupling five percent of truckload carriers into turnpike doubles and five percent of LTL carriers into triples, 148 fewer combination units traveled on the dedicated truck facility. This led to additional savings in crash and travel costs. Table 4.11 presents the results of the benefit to cost analysis for scenario two.

Table 4.11 Benefit to cost analysis for scenario two

	Travel Costs	*Crash Costs*	*Total User Costs*	*Benefit*	*Cost*	*B/C*
Six lane Reconstruction	$27,206,883,100	$436,572,110	$27,643,455,210		$1,137,734,941	
25% Truck Diversion	$26,638,616,879	$388,283,692	$27,026,900,571	$616,554,639	$1,618,266,746	1.28
50% Truck Diversion	$26,215,999,800	$391,003,177	$26,607,002,977	$1,036,452,233	$1,618,266,746	2.16
75% Truck Diversion	$25,494,266,334	$361,193,368	$25,855,459,702	$1,787,995,508	$1,618,266,746	3.72
100% Truck Diversion	$24,432,810,530	$340,841,750	$24,773,652,280	$2,869,802,930	$1,618,266,746	5.97

Table 4.11 summarizes the scenario where ten percent of truckload carriers coupled their loads into turnpike doubles and ten percent of LTL carriers coupled their loads into triples. Travel and crash cost savings were found in the analysis when coupling loads into double or triples reduced the AADT on the dedicated truck facility by 293 daily counts. Table 4.12 displays the results of the benefit to cost analysis for scenario 3.

Table 4.12 Benefit to cost analysis for scenario three

	Travel Costs	*Crash Costs*	*Total User Costs*	*Benefit*	*Cost*	*B/C*
Six lane Reconstruction	$27,206,883,100	$436,572,110	$27,643,455,210		$1,137,734,941	
25% Truck Diversion	$26,516,796,382	$388,204,716	$26,905,001,099	$738,454,111	$1,618,266,746	1.54
50% Truck Diversion	$26,094,358,807	$390,748,441	$26,485,107,248	$1,158,347,962	$1,618,266,746	2.41
75% Truck Diversion	$25,311,804,844	$360,862,871	$25,672,667,715	$1,970,787,495	$1,618,266,746	4.10
100% Truck Diversion	$24,146,893,081	$340,435,493	$24,487,328,574	$3,156,126,636	$1,618,266,746	6.57

Table 4.12 shows the results of the benefit to cost analysis for the scenario where fifteen percent of truckload carriers coupled their loads into turnpike doubles and fifteen percent of LTL carriers coupled their loads into triples. Scenario 3 offers the highest benefit to cost ratios for all scenarios because additional crash and travel cost savings can be found on the dedicated truck facility when additional percentages of trucks couple into turnpike double and triple combination units. Specifically, travel and cost savings increased from scenario 2 when coupling reduced the AADT on the dedicated truck facility by 439 daily counts. In summary, it is evident through the sensitivity analysis that heightened levels of freight productivity and decreased crash costs are possible when increasing amounts of truckload carriers couple into turnpike doubles and LTL carriers couple into triples on the dedicated truck facility.

If large percentages of trucks couple into turnpike doubles or triples, concern should be given to the heightened levels of pavement deterioration and bridge wear that may occur due to heavier vehicle loadings. Samuel and Poole have recommended heavy duty pavement designs for dedicated truck lanes that could withstand significant volumes of LCVs (11, p. 11).

HERS-ST was used to calculate road user travel costs. Because HERS-ST is not sensitive to the differences in performance between an LCV and standard combination tractor-trailer, there are some inaccuracies in the analysis. It was also assumed that the crash performance of LCVs would be the same as prior experience with standard combination tractor-trailers based on past experience on I-80.

Potential twenty year toll revenues

Additional toll revenue discount calculations were computed for each diversion scenario, where per-mile toll rates were used from the Kansas Turnpike to determine the potential savings of tolling trucks that used the dedicated truck facility to service the debt incurred on bonds to construct the facility. These costs were not used in the benefit to cost analysis, and they represent a transfer payment between the motor carrier firm and operator of the toll facility. The toll costs from the Kansas Turnpike were used for trucks because I-70 is a major trans-national trucking route, it is a toll facility, and LCV operation is allowed. Table 4.13 shows the truck tolls by number of axle that were used in the benefit to cost analysis.

Table 4.13 Truck tolls by Axle per mile for 164 mile study corridor

	4 Axle	*5 Axle*	*6 Axle*	*7 Axle*	*8 Axle*	*9 Axle*
Toll per mile	$0.10	$0.15	$0.20	$0.28	$0.33	$0.36
Entire corridor	$16.40	$24.60	$32.80	$45.69	$53.89	$58.57

The tolls for the entire corridor were calculated by multiplying the toll (in cents per mile) by 164 miles. In the analysis, the revenues were calculated based upon the diversion percentages established in the previous sections. Table 4.14 shows the twenty year toll revenues if combination units were tolled on the dedicated truck facility for scenario one where five percent of truckload carriers couple into turnpike doubles and five percent of LTL carriers couple into triples. Figure 4.15 depicts the potential twenty year toll revenues for scenario two if combination units were tolled on the dedicated truck facility. Figure 4.16 shows the potential twenty year toll revenues if fifteen percent of LTL carriers coupled their loads into triples and fifteen percent of truckload carriers coupled their loads into turnpike doubles. The twenty year totals were discounted at a rate of four percent. The largest twenty year revenues are generated when fifteen percent of LTL carriers couple their loads into triples and fifteen percent of truckload carriers couple their loads into turnpike doubles.

Table 4.14 shows the twenty year toll revenues if combination units were tolled on the dedicated truck facility for scenario one where five percent of truckload carriers couple into turnpike doubles and five percent of LTL carriers couple into triples.

Table 4.14 Potential twenty year revenues obtained from tolling the simulated truck lanes based upon number of axles, scenario one

	4 & 5 axle	*6 axle*	*7 axle*	*8 axle*	*9 axle*	*Discounted Total*
25% Truck Diversion	$377,099,431	$14,868,422	$2,417,819	$33,144,495	$3,099,768	$430,629,934
50% Truck Diversion	$754,198,861	$29,736,843	$4,835,638	$66,288,991	$6,199,535	$861,259,869
75% Truck Diversion	$1,131,298,292	$44,605,265	$7,253,456	$99,433,486	$9,299,303	$1,291,889,803
100% Truck Diversion	$1,508,397,723	$59,473,687	$9,671,275	$132,577,981	$12,399,071	$1,722,519,737

The twenty year totals are discounted at a rate of four percent. The potential twenty year revenues for the LCVs are based on the assumption that five percent of LTL carriers would couple into triples and five percent of truckload carriers would couple into turnpike doubles. Figure 4.15 depicts the potential twenty year toll revenues for scenario two if combination units were tolled on the dedicated truck facility.

Table 4.15 Potential twenty year revenues obtained from tolling the simulated truck lanes based upon number of axles, scenario two

	4 & 5 axle	*6 axle*	*7 axle*	*8 axle*	*9 axle*	*Discounted Total*
25% Truck Diversion	$377,099,431	$14,868,422	$28,100,768	$66,288,991	$6,199,535	$492,557,146
50% Truck Diversion	$754,198,861	$29,736,843	$56,201,536	$132,577,981	$12,399,071	$985,114,293
75% Truck Diversion	$1,131,298,292	$44,605,265	$84,302,303	$198,866,972	$18,598,606	$1,477,671,439
100% Truck Diversion	$1,508,397,723	$59,473,687	$112,403,071	$265,155,962	$24,798,142	$1,970,228,585

It is evident through the increase in trucks coupling into doubles and triples that discounted toll revenues have increased from the previous totals in scenario 1. Table 4.16 presents the potential twenty year toll revenues if fifteen percent of LTL carriers coupled their loads into triples and fifteen percent of truckload carriers coupled their loads into turnpike doubles.

Table 4.16 Potential twenty year revenues obtained from tolling the simulated truck lanes based upon number of axles, scenario three

	4 & 5 axle	*6 axle*	*7 axle*	*8 axle*	*9 axle*	*Discounted Total*
25% Truck Diversion	$377,099,431	$14,868,422	$28,100,768	$99,433,486	$9,299,303	$528,801,409
50% Truck Diversion	$754,198,861	$29,736,843	$56,201,536	$198,866,972	$18,598,606	$1,057,602,819
75% Truck Diversion	$1,131,298,292	$44,605,265	$84,302,303	$298,300,458	$27,897,910	$1,586,404,228
100% Truck Diversion	$1,508,397,723	$59,473,687	$112,403,071	$397,733,944	$37,197,213	$2,115,205,637

The largest twenty year revenues are generated when fifteen percent of LTL carriers couple their loads into triples and fifteen percent of truckload carriers couple their loads into turnpike doubles.

4.6 Motor carrier user cost savings from use of the dedicated truck facility

An additional analysis was conducted to determine the financial incentive for the motor carrier industry to use the dedicated truck facility. In essence, this analysis compares the cost savings a truck operator would realize from using the dedicated facility instead of I-80 to the toll charges it would incur for using the dedicated facility. The primary cost savings are the savings that arise from travel time reduction and reduced crash risk. Additionally, it is assumed that trucks using the dedicated facility would not be assessed the state fuel tax since they would be paying a toll charge.

The toll data obtained from the Kansas Turnpike was used as an estimate of the toll charge that would be assessed for the hypothetical 164-mile dedicated facility. A five axle truck was used as an example in this analysis because this tractor-trailer configuration is the most common combination unit that currently uses the I-80 corridor. The crash reduction costs and travel time cost savings were used from the previous sections, but the cost data was modified to represent a single truck journey over the dedicated facility. The state diesel fuel tax was obtained from the Iowa DOT and aggregated over the 164 mile corridor to determine the fuel tax charges for a five axle truck over the length of the proposed corridor. The Iowa DOT imposes 0.225 cents per gallon tax on diesel fuels. Average speed data was used from the HERS-ST analysis to determine the travel cost savings for the motor carrier industry. Table 4.17 depicts the potential travel cost savings for trucks that use the dedicated facility. The unit values from Table 4.7 were used to calculate the travel time cost.

Table 4.17 Travel time cost savings calculation

	Average speed	*Travel time (hr:min)*	*Travel time cost*
Mainline I-80	69	2:23	$281.21
Dedicated truck facility	73	2:15	$278.39

The travel time cost savings indicates that it would cost a truck 2.82 dollars less to use the dedicated facility (i.e., $281.21 - $278.39). It is evident from Table 4.17 that the dedicated truck facility would produce a lower travel time and reduced travel time cost. The crash cost savings was calculated from the difference in crash cost savings between the mainline I-80 and the dedicated truck facility in HERS-ST. The average crash cost for the mainline I-80 is 38 dollars per 1000 VMT and 29 dollars per 1000 VMT for the dedicated truck facility. The crash cost savings calculations for a single, combination unit truck are listed below.

Mainline I-80: $38* (164/1000) = $6.23
Dedicated truck facility: $29 * (164/1000) = $4.76

The crash cost savings that a truck would realize from using the dedicated facility is 1.48 dollars. Table 4.18 displays the cost variables that were used in the analysis of the cost savings realized by a five axle trailer using the 164 mile tolled dedicated truck facility.

Table 4.18 Potential cost savings for a five axle truck using the dedicated truck facility

Travel time cost savings (8 minutes)	$2.82
Crash cost savings (164 miles) per 1000 VMT	$1.48
Fuel tax cost savings (164 miles)	$5.26
Total user cost savings	*$9.56*
Toll cost (5 axle)	$24.60

The total user cost savings in Figure 4.18 represents a reduction in the travel, crash, and fuel tax costs for a five axle truck traveling the entire 164 mile dedicated truck facility. Using the dedicated truck facility can be considered advantageous the motor carrier industry when the total user costs savings exceed the cost of using the facility. Table 4.18 has indicated that the total user cost savings are less than the cost of tolling a five axle truck; therefore it is not considered advantageous for the motor carrier industry to use the dedicated truck facility. The state of Iowa could require all combination unit trucks to use the dedicated truck facility, and pay the full cost of 24.50 dollars. Another option would only charge each truck 9.56 dollars, and subsidize the remainder of the toll cost through state or federal funding.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

From this research, several important conclusions can be made concerning the benefits of dedicated truck facilities on rural interstate highway corridors. Since very few truck only facilities exist in the United States, there is a significant degree of uncertainty with these assumptions. First, the descriptive analysis of crash data has shown that the diversion of a percentage of combination unit trucks to a dedicated facility may decrease the amount of car-truck collisions. Since cars and other vehicles are at fault in the majority of collisions involving at least one truck, the number of crashes on the general-purpose lanes may not decrease as dramatically as it may with truck only facilities. Second, the HERS-ST analysis has shown that the scenarios that consider a diversion to a dedicated truck facility offer safer operating conditions with greater benefits to freight productivity than the scenario that does not consider a dedicated truck facility. Third, the HERS-ST analysis has shown that capacity improvements would not be necessary for the general purpose lanes I-80 corridor if a dedicated truck facility was constructed and at least 25 percent of the combination unit trucks diverted from the general purpose lanes to this facility. Fourth, the benefit to cost ratios was greater than 1.0 when at least 25 percent of the combination units on the I-80 corridor diverted to the dedicated truck facility. Travel cost savings produced the largest portion of the benefits in the analysis. Additional benefits were accrued when successive percentages of truckload carriers couple their loads into turnpike doubles and truckload carriers couple their loads into triples. Incentives may need to be granted to motor carrier companies that use the dedicated truck facility and couple their loads into LCVs.

5.2 Recommendations

While this thesis is intended to be an academic exercise to partially fulfill the requirements of a master's degree, it is also intended to be used by the Iowa DOT as a guide for future capacity improvements along the I-80 corridor. This research has shown that a dedicated truck facility may improve the safety, operations and freight productivity on the I-80 corridor for all vehicles, but the capital costs of constructing and maintaining such a facility would be too large for the Iowa DOT to bear alone. Therefore, an alternative financing structure would have to be created, possibly a public-private partnership or concessionaire would be the most feasible option to finance the construction of this facility. A public-private partnership would award the contract to plan, design, build, and operate the dedicated truck facility for a set time period before turning it over to a state DOT. Debt would be serviced through an automated truck tolling system.

In order for the state of Iowa and the Iowa Department of Transportation to undertake this initiative, several policy and legislation changes would be required. Policy would need to be modified to allow tolling on state owned highways in Iowa. Legislation would need to be changed to allow private ownership of highways in Iowa if a concessionaire were to finance the construction of a dedicated truck facility. Traditionally, the state of Iowa has adopted a 'pay as you go' philosophy with transportation infrastructure projects. While the state of Iowa does allow revenue bonding for capital projects, the Iowa DOT has not used this financial strategy. Iowa DOT policy would need to be modified to allow the use of bonds to finance transportation infrastructure projects. Additional legislation could be enacted by the state of Iowa to require that all combination trucks that travel on the I-80 corridor use the dedicated truck facility. Given that the proposed design calls for an interchange on the dedicated facility at each location where an interchange exists today, the trucking industry would be provided an equivalent level of access after being restricted to the dedicated facility.

Further research is required in determining the safety and operating conditions of dedicated truck facilities on rural interstate corridors. Similarly, additional research on the safety and operating characteristics of a general purpose-lanes interstate corridor after combination trucks have been diverted to a truck only facility would be useful.

APPENDIX A: Benefit and cost variables related to the construction of a dedicated truck facility

This appendix explains the benefits and costs of constructing a truck only facility according to the reviewed literature.

Benefits of truck only facilities

- Freight industry savings
  - Reduced operating costs
    - Labor, fuel, maintenance
  - Travel time savings
  - LCV operation

- User cost savings
  - Reduced delay
  - Fewer crashes
  - Reduced energy consumption
    - Reduced emissions

Costs of truck only facilities

- Costs will vary by facility design
  - Construction
  - Maintenance and operating cost
  - Right of way acquisition

Financing

- Alternative funding mechanisms required to finance truck only facilities
  - Public-private partnership
  - Concessionaire
  - Tolling to recover capital costs of constructing the truck only facility

APPENDIX B: Methodology used in calculating the benefit to cost analysis

This appendix explains the methodology of computing the benefit to cost analyses in for the general purpose lanes I-80 corridor when percentages of combination units have been removed and for the dedicated truck facility. Microsoft Excel was used to develop the benefit to cost analyses. Each benefit to cost analysis was developed by using different spreadsheets with multiple worksheets. A baseline worksheet was created initially with an AADT breakdown by vehicle type, and these figures were used to calculate VMT and VHT for trucks and other vehicles.

For the sensitivity analysis, successive percentages of combination trucks were subtracted from the baseline truck AADT based on assumptions of percentages of truckload and LTL carriers that would couple into turnpike doubles and triples. Separate spreadsheets were utilized to calculate the crash costs and travel time costs for each scenario in the sensitivity analysis. Potential generated revenues from tolling trucks were calculated for each scenario by multiplying the AADT per number of axles by the cost per mile data that was obtained from the Kansas Turnpike website. A cost summary worksheet was developed where the total crash and revenue totals for each scenario were added together. The benefits were calculated for each scenario in the benefit to cost analyses by subtracting the total user costs for the given scenario from the total user costs from the existing conditions on I-80 corridor. In summary, Microsoft Excel offered additional levels of flexibility that were not possible with HERS-ST.

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