ANALYSIS OF ROADWAY SAFETY UNDER ALTERNATIVE PROJECT DELIVERY SYSTEMS

FINAL PROJECT REPORT

by

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16. Abstract

In the United States, most highway projects have been with using the traditional design-bid-build delivery system. Moving on to regular conditions assessment, maintenance of a road is then performed on the basis of the availability of funds and the priorities established for road maintenance. When maintenance funds are scarce, serviceability of roads is impacted, which affects road safety. The alternative project delivery systems, such as design-build-operate-maintain, design-build-finance-operate-maintain, and other public-private partnership (PPP) models, provide for more consideration of the life cycle of highways. Particularly under performance-based long-term contracts, which are the norm for PPP systems, road maintenance and performance become controlling parameters in compensating contractors for their work. With serviceable, well maintained roads, it is expected that road safety records will improve.

Through content analysis of PPP procurement documents and agreements, this research investigated PPP projects for their contractual safety terms, such as the design of safety payments, measurements, and safety specifications. Through statistical analysis, the research surveyed PPP projects' roadway safety records and compared them with the safety records of states, localities/cities, and public non-PPP highways. The findings showed that safety rates for PPPs are better than those of traditionally delivered highways, but not on all dimensions. This was represented by better (lower) injury and accident/crash rates on PPP projects than those rates for state, locality, and public non-PPP projects. However, the fatality rates on PPP projects experienced instability or fluctuation, as they did not remain lower in all years and/or on all projects in comparison to public non-PPP projects (PPP fatality rates were better in comparison those of states and localities). Additionally, this study found that PPP projects did not provide more consideration for safety beyond that normally available from traditional delivery. Safety was an objective in most (76 percent) of the projects; however, without proactive mechanisms to implement that objective. Around half of the projects mentioned safety as part of the proposal evaluation, but only two projects assigned points or weights in the evaluation. None of the projects provided ways tolink the contractors' compensation to achievement of better accident/fatality/injury rates of the projects.

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List of Abbreviations

AADT; Average annual daily traffic
AAR: Actual accident rate
BAB: Build America Bonds
BCMOT: British Columbia Ministry of Transportation
CBA: cost-benefit analysis
DBB: Design-bid-build
DBFOM: Design-build-finance-operate-maintain
DBOM: Design-build-operate-maintain
FARS: Fatality Analysis Reporting System
GARVEEs: Grant Anticipation Revenue Bonds
GEB: Golden Ears Bridge
GHSA: Governors Highway Safety Association
HSIP: Highway Safety Improvement Program
MVMT: Million vehicle miles traveled
NCHRP: National Cooperative Highway Research Program
NCSL: National Conference of State Legislatures
NHTSA: National Highway Traffic Safety Administration
OLB: Okanagan Lake Bridge
PAB: Private Activity Bonds
PacTrans: Pacific Northwest Transportation Consortium
PPP: Public-private partnership
RFP: Request for proposal
RI: Risk index
RFQ: REques for quotation
SIB: State Infrastructure Banks
STRR: Surface Transportation Reauthorization and Reform Act
STS: Sea to Sky Highway
TIFIA: Transportation Infrastructure Finance and Innovation Act
VMT: Vehicle miles traveled
WSDOT: Washington State Department of Transportation
SHSO: State Highway Safety Offices

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Executive Summary

Roadway safety is an important aspect of reliable and safe transportation systems. Poor roadway design and poor pavement conditions are among the factors that can render a highway unsafe, increasing the numbers of accidents, injuries, and fatalities. Successes in achieving safety goals have been reached through advancement in engineering dimensions (e.g., better structural design). However, little attention has been given to investigate other ways to improve roadway safety performance. While several studies have shown the potential of public-private partnerships (PPP) for improving cost efficiency and expediting delivery time, research on the relationship between roadway safety and PPP has not looked at contractual terms and safety performance. To fill the gap between PPP and roadway safety performance in the U.S., the objectives of this research were twofold. One was to identify whether there are any differences in traffic safety performance between PPP roads and traditional, publicly operated roads. That is, this project investigated the roadway safety status (e.g., the number of accidents, fatalities, and injuries) of projects that were delivered using PPPs by looking at the average roadway safety of the localities (e.g., city, county, or state) of the projects and comparing them to a comparable set of roads, in the locality of the PPP projects, that were delivered by traditional means (e.g., design-bid-build). Another research goal was to investigate the contractual terms related to roadway safety of transportation PPP projects in the U.S. and to develop recommendations for public agencies to articulate operation-related contractual terms for safety improvement.

For the first goal of this research, safety data (e.g., number of fatalities) were analyzed to determine the safety performance differences between PPP projects and state roads. Safety data from 2011 to 2015 were collected, including fatality, injury, and crash rates, and the traffic data were aggregated into four groups: PPP highways (11 operational PPP projects), the

localities/cities (11 counties/cities of the selected PPP projects), comparable public non-PPP projects group (17 highways in the same localities as the PPP projects), and states (five states with the selected PPP projects). Four-level statistical analysis was consulted to check the difference of means, analogies, correlations, and the statistical significance of the results. These included the following:

- a broad group comparison of the annual means/averages of the safety rates (fatality, injury, and crash rates) of each group over the study period,
- individual project comparisons in which the annual safety rates of each PPP project were compared to comparable rates from local non-PPP highway projects, those of its locality/city, and those of its state,
- individual project comparisons in which the average over the available years from 2011 to 2015 was compared to the averages of local non-PPP highway projects, those of its locality/city, and that of its state, and
- testing of the hypothesis that the PPP group safety performance was better than that of the state level group, locality/city-level group, and the non-PPP project-level group.

The findings showed that safety rates for PPPs were better than those of traditionally delivered highways, but not on all dimensions. This was represented by the better (lower) injury and accident/crash rates on PPP projects than those of state, locality, and non-PPP projects. However, the fatality rates for PPP projects experienced instability or fluctuation, as they did not remain lower in all years and/or for all projects in comparison to the public, non-PPP projects (PPP fatality rates were better in comparison to those of states and localities).

For the second goal of the research, content analysis of PPP procurement and contractual documents was the major method used to investigate how safety is managed in current U.S. transportation PPP projects. The work included analysis of 17 target projects in eight states, including three in Florida, two in California, four in Texas, four in Virginia, and one each in Indiana, Puerto Rico, Colorado, and Illinois. The study found that PPP contracts in the United States did not provide expanded consideration of safety beyond what was normally available in traditional project. Safety was an objective in most (76 percent) of the projects; however, the project did not have proactive mechanisms to implement this objective. Around half of the projects mentioned safety as part of the proposal evaluation, but only two projects had assigned points or weights for evaluation. None of the projects provided ways to link the contractors' compensation to achievement of better accident/ fatality/injury rates; there were no core safety payments and no safety incentives. Case studies of safety-related contractual terms in Canadian projects were also evaluated. This report provides recommendations to achieve safety goals through PPP contractual terms that would link contractors' compensation to the achievement of roadway safety improvements.

Improvement in road safety is an important objective for all highway agencies. There are multiple ways to address safety improvement, and this research addressed a dimension that had not been addressed before. When a safety objective is ranked high for a highway, it is important for decision makers to determine the delivery systems that could be used to improve the safety record. This research recommends PPP contractual safety measures to use in managing safety in the long term. State/city/county managers or other stakeholders should find the outcome useful in obtaining more information about the relationship between safety, maintenance, and delivery systems. This will help them in setting priorities for road maintenance and in choosing delivery systems. This research should be considered as an initial step toward a more substantial analysis that would segregate the states' safety data into groups, e.g., in clustered analysis, which would recognize the design-bid-build system and other traditional systems, along with the historical maintenance records for the highways.

Chapter 1 Introduction

1.1 General Background

Roadway safety is an important aspect of reliable and safe transportation systems. There are several factors that render a highway unreliable or unsafe in terms of the number of injuries and fatalities, including driving behavior, roadway design or engineering, and poor pavement conditions. To reduce injuries and fatalities, state and federal agencies have continuously worked to improve roadway safety. For example, the Federal Highway Safety Improvement Program (HSIP – http://safety.fhwa.dot.gov/hsip/) was developed in 2005 following to The Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU). HSIP was continued as a core federal-aid program following the Moving Ahead for Progress in the 21st Century Act (MAP-21). HSIP provided funds for safety improvement projects to reduce traffic fatalities and injuries on all public roads.

From an engineering dimension, research focused on the engineering aspects of highway safety is abundant. For example, Persaud (2001), in a study for the National Cooperative Highway Research Program (NCHRP), tried to establish a relationship between crashes and associated factors, identifying locations for treatments and evaluating the safety effects of engineering improvements. Persaud studied the statistical tools used in safety analysis and surveyed states for their highway safety analysis practices. Other safety engineering work has included, for example, the FHWA 2010 Highway Safety Manual and the FHWA's Interactive Highway Safety Design Model. Jo et al. (2011) developed a decision support system framework to help highway agencies in developing cost-effective safety improvement projects.

In addition to engineering facors, roadway safety can be related to how well roads are maintained. Roads with pavement cracks, rutting, potholes, and the other pavement distresses and deficiencies can lead to highway traffic accidents. It is fair to assume that safe roads with fewer collisions/accidents have received sufficient funding for road maintenance. Funding for maintenance is available through state tax revenues. Following MAP-21 and the HSIP program, federal funds for safety projects were also allocated to the states, and through HSIP reporting requirements, states had to show that the allocated funds contributed to improving safety and reducing fatalities and injuries. In Washington state, the HSIP report showed that HSIP program funds were divided into 70 percent for local safety projects and 30 percent for state highway safety projects (Washington State 2014). With shortages of state funds, and based on road conditions, roads and highways in any state may have to compete against other projects to obtain sufficient and timely funding for maintenance.

Alternatively, road maintenance and financing may be provided as part of a contractual delivery system in which certain delivery routes are selected. For instance, some of the available public-private partnerships (PPP) models, such as design-build-operate-maintain (DBOM) and design-build-finance-operate-maintain (DBFO), provide for both financing and maintenance (FHWA 2015; Abdel Aziz 2007a, 2007b). In the United States, the use of such PPP procurement models has been on the rise, and around 33 states have authorized the use of PPPs. Furthermore, the federal government has provided for several credit facilities to encourage states to use PPPs, including TIFIA loans (Transportation Infrastructure Finance and Innovation Act), GARVEEs (Grant Anticipation Revenue Bonds), Build America Bonds (BABs), Private Activity Bonds (PABs), State Infrastructure Banks (SIBs), and Section 129 loans. The 2012 federal authorization, Moving Ahead for Progress in the 21st Century Act (MAP-21) strongly encouraged states to use PPPs by allowing tolls on interstate highways, which had been forbidden previously. Furthermore, the newest 2015 federal authorization, the Surface

Transportation Reauthorization and Reform Act (STRR), pushed for a strong relationship between all levels of government and the private sector and provided for the establishment of the National Surface Transportation and Innovative Finance Bureau to help state, local, and private sector partners move transportation projects forward. STRR promoted private investment in our surface transportation systems.

Several of the DBFOM projects in British Columbia have adopted PPP contractual agreements that emphasized roadway safety in their contracts. Examples include the Sea-To-Sky (STS) highway, the Okanagan Lake Bridge (OLB), and the Golden Ears Bridge (GEB) (Abdel Aziz 2007a). The agreement for the STS provided part of the contractor compensation/incentive to be tied to improvements in the highway safety index. For the OLB and GEB projects, safety payments were part of the compensation for the contractor (the other payments included availability payments, traffic volume payments, and user satisfaction payments). Similar provisions can be used in U.S. PPP projects, and this research investigated these issues.

While there several studies have showed the potential of PPPs for improving cost efficiency and expediting the delivery time, studies on the relationship between roadway safety and PPP are missing with regard to contractual terms and safety performance. This research tried to fill this gap. Establishing that safety would improve if particular project delivery systems were used would provide decision makers with possible systems to choose from when safety was of major concern or when safety was one of the main objectives of a project. The outcome of this research will benefit highway agencies by providing officials and decision makers with a comprehensive account of how safety can be managed through contract terms that link contractors' compensation to improvements in the safety records of the projects.

1.2 Research Objective

Roadway safety performance of highway projects developed under alternative delivery systems with regard to contractual safety terms has been scarcely analyzed. The implementation of PPP projects is expected to affect the safety performance of roads, but the strength of the relationship between delivery method and safety performance is unknown, which makes it difficult to evaluate PPP beyond cost and time performance. The need to ensure long-term safety performance on a highway may require decision makers to use an alternative delivery system rather than a traditional one.

The objectives of this research included the following:

1) Identify whether there is a relationship between roadway safety and the project delivery system. That is, investigate the roadway safety status (*e.g.,* collisions, fatalities, injuries) of projects that were delivered with PPP delivery systems (*e.g.,* DBOM, DBFO-Real Toll, DBFO-Availability, *etc*.) and compare it to that of normal or average roadway safety in the localities/cities of the projects.
2) Investigate the contractual terms related to roadway safety of PPP projects and develop best practices or lessons. For example, investigate the contractual terms related to the following:
    a. Safety measures or specification
    b. The design of safety payments or compensation for safety improvement
    c. Penalties/deduction systems.

1.3 Key Research Methodology

To achieve the research objectives, a number of research tasks were designed and followed. These tasks are summarized as follows:

- Task 1 – Identification of Target States: This task identified a set of target states for study purposes on the basis of a number of selection criteria. According to the selected target states, a number of representative PPP transportation projects were identified as the target projects.
- Task 2 – State Roadway Safety Data Collection: General safety data (*e.g.,* total crashes, fatalities, injuries, *etc.*) were collected from the target states identified in Task 1. These data were used to establish the norm or average safety performance indexes or collision/accident statistics, which were used to represent the benchmarks for measuring and comparing the safety statistics of the PPP projects.
- Task 3 – PPP Safety Contractual Terms and PPP Roadway Safety Data Collection: Data at two levels were collected in this task. First, contractual safety provisions and safety payment/incentives were collected from the major PPP projects in the target states and the leading PPP countries, such as Canada and the United Kingdom. PPP project-level roadway safety data were collected, including safety records, collisions/crash records, and statistics from the target PPP projects selected in the target states.
- Task 4 – Analysis of Roadway Safety Data: Data collected in tasks 2 and 3 were analyzed to determine whether PPP projects would provide better safety performance than the average or benchmark.
- Task 5 – Analysis of Contractual Safety Terms: Contractual safety data collected in Task 3 were analyzed to investigate how safety was managed and accounted for, *e.g.,* safety measures, specifications, and safety payments and incentives.

Chapter 2 Literature Review

2.1 Public Private Partnership

Public-private partnership (PPP), originated in the United Kingdom, is an innovative procurement model for public sector infrastructures, facilities, and services (Yescombe 2011). It can be broadly defined as a long-term agreement, usually over 20 years, between public and private sector entities for mutual benefit (Treasury 2012). As defined by the World Bank (2016), "Public-private partnerships (PPPs) are a mechanism for government to procure and implement public infrastructure and/or services using the resources and expertise of the private sector. Where governments are facing aging or lack of infrastructure and require more efficient services, a partnership with the private sector can help foster new solutions and bring finance. PPPs combine the skills and resources of both the public and private sectors through sharing of risks and responsibilities. This enables governments to benefit from the expertise of the private sector, and allows them to focus instead on policy, planning and regulation by delegating day-to-day operations." The US Department of Transportation (USDOT 2013) had a similar definition, stating: "Public-Private Partnerships (P3s) are contractual agreements formed between a public agency and a private entity that allow for greater private sector participation in the delivery and financing of transportation projects. Typically, this participation involves the private sector taking on additional project risks, such as design, finance, long-term operation, maintenance, or traffic revenue. P3s are undertaken for a variety of purposes, including monetizing the value of existing assets, developing new transportation facilities, or rehabilitating or expanding existing facilities."

One major benefit of this alternative system is that PPP allows risks and financial pressures to be shared by seeking to involve the private sector in nontraditional areas of a project

(Yescombe 2011). Through PPP, government services can be provided by private investment instead of being funded by government taxes or other public resource (Abdel Aziz 2007b). Thus, the financial and operation risks can be allocated to the private sector. The benefits of adopting PPP were summarized by Braddon and Foster (1999), including the following: 1) reducing the role and scope of the government while inviting private sector involvement in the gap that is left; 2) creating new opportunities for private expansion into traditional areas of the public sector; 3) attracting new capital resources and investments from the private sector; and 4) spurring competition by increasing market pressures on services remaining within the government.

One of the most common ways of implementing PPPs for managing infrastructure is through a concession approach. This basically consists of transferring the final design, construction, and maintenance and operations of the infrastructure to a private consortium in exchange for the right of the private entity to receive profitable compensation by charging fees to the user or to the government on behalf of the user, which is usually regarded as a shadow toll, for a period of time contractually agreed in advance (Vassallo and Gallego, 2005). In recent projects, some states have started to use availability payments over the term of agreement to compensate the private partner regardless of whether or not tolls have been charged. The key consideration in such PPP concessions is to motivate the private sector to manage and operate the infrastructure in a proactive way (Vassallo et al. 2009). In this respect, PPP has been evolving from the traditional demand-based contract to a performance-based contract that refers to different factors such as availability of lanes, traffic congestion, state of the pavement, and safety. Under a performance based contract, the private sector receives periodic payments from the public authority during the operation and maintenance (O&M) phase, as long as the asset or facility is available for use in accordance with detailed requirements and performance standards set out in the PPP contract (FWHA 2016). For roadway safety, in a performance-based PPP concession, the public sector commonly includes incentives or assigns a specific safety payment tied to roadway safety indicators, which are used to evaluate safety performance (*e.g.,* total collisions, injuries, and fatalities per 100 VMT).

2.2 PPP Payment Mechanisms and Safety Payments

A payment mechanism is a compensation approach used to pay for the services and other efforts provided by the PPP concessionaire (Abdel Aziz 2007a). In traditional project delivery systems, such as design-bid-build (DBB), payment mechanisms provide compensation to the contractor through a construction capital payment, which is usually calculated on the basis of quantities of work, material costs, and labor and equipment hours. In a PPP performance-based contract, however, different types of payments may be implemented to achieve the different objectives of the government for a project and to motivate the contractor to offer its best performance. Common types of payments used in current PPP projects include traditional capital payment, usage/capacity payment, availability payment, operation and maintenance payment, safety payment, user satisfaction payment, quality payment, and end of term payment (Abdel Aziz 2007a). According to Abdel Aziz and Abdelhalim (2015), a payment mechanism generally includes the following: 1) a structure of different payment types (*e.g.,* a combination of availability payment, traditional capital payment, and safety payment); 2) percentage/ shar / weight of each payment in the overall mechanism; 3) a set of performance measures or indexes tied to the specific payments; 4) a deduction or penalty structure for unsatisfactory performance.

The design of the payment mechanism in the PPP should reflect the government’s particular objectives in developing the project (Treasury 2003). In the other words, a payment mechanism can be regarded as the government vehicle of achieving the project goals, such as transferring risks and certain operational responsibilities to the private sector. Different payment types in a payment mechanism will reflect the transfer of specific risks or responsibilities from the public sector to the private sector.

Safety payment is an appropriate tool when roadway safety is regarded as a significant goal for the project. A safety payment is used to compensate the concessionaire's efforts and inputs toward improving roadway safety (*e.g.,* reducing the accident rate). Such payments should be tied to safety performance and should be paid to the concessionaire only if performance meets or exceeds the required level. Safety performance can be measured with certain safety indexes (*e.g.,* deaths per 100 million vehicle miles traveled). According to Abdel Aziz (2007a), a safety payment can be implemented in several ways, such as 1) explicit payment adjusted by a comparison of actual accident statistics to those of comparable roads or to an average local rate; 2) payment deductions for unsatisfactory safety performance; 3) payment deductions for the remedial works needed to rectify safety problems. A safety payment can be used as an incentive or as a pure bonus. For example, in the Sea-To-Sky highway project in British Columbia, the contract stated, "the Concessionaire will be entitled to a safety performance payment in contract year *n* if the safety performance of the concession highway exceeds the provincial safety performance record for comparable highways on a three-year rolling average basis." Safety payments can also be regarded as a core payment in some projects. Such safety payments commonly contain a monetary punishment or deduction mechanisms. For example, in the Golden Ears Bridge project in British Columbia, the safety initiative payment is included in the payment mechanism to compensate the concessionaire's inputs to improve roadway safety. The safety payments for these projects are detailed later in this research report.

2.3 Safety Performance Measures / Indicators

Research similar to this study has been completed on the European PPP market. Some European countries, such as Spain, Finland, Hungary, Norway, Portugal, and the United Kingdom, already include a set of roadway safety incentives tied to performance indicators in PPP concession contracts (Villar and Vassallo 2014). In their analysis of PPP contracts in Europe, Villar and Vassallo (2014) observed that the indicators used to evaluate roadway safety performance were heterogeneous. The differences came from the various formulas used to transfer the initial accident data to the comparable safety indicators. The types of initial accident data commonly were total crashes, injury crashes, fatal crashes, injuries, fatalities, and combinations of the numbers of light accidents, serious accidents, and fatal accidents. Most of the PPP contracts in Europe were based on only one type of these initial data to develop the indicator. To reduce distortions in road safety results, the exposure to traffic (risk) needs to be taken into consideration when initial data are transferred to comparable indicators. Although the initial data would be selected in the same way because of various ways of introducing the exposure to traffic (risk), final indictors could be quite different. In most existing European projects, the initial accident data were divided by the volume of annual traffic, where average annual daily traffic (AADT) was an important factor for representing exposure to traffic (Vassallo et al., 2009). The two most representative safety indicators used in European PPP projects are summarized in table 2.1, including the Risk Index (RI) in comparison to similar roads and the actual accident rate (AAR) in comparison to similar roads. The first indicator measures the proportional difference between the risk index (*e.g.,* injuries related to traffic) of the road and the same risk index of similar roads or a benchmark. The second indicator uses the AAR instead of RI. AAR is calculated on the basis of different accident levels, including light accidents, serious accidents, fatal accidents, and other accidents. As such, the second indicator can assess the existence of accidents and their severity.

A set of recommendations for developing safety indicators were also proposed by Vassallo et al. (2009), including the following:

- the database used for measuring the indicator should be accessible and reliable;
- for the sake of a more comprehensive assessment, the accident severity (e.g., fatal accidents, serious injury accidents, and light accidents) should be taken into account in an indicator;
- the exposure to the traffic (risk) must be contained in the indicator;
- an appropriate period for the safety analysis should be longer than one year;
- the indicator must be simple and easily understandable.

Table 2.1 Two representative road safety indicators in European PPP contracts (Vassallo et al., 2009)

Road Safety Indicator	Risk Index (RI) in comparison to similar roads
Formula	
$$RI = \frac{num.of\ total\ injury\ crashes\ along\ one\ year \times 10^6}{length\ of\ the\ road \times AADT \times 365} \quad (2.1)$$ $$RI_{sr} = \frac{\sum_r^1 num.of\ total\ injury\ crashes\ in\ the\ current\ year\ in\ the\ similar\ road\ 'r' \times 10^6}{\sum_r^1 length\ of\ the\ similar\ road\ 'r' \times AADT\ in\ the\ road\ 'r' \times 365} \quad (2.2)$$ $$RSI = \frac{RI_{sr} - RI}{RI_{sr}} \quad (2.3)$$ where: • RSI: road safety indicator • RI_{sr}: road safety index of similar roads (injury crashes / volume of traffic; both for the year of assessment in all similar roads of the region)	

Road Safety Indicator	Actual Accident Rate (AAR) in comparison to similar roads
Formula	
$$AAR = \frac{(FA \times 130 + SA \times 70 + LA \times 5 + OA)}{length\ of\ the\ road \times AADT \times 365} \times 10^6 \quad (2.4)$$ $$RSI = AAR_{sr} - AAR \quad (2.5)$$ where: • FA = number of fatal accidents • SA = number of serious accidents • LA = number of light accidents • OA = number of other accidents • RSI: road safety indicator • AARsr: The AAR of similar roads	

2.3.1 Introduction of Traffic Safety Performance Measures in the U.S.

In the United States, a number of similar safety performance measures have been widely used by public agencies to assess state traffic performance. For example, Federal Law 23CFR 1200.10 (a)(1) requires each state to develop the following annually:

"(a) A performance plan, containing the following elements: (1) A list of objective and measurable highway safety goals, within the National Priority Program Areas and other program areas, based on highway safety problems identified by the State during the processes under paragraph (a)(2) of this section. Each goal must be accompanied by at least one performance measure that enables the State to track progress, from a specific baseline, toward meeting the goal (e.g., a goal to "increase safety belt use from __ percent in Year __ to __ percent in Year __," using a performance measure of 'percent of restrained occupants in front outboard seating positions in passage motor vehicles')."

In order to 1) set project safety goals, 2) connect goals to specific actions, 3) allocate public resources, 4) monitor and evaluate progress, and 5) communicate the priorities, results and value to society of various traffic program areas and activities, in 2008, the National Highway Traffic Safety Administration (NHTSA) and the Governors Highway Safety Association (GHSA) agreed on a minimum set of 14 performance measures to be used by states and federal agencies in the development and implementation of behavioral highway safety plans and programs (Hedlund 2008). The 14 performance measures are summarized in table 2.2. This minimum set of performance measures is developed by an expert panel consisting of NHTSA, state highway safety offices (SHSOs), academic and research organizations, and other key groups, with staff assistance from the GHSA and the Preusser Research Group (PRG).

Table 2.2 Safety performance measures

Type of Measure	Performance Measures	Data Source
Outcome	Number of traffic fatalities	FARS
Outcome	Number of serous injuries	State crash data set
Outcome	Fatalities/VMT	FARS, FHWA
Outcome	Number of unrestrained passenger vehicle occupant, all seat positions	FARS
Outcome	Number of fatalities in crashes involving a driver or motorcycle operator with a blood alcohol concentration of .08 g/dL or higher	FARS
Outcome	Number of speeding-related fatalities	FARS
Outcome	Number of motorcyclist fatalities	FARS
Outcome	Number of unhelmeted motorcyclist fatalities	FARS
Outcome	Number of drivers age 20 or younger involved in fatal crashes	FARS
Outcome	Number of pedestrian fatalities	FARS
Behavioral	Observed seat belt use for passenger vehicles, front seat outboard occupants	Survey
Activity	Number of seat belt citations issued during grant-funded enforcement activities	Grant activity reporting
Activity	Number of impaired-driving arrests made during grant-funded enforcement activities	Grant activity reporting
Activity	Number of speed citations issued during grant-funded activities	Grant activity reporting

According to the NHTSA report (Hedlund 2008), the proposed safety performance measures could be divided into three distinct subjects: outcomes, behaviors, and activities. Outcome measures, based on traffic crash data, are used to set national and state safety goals, allocate funding and other public resources, and assess performance both overall and in key areas. The data used for outcome measures should be accurate. For national use, the data should be uniform and consistent across states and over time; for state use, the data do not need to be uniform or consistent with other states, but they should be consistent over time. However, the data may not be especially timely. The most common outcome measures used at the federal, state, and local levels are annual traffic fatality and annual traffic fatalities rates (fatalities per vehicle miles traveled).

Behavior measures use data either from direct observations (*e.g.,* belt use or vehicle speed) or from some method of self-reporting (*e.g.,* surveys). Behavior measures provide a link between specific activities and outcomes by assessing whether such activities have influenced behaviors. Behavior measures help states assess the effectiveness of their specific activities in a timely manner, which in turn allows the state to allocate limited resources efficiently.

Activity measures cover a wide range of specific actions taken in an attempt to affect outcome measures (e.g., reducing crashes). They document how specific programs and activities are implemented. Examples include (1) counts of activities (*e.g.,* checkpoints conducted, public service announcements (PSAs) aired, motorcycle operators' training courses held); (2) funds or hours used to conduct the activities (e.g., law enforcement hours used for checkpoints, cost of PSAs, costs or instructor hours for motorcycle operator training); and (3) counts of persons affected (e.g., drivers passing through checkpoints, number of viewers for PSAs, number of motorcycle operators trained). Activity measures may not be consistent across states or over time because different states may use different activities at different times to advance their highway safety programs. However, activity measures should still be timely (Hedlund 2008).

The three types of measures work together to document overall performance. Activity measures document what was done; behavior measures document whether the activities changed behaviors; and outcome measures document whether the change of behaviors actually improved safety performance (*e.g,.* reducing crashes, injuries or fatalities).

2.3.2 Safety Performance Measures Currently Used by States

The GHSA supports 10 performance measures for use by all states, which are listed in the GHSA guidelines for developing Highway Safety Plans, including traffic fatalities, fatalities per MVMT, injuries by population, observed belt use rate, alcohol related fatalities, alcohol related fatalities per VMT, and percentage of all fatalities that involve alcohol (GHSA 2004). Nine of the ten measures are outcome measures obtained from the Fatality Analysis Reporting System (FARS) and state crash data files. Observed belt use is the only behavior measure, and there are no activity measures. According to NHTSA (Hedlund 2008), all states use performance measures, at least implicitly, in their annual highway safety (Sec. 402) plans. But not a single measure is used by all states. While the ten GHSA-supported measures are used most frequently, only four states include all of them in their safety reports. The outcome measures used to evaluate safety performance are quite different for each state. Such differences are based on two major factors: what to count (*e.g.,* crashes, injuries crashes, serious injury crashes, fatal crashes, injuries, serious injuries, fatalities) and how to incorporate the exposure of traffic (normalization) (*e.g.,* rates per VMT, per population, per registered driver). A total 45 states have an overall performance goal of reducing traffic fatalities, fatalities/MVMT, or both (Hedlund 2008).

2.4 PPP on Improving Roadway Safety Performance

2.4.1 Similar Research Based on PPP Projects in Mexico

Cornell University conducted research led by Geddes (2014) regarding the effects of PPP on traffic safety. In that research, the data set was constructed on the basis of Mexico's federal toll roads. According to the management approaches, the Mexico federal toll roads, as a categorical independent variable, were divided into three types: toll roads managed by the federal government, toll roads managed by the state, and toll roads managed by the private sector. The dependent variables used for observation consisted of a variety of traffic incidents, such as accidents/crashes, fatal accidents, car collisions, and fixed object collisions. By employing a number of statistical techniques, such as locality-fixed effects, time-fixed effects, and robust standard errors, the research produced results that indicated that private management of federal roads in Mexico did not have a statistically significant effect on any safety measures.

2.4.2 Similar Research Based on the PPP Projects in Spain

Other similar research was completed on the basis of European PPP projects (Vassallo et al. 2009). In that research, PPP projects in Spain were used as the specific research population, since most Spanish PPP highway projects contained safety incentives within their concession contracts. The database in that research covered the year 2006, since that was the most recent year for a complete database at the time. The data consisted of two parts: police-reported accident data (*e.g.,* crashes, injuries, and fatalities) and traffic data (*e.g.,* AADT and number of intersections). The major independent variables selected in the research included AADT, percentage of heavy goods vehicles (%HGV), number of intersections for each stretch (INT), road operation (RO), and incentives (INC). Among them, the first three variables had potential influence on roadway safety and did not depend on a concessionaire's ability to manage the road, and the last two variables could indicate the differences between PPP projects and traditional projects (Rangel, Vassallo, and Arenas 2012). As with the Cornell research, the RO variable here was also a categorical variable and used to identify the types of roads, including two levels of public highways and toll highways / PPP highways. The dependent variables used in the research were fatal rate, injury rate, and accident rate. Table 2.3 presents part of the database used in the research. Poisson and Negative Binomial (NB) regressions were to determine the relationship between independent variables and dependent variables. The NB model indicated that the INC variable was statistically significant with the dependent variables. This result can be interpreted to mean that the roads with incentives had fewer fatalities, injuries, and accidents than roads without incentives. Rangel, Vassallo, and Arenas (2012) concluded that PPP contracts with a safety payment or incentives were effective at encouraging concessionaires to implement safety approaches and could improve safety performance. Villar and Vassallo (2014) conducted another project to analyze the relationship between the size of monetary incentives in PPP contracts and the ultimate improvement of safety performance. In that follow-up research, a methodology was developed to identify the optimal safety incentives in PPP contracts through a cost-benefit analysis (CBA).

Table 2.3 Descriptive statistics by road operation and total in year 2006 (Rangel, Vassallo, and Arenas 2012)

Variable	RO	Mean	S.D.	Range	Minimum	Maximum
AADT	AV	23,686.04	21,875.96	139,040.00	1,270.00	140,310.00
	1AV	35,735.05	34,262.09	186,365.00	5,135.00	191,500.00
	TH	16,508.43	12,950.00	58,093.00	1,094.00	59,187.00
	Total	26,080.92	26,046.31	190,406.00	1,094.00	191,500.00
%HGV	AV	18.53	10.12	72.40	2.80	75.20
	1AV	23.37	8.95	48.10	4.60	52.70
	TH	10.35	5.39	32.60	1.50	34.10
	Total	18.63	10.08	73.70	1.50	75.20
INT	AV	2.08	1.21	8.00	0.00	8.00
	1AV	2.38	1.59	12.00	0.00	12.00
	TH	1.54	0.70	3.00	0.00	3.00
	Total	2.08	1.29	12.00	0.00	12.00
Millions of vehiclekilometers	AV	52.28	56.22	451.28	0.42	451.70
	1AV	79.25	70.65	355.89	3.13	359.02
	TH	42.51	42.91	250.19	0.48	250.67
	Total	58.68	60.60	451.28	0.42	451.70

Chapter 3 Study Data

3.1 Study Target States and Target Projects (Task 1)

3.1.1 The Selection of Target States

As the first step of this research, a set of target states needed to be identified. According to the National Conference of State Legislatures (NCSL) (2016), enabling statutes that grant an existing or new executive agency thet authority to enter into one or more PPP agreements for transportation projects – and define the limits of that authority – are a necessary precursor to PPP implementation. These statutes set conditions that promote or prevent PPPs, guide development of state PPP programs, provide foundations for PPP contracts, and affect the risks involved for each party. PPP legislation was first enacted more than 20 years ago in California (Assembly Bill 680, 1989). A few years later, in 1995, Virginia adopted its comprehensive Public-Private Transportation Act. The number of states with PPP enabling statutes continues to grow. On the basis of a recent report provided by the NCSL (Rall, Reed, and Farber 2014), 33 states and Puerto Rico have legislation allowing PPPs for highway and bridge projects. Some of the legislation is broad, allowing PPPs for a variety of projects across multiple sectors without further approvals, while other legislation is more limited and may require additional legislative approval of PPPs or limit the number or type of PPPs that state agencies may undertake. Table 3.1 shows the states with PPP enabling legislation, provided by the NCSL (updated in 2014). The information can be categorized as states with broad legislation, states with limited or project-specific legislation, and states with no legislation to enable PPPs.

Table 3.1 NCSL list of states with PPP enabling legislation (Updated in February 2014)

NCSL LIST OF STATES WITH PPP ENABLING LEGISLATION			
States with Broad Legislation	1. Arizona	9. Louisiana	17. Puerto Rico
	2. Alabama	10. Maine	18. South Carolina
	3. California	11. Maryland	19. Utah
	4. Colorado	12. Massachusetts	20. Washington
	5. Delaware	13. Mississippi	21. West Virginia
	6. Georgia	14. North Dakota	22. Wisconsin
	7. Florida	15. Ohio	23. Virginia
	8. Illinois	16. Oregon	17. Texas
States with Limited or Project-Specific Legislation	1. Alaska	5. Minnesota	9. Pennsylvania
	2. Arkansas	6. Missouri	10. Tennessee
	3. Connecticut	7. Nevada	
	4. Indiana	8. North Carolina	
States with No Legislation Enabling PPPs	1. Hawaii	7. Montana	13. Oklahoma
	2. Idaho	8. Nebraska	14. Rhode Island
	3. Iowa	9. New Hampshire	15. South Dakota
	4. Kansas	10. New Jersey	16. Vermont
	5. Kentucky	11. New Mexico	17. Wyoming
	6. Michigan	12. New York	

Even though over half of the states have legislation enabling PPPs, a much smaller number of states has completed a satisfactory number of PPP projects that was helpful for research purposes, and Oregon is the only PacTrans consortia state with some PPP experience. Therefore, this study identified appropriate states that have

- PPP enabling legislation;
- An availability of sufficient roadway safety data (i.e., traffic crash reports, traffic volume reports, etc.);
- a wealth of experience and history with using PPPs.

On the basis of the above selection principles and the research goal for PacTrans, the target states were divided into two groups. The main feature of the first group was that the selected states had a wealth of experience with PPPs (i.e., were early adopters and industry leaders) and higher PPP completion (i.e., projects with abundant searchable documents). On the basis of the review profiles of the existing PPP projects in each state provided by the FHWA, Public Works Financing (PWF), and the author's database, the target states selected in the first group included California, Florida, Indiana, Texas, Virginia, and Puerto Rico. The second group of states included all states affiliated with the PacTrans consortium. They were Alaska, Idaho, Oregon, and Washington. Although this second group of states could not be considered as experienced PPP adopters, collecting their safety data would serve to develop a pre-PPP baseline that could be used to evaluate potentially obtainable improvements if PPP were employed more in future Northwest projects.

3.1.2 PPP Enabling Status in the Selected States

In July 2014, President Obama announced the launch of the "Build America Investment Initiative," a government-wide initiative that aimed, among other things, to increase infrastructure investment by engaging with state and local governments as well as private-sector investors, to encourage collaboration, expand the market for PPPs, and get more out of existing federal financing programs. This initiative included the establishment of the Build America Transportation Investment Center (BATIC), housed with the US Department of Transportation (USDOT). According to a report on U.S. PPP, provided by Squire Patton Boggs, LLP in 2015, the PPP enabling situation in each selected state was as follows:

3.1.2.1 Group 1

California. California continues to be a leader in the PPP sector, with some of the most innovative projects. On February 20, 2009, the California legislature approved Senate Bill Second Extraordinary Session 4 (SBX2 4) Chapter 2, Statutes of 2009, which established legislative authority until January 1, 2017, for regional transportation agencies and Caltrans to enter into an unlimited number of PPPs, and it removed restrictions on the number and type of projects that could be undertaken (Caltrans Website http://www.dot.ca.gov/hq/innovfinance/public-privatepartnerships/PPP_main.html). So far California PPP statutes have authorized the following:

- The California Department of Transportation (Caltrans) and regional transportation agencies to enter into PPP agreements
- Local government agencies to use private sector capital to develop specified projects if certain conditions are met
- The state judiciaries to plan, construct, acquire, and operate its court facilities through the use of PPPs.

Florida. Florida has been a leader in the PPP sector, with some of the most significant P3 transactions in the U.S., including the Port of Miami Tunnel and the I-595 Corridor projects. Florida's initial P3 legislation was limited to transportation projects. But on May 3, 2013, the Florida legislature passed House Bill 85 (HB85), expanding Florida's PPP statute to allow PPPs to be used in other sectors. The new law, which became effective July 1, 2013, allows any responsible public entity (including counties, municipalities, school boards, regional entities, and other state subdivisions) to use the PPP structure to develop any project that serves a public purpose.

Indiana. Indiana is becoming a leader in the P3 sector. Nowadays, Indianan has in place broad P3 legislation that authorizes the Indiana Finance Authority (IFA) to enter into P3 agreements with private entities (*Ind. Code Ann. # 8-15.5-1-1 to 8-15.5-13-8*). Under this legislation, the IFA can enter into agreements with a private sector party to, among other things, plan, design, acquire, construct, improve, expand, lease, operate, repair, manage, maintain, or finance toll road projects. The Indiana Department of Transportation (IDOT) is also authorized to enter into PPP agreements to develop, finance, or operate transportation projects, including toll ways, roads, bridges, and some rail projects (*Ind. Code Ann. # 8-15.7-1-1 to 8-15.7-16-8*). Cities and other local jurisdictions are also allowed to enter into P3 agreements (*Ind. Code Ann. # 5-23-1-3*).

Texas. Texas has in place P3 legislation, the Texas Public Private Infrastructure Act. As a leader in the PPP sector, Texas has implemented several P3 projects, including the North Tarrant Express Segments 3A&3B project, which reached financial closure in September 2013. Texas remains very active, with several projects in the pipeline despite the cancellation or postponement of several PPP procurements in recent years and the financial difficulties faced by certain projects in the state, such as the SH 130 toll road. In 2011, the Texas legislature enacted the Public and Private Facilities and Infrastructure Act to encourage private investment in public use facilities and infrastructures. The law authorized PPPs for a wide range of social infrastructure projects, including facilities for mass transit, water supply and power generation, and oil and gas pipelines. Currently, Legislation passed by the Texas legislature may catalyze more private investment. House Bill 2475 signed into law on June 19, 2015, established a new “center for alternative finance and procurement” that will assist government entities in selecting PPP projects for nearly any type of public infrastructure (http://water.velaw.com/TexasLegislatureAuthorizesNewPublic-PrivatePartnershipCenter.aspx).

Virginia. Virginia is a leader in the U.S. PPP sector and has completed some of the most significant P3 projects in recent years, including the Midtown Tunnel Project. Virginia has broad P3 legislation in place:

- The Public-Private Education Facilities and Infrastructure Act of 2002 that allows private entities to acquire, design, construct, improve, renovate, expand, equip, maintain, or operate qualifying projects, including schools, wastewater treatment plants and telecommunications infrastructure (Va. Code Ann. # 56-575.1 to 56-575.18).
- The Public-Private Transportation Act of 1995 (PPTA) applies to transportation projects, including roads, rail, transit and aviation (Va. Code Ann. #56-556 to 56-575).
- On November 12, 2014, the Commonwealth Transportation Board (CTB) approved new PPP guidelines that aim to increase transparency and competition and to better evaluate the public's risk under PPP transportation projects. The new guidelines followed a six-month long public outreach program by the CTB.

Puerto Rico. On June 8, 2009, the Commonwealth of Puerto Rico enacted legislation that authorizes PPPs for projects across multiple classes of infrastructure. Commonly known as the "PublicPrivate Partnership Act," the legislation of SB469 creates the PPP Authority as a public corporation and affiliate of the Government Development Bank for Puerto Rico and designates the Authority as the sole government entity responsible for determining the functions, services, or facilities for which PPPs are to be established (Puerto Rico DOT website).

3.1.2.2 Group 2

Alaska. In 2003, the Alaska legislature authorized the Knik Arm Bridge and Toll authority to enter into PPPs in any form to finance, design, construct, maintain, improve, or operate the Knik Arm Bridge (*See Alaska Statute. #19.75.111 to 990*). Knik Arm Bridge has been the only PPP trial in Alaska.

Idaho. Idaho has not yet employed PPP, and there has been no legislation enabling PPP yet.

Oregon. In January 2006, the Oregon Department of Transportation (ODOT), under the OregonInnovative Partnerships Program (OIPP), signed a PPP agreement with the Oregon Transportation Improvement Group (OTIG) to deliver new transportation infrastructure projects to the state.

Washington. The Transportation Innovative Partnerships Act was enacted in 2005 (codified as Chapter 47.29 RCW). This law phased out the previous PPIT Act (RCW 47.46) and created a new public-private partnership law in Washington. The new law allows transportation-related projects and programs of all modes to be eligible for development as a public-private partnership under the Transportation Innovative Partnership Program (TIPP). The TIPP program is administered by WSDOT but overseen by the Washington State Transportation Commission. The Commission has final approval authority for any TIPP agreement negotiated between WSDOT and a private partner. The Commission was directed to enact administrative rules to carry out the TIPP program. In 2006, the Washington State Transportation Commission formally adopted administrative rules to implement the TIPP. The new program rules can be found at WAC 468-600 (WSDOT http://www.wsdot.wa.gov/Funding/Partners/History.htm).

3.1.3 The Selection of Target PPP Projects

As the second step in Task 1, target PPP projects were identified within the selected states. Because of the insufficient experience within the second group of states in employing PPP and the limited nature of the PPP projects in those states, the target PPP projects were selected only from the first group of states, which were more representative and appropriate for research purposes. Among the states in Group 1, four had more PPP completions and more searchable PPP documents, including California, Florida, Texas, and Virginia. Table 3.2 to table 3.5 list all current transportation PPP projects in these four states. The main sources for project information were compilations from the Federal Highway Administration's (FHWA) Public Works Financing (PWF).

Table 3.2 includes all existing projects or projects in active procurement related to transportation PPPs in Florida. To date, 17 transportation PPP projects have been conducted in Florida. Two of them were issued in 2014 and were in the procurement stage (under consideration); seven of them were under construction; three of them were open the public for use (in operation); and five of them had completed contracts.

Table 3.3 includes all existing projects or projects in active procurement related to transportation PPPs in California. To date, six PPP projects related to roadways have been conducted in California. Two of them were newly issued in 2014 and were in the procurement stage (under consideration); one was under construction; and three were open for public use (in operation).

Table 3.2 Transportation PPP projects in Florida

Selected States	PPP Projects	Status	PPP Types	Project Sizes ($)
Florida	I-395	Under Consideration		
	Tampa Bay Express	Under Consideration	DBOM	
	I-4 Ultimate in Orange & Seminole Counties	Under Construction	DBFOM	2.3 B
	SR 79	Under Construction	DBF	98 M
	I-75 North of SR 80 to South of SR 78	Under Construction	DBF	72 M
	SR 9B	Under Construction	DBF	95 M
	I-95 from South of SR 406 to North of SR 44	Under Construction	DBF	130 M
	Palmetto Section 5 - SR 826/836 Interchange	Under Construction	DBF	566 M
	US 19	Under Construction	BF	124 M
	PortMiami Tunnel (1st availability payment procurement in US)	In Operations	DBFOM	1.113 B
	I-595 Improvements	In Operations	DBFOM	1.2 B
	I-4 Connector	In Operations	BF	434 M
	I-75 in Lee and Collier Counties	Contract Complete	DBF	458 M
	Palmetto Expressway Widening and Interchange Improvements Section 2	Contract Complete	DBF	190 M
	I-95 Widening/Pineda Causeway Interchange	Contract Complete	DBF	199 M
	I-95 Express Lanes Phase I	Contract Complete	DBF	139 M
	US 1 Improvements in the "18-mile Stretch"	Contract Complete	DBF	114 M

Table 3.3 Transportation PPP projects in California

Selected States	PPP Projects	Status	PPP Types	Project Sizes ($)
California	Highway 156 West Corridor	Under Consideration	DBFOM	270 M
	High Desert Corridor (SR14 in LA to SR18 In San Bernardino)	Under Consideration		3.6 B
	SR 91 Corridor Improvement Project	Under Construction	DB	1,311.7 M
	SR 125 (South Bay Expressway)	In Operations	DBFOM	658 M
	The Presidio Parkway	In Operations	DBFOM	1.1 B
	Foothill/Eastern and San Joaquin Toll Roads	In Operations	DB	3.264 B

Table 3.4 Transportation PPP projects in Texas

Selected States	PPP Projects	Status	PPP Types	Project Sizes ($)
Texas	SH 360	Under Consideration	DBM	
	SH 288 Toll Concession	Under Consideration	DBFOM	320 M
	SH 183 Managed Lanes	Under Construction	DBFOM	1.586 B
	SH 71 Toll Lanes Project	Under Construction	DB	
	Loop 375 Border Highway West Extension	Under Construction	DB	448 M
	Energy Sector Roadway Repair Project	Under Construction	DB	
	Loop 1604 Western Extension Project	Under Construction	DB	126 M
	IH 35E Managed Lanes	Under Construction	DB	4.8 B
	SH99/Grand Parkway	Under Construction	DB	2.9 B
	Horseshoe Project	Under Construction	DB	818 M
	DFW Connector	Under Construction	DB	1.1 B
	LBJ 635 / IH 635 managed lanes	Under Construction	DBFOM	3.1 B
	North Tarrant Express (Seg 1,2, 3A, 3B)	In Operations	DBFOM	3.83 B
	SH 130	In Operations	DBFOM	1.3 B
	183-A Turnpike	In Operations	DB	304.7 M

Table 3.4 includes all existing projects or projects in active procurement related to transportation PPPs in Texas. To date, 15 transportation PPP projects had been conducted in Texas. Two of them were issued in 2014 and in the procurement stage (under consideration); ten of them were under construction; and three of them were open for public use (in operation).

Table 3.5 includes all existing projects or projects in active procurement related to transportation PPPs in Virginia. To date, 12 transportation PPP projects had been conducted in Virginia. One was current in the procurement stage (under consideration); three were under construction; and eight were open for public use (in operation).

Table 3.5 Transportation PPP Projects in Virginia

Selected States	PPP Projects	Status	PPP Types	Project Sizes ($)
Virginia	New Thimble Shoal Channel Tunnel Project	Under Consideration	DBFOM	644 to 883 M
	Elizabeth River Tunnels	Under Construction	DBFOM	2.1 B
	US Route 121 (Coafields Expressway)	Under Construction	DB	5.1 B
	Downtown Tunnel/Midtown Tunnel/ MLK Extension	Under Construction	DBFOM	2,089 M
	Route 58	In Operations	DB	222.75 M
	Route 28	In Operations	DB	349 M
	I-495 Express Lanes	In Operations	DBFOM	2.068 B
	I-95 Express Lanes	In Operations	DBFOM	925 M
	Route 199	In Operations	DB	32 M
	Route 288	In Operations	DB	236 M
	Pocahontas Parkway (Route 895)	In Operations	(99 year Concession)	611 M
	Dulles Greenway	In Operations	DBFOM	350 M

The target PPP projects in this research were identified on the basis of the following criteria:

1. The procurement model – projects with design-build-finance-operatio-maintenance (DBFOM), design -build –operation-maintenance (DBOM), or a long-term concession (i.e., over 50 years) were preferred.
2. The availability of procurement documents (i.e., RFQ, RFP, a comprehensive agreement / general contract, technical requirements, etc.)
3. The availability of sufficient roadway safety data (*e.g.,* traffic crash reports) and traffic volume data (*e.g.,* AADT or VMT).

The 17 projects that had the most research value were identified and are summarized in table 3.6. Because California, Florida, Texas, and Virginia had more searchable PPP projects than the other two targets, Indiana and Puerto Rico, 13 projects were selected from those four states. Of those 13 projects, three of them were in Florida, including the port of Miami Tunnel, the I-595 Improvement, and the I-4 Connector; two of them were in California, including the SR125 (South Bay Expressway) and the Presidio Parkway; four of them were in Texas, including LBJ 635 (IH 635 Managed Lanes), the North Tarrant Express (Seg. 1, 2, 3A, & 3B), SH 183 Managed Lanes, and SH 130; and four of them were in Virginia, including the Elizabeth River Tunnels, I-495, I-95, and the Pocahontas Parkway (Route 895). For the sake of involving more long-term leasing projects in this research, four projects with longer than 45 years of leasing concessions were selected. Of those four long-term lease projects, two were from the other two target states /U.S. territory in Group 1, including the Indiana Toll Road in Indiana and the PR-22 and PR-5 Toll Road in Puerto Rico. The data were supplemented by data from the Northwest Parkway in Colorado and the Chicago Skyway in Illinois to provide more long-term lease projects. Finally, to enrich the analysis and provide more PPP projects in the sample, two highway projects from British Columbia, Canada—the Seat-To-Sky Highway (STS) and the William R. Bennett Bridge—were detailed as case studies.

Table 3.6 Information on target PPP projects

Project	State	Project Delivery/Contract method	Year of Financial Closure	Status
The Port of Miami Tunnel	Florida	DBFOM	2009	In Operation
I-595 Improvement	Florida	DBFOM	2009	In Operation
I-4 Ultimate	Florida	DBFOM	2014	Under Construction
SR125 (South Bay Expressway)	California	DBFOM	2003	In Operation
The Presidio Parkway	California	DBFOM	2012	In Operation
LBJ 635 (IH 635 Managed Lanes)	Texas	DBFOM	2008	In Operation
North Tarrant Express (Seg. 1, 2, 3A, & 3B)	Texas	DBFOM	2009	In Operation
SH 183 Managed Lanes	Texas	DBFOM	2014	Under Construction
SH 130 Seg. 5 & 6	Texas	DBFOM	2007	In Operation
Elizabeth River Tunnels	Virginia	DBFOM	2012	Under Construction
I-495	Virginia	DBFOM	2008	In Operation
I-95	Virginia	DBFOM	2012	In Operation
Pocahontas Parkway	Virginia	Lease-Develop-Operate	2007	In Operation
Indiana Toll Road	Indiana	75-year long-term lease	2006	In Operation
PR-22 and PR-5 Toll Road	Puerto Rico	40-year long-term lease	2011	In Operation
Northwest Parkway	Colorado	Long-term lease	2007	In Operation
Chicago Skyway	Illinois	99-year long-term lease	2005	In Operation

3.2 Data Collection for Roadway Safety Performance

The data collection was divided into two parts, benchmark safety data and PPP project safety data. The types of collected data were identified on the basis of the availability of a database. According to a search, traffic crashes (total crashes), injuries, and fatalities are commonly used in state annual crash facts/reports. These three types of data then were treated as the initial data collected in this study. In the literature, we found that exposure to traffic (risk) should be taken into consideration in order to reduce distortions in roadway safety results. Therefore, this study used traffic flow to represent exposure to traffic. Traffic flow can be determined on the basis of annual average daily traffic (AADT) or vehicle miles traveled (VMT), which is calculated as AADT multiplied by the road length.

3.2.1 Benchmark Safety Data Collection (Task 2)

A comprehensive search for Annual Crash Facts feports or other traffic crash statistics in the target states was conducted to collect state-level and local-level (city/county) roadway safety data. These data were used to establish the norm or average safety performance measures or accident statistics, which represented the benchmarks by which to compare and evaluate the safety performance of the PPP projects. Because the target PPP projects selected in California were still under construction and the traffic safety data were unavailable during the research period, California was not included in the data collection. The benchmark safety data collection for the other target states are summarized as follows.

3.2.1.1 Florida

The Florida Department of Highway Safety and Motor Vehicles (DHSMV) collects data and conducts research in order to provide lawmakers, partners, stakeholders, the media, and citizens with important facts and valuable information related to public safety and motor services. The DHSMV has a center for Crash and Citation Reports and Statistics (http://www.flhsmv.gov/resource-center/crash-citation-reports/), which is available for the public to get state-level, county-level, and city-level traffic safety data in the previous 10 years. Additionally, the Florida Department of Transportation (FDOT) generates an Annual Crash Facts report to compile and analyze traffic and safety data and emerging trends in order to support public safety improvements and policy decision-making. Table 3.7 summarizes the data collection at the state level, and table 3.8 summarizes the data collection at the local level, which was based on project location.

Table 3.7 Florida state-level benchmark data collection

Florida Statewide Data				
Year	Total Crashes	Injuries	Fatalities	Annual Vehicle Miles Traveled (AVMT)
2015	374003	243229	2898	NA
2014	344261	225678	2495	201,040,404,585
2013	317192	211082	2404	192,701,815,700
2012	283365	198484	2420	190,850,891,575
2011	229210	182007	2398	195,755,149,806

Table 3.8 Florida locality-level benchmark data collection

Florida City/County Level Data				
PPP Project		The Port of Miami	I-595 Improvements	I-4 Ultimate
Locality		Miami-Dade County	Broward County	Orlando City
Total Crashes	2015	63,245	38,370	25,952
	2014	60,175	34,839	23,026
	2013	53,033	32,747	21,421
	2012	51,605	31,306	20,225
	2011	51,125	32,104	20,467
Injuries	2015	32,686	23,468	19,886
	2014	31,758	22,157	17,563
	2013	28,716	21,694	16,554
	2012	29,819	21,340	16,144
	2011	32,184	22,312	17,521
Fatalities	2015	324	197	194
	2014	281	173	158
	2013	224	180	171
	2012	226	187	178
	2011	302	178	159
Annual Vehicle Miles Traveled (AVMT)	2015	NA	NA	NA
	2014	19,440,049,650	16,408,256,355	13,282,182,100
	2013	18,651,946,760	16,052,928,125	12,740,271,710
	2012	18,653,870,310	16,052,374,785	12,446,484,670
	2011	19,479,229,480	15,802,992,550	12,163,739,975

3.2.1.2 Texas

The Texas Department of Transportation (TxDOT) is the custodian of crash records for the state. Texas Transportation Code §550.062 requires any law enforcement officer who, in the regular course of duty, investigates a motor vehicle crash that results in injury or the death of a person or damage to the property of any one person to the apparent extent of $1,000 or more to submit a written report of that crash to TxDOT no later than the 10th day after the date of the crash. TxDOT collects crash reports from every law enforcement agency in Texas and for crashes that occur on any public roadway in Texas, not just crashes occurring on the state highway system. The state retention schedule for crash reports and data is five years plus the current year. Information outside this retention schedule is not available. A crash reporting system is available online that for consultation at http://www.txdot.gov/inside-txdot/formspublications/drivers-vehicles/publications/ annualsummary.html. Table 3.9 and table 3.10 summarize the status of data collection at the state level and local level, respectively.

Table 3.9 Texas state-level benchmark data collection

Texas Statewide Data				
Year	Total Crashes	Injuries	Fatalities	Annual Vehicle Miles Traveled (AVMT)
2015	NA	NA	NA	NA
2014	476875	175752	3534	248,824 M
2013	445829	170163	3408	244,536 M
2012	417707	166991	3417	237,821 M
2011	452347	168271	3016	237,443 M

Table 3.10 Texas locality-level benchmark data collection

Texas City/County Level Data					
PPP Project		IH 635 Managed Lanes	North Tarrant Express	SH 183 Managed Lanes	SH 130
Locality		Dallas-Fort Worth County	Dallas-Fort Worth County	Dallas-Fort Worth County	Travis County
Total Crashes	2015	NA	NA	NA	NA
	2014	43,052	43,052	43,052	15,415
	2013	40,896	40,896	40,896	16,106
	2012	36,491	36,491	36,491	16,177
	2011	35,315	35,315	35,315	15,532
Injuries	2015	NA	NA	NA	NA
	2014	34,672	34,672	34,672	12,884
	2013	33,786	33,786	33,786	13,644
	2012	31,747	31,747	31,747	14,501
	2011	31,297	31,297	31,297	13,140
Fatalities	2015	NA	NA	NA	NA
	2014	238	238	238	95
	2013	227	227	227	112
	2012	211	211	211	105
	2011	179	179	179	84
Annual Vehicle Miles Traveled (AVMT)	2015	27,502,553,114	27,502,553,114	27,502,553,114	NA
	2014	27,103,855,113	27,103,855,113	27,103,855,113	9,281,029,525
	2013	26,706,264,124	26,706,264,124	26,706,264,124	9,401,992,200
	2012	26,312,972,116	26,312,972,116	26,312,972,116	9,341,624,341
	2011	25,917,222,839	25,917,222,839	25,917,222,839	9,022,820,718

Additionally, Texas has a comprehensive safety database that is accessible to the public. The authors further selected some comparable public highways or public toll roads to collect safety data. Such data were used to establish a public, non-PPP project-level benchmark and to compare that with PPP project safety performance. Table 3.11 summarizes the collection of non-PPP project-level safety benchmark data.

Table 3.11 Texas non-PPP project-level benchmark data collection

Public Project Level Data					
Project		IH 35W from SH 183 to IH 820	I30 from I35E to SH 12	SH 45 Toll from I 35 to SH 130	I 35 from SH 183 to SH 290
Type		Public Highway	Public Highway	Public Toll Road	Public Highway
Total Crashes	2015	232	294	17	351
	2014	165	275	17	354
	2013	137	286	11	364
	2012	145	277	16	379
	2011	91	264	9	332
Injuries	2015	81	74	5	97
	2014	45	79	4	105
	2013	49	85	2	112
	2012	56	89	3	124
	2011	35	77	3	109
Fatalities	2015	0	1	0	11
	2014	4	2	1	7
	2013	1	4	0	8
	2012	1	5	1	6
	2011	2	4	0	9
Annual Vehicle Miles Traveled (AVMT)	2015	NA	NA	NA	NA
	2014	361,128,080	541,112,318	30,059,502	805,185,036
	2013	361,782,160	604,225,928	25,194,782	814,752,270
	2012	359,160,000	629,625,000	25,068,200	843,588,000
	2011	315,360,000	570,860,000	20,600,600	772,632,000

3.2.1.3 Virginia

The Traffic Records Management, Reporting and Analysis Division, of the Virginia Highway Safety Office (VAHSO) manages the state's highway safety traffic records information system, which houses millions of traffic crash records. Data that are collected, stored, and analyzed by this division are used for problem identification and resolution by local, state, and federal entities across the Commonwealth. These data aer housed in the Traffic Records Electronic Data System (TREDS). TREDS, the first of its kind in Virginia, is a state-of-the-art traffic crash data system that automates and centralizes crash information from across the state.

The Traffic Records Management, Reporting and Analysis Division engages in strategic planning to ensure the effective use of its existing Virginia traffic records information system to support and highlight the Commonwealth's safety programs and grant funding initiatives (Virginia Department of Motor Vehicle website). The Virginia Traffic Crash Facts publication is the result of the cooperative efforts of the Virginia Department of Motor Vehicles, the Virginia Department of State Police, and the Virginia Department of Transportation. It provides a comprehensive statistical overview of traffic crashes occurring in Virginia. The following website provides Annual Traffic Crash Reports from 2011 to 2014: http://www. dmv.state. va.us/safety/#crash_data/crash_facts/index.asp. Additionally, an accident data center is available online at http://accidentdatacenter.com/us/virginia. Table 3.12 and table 3.13 summarize the status of data collection for Virginia at the state level and local level, respectively. As with Texas, the authors were also able to establish a non-PPP project-level benchmark by collecting data from a set of comparable public highways in Virginia. The non-PPP project-level benchmark data are shown in table 3.14.

Table 3.12 Virginia state-level benchmark data collection

Virginia Statewide Data				
Year	Total Crashes	Injuries	Fatalities	Annual Vehicle Miles Traveled (AVMT)
2015	NA	NA	NA	NA
2014	120282	63384	700	81,009 M
2013	121763	65114	741	80,767 M
2012	123579	67004	775	80,737 M
2011	124721	64421	764	80,974 M

Table 3.13 Virginia PPP locality-level benchmark data collection

Virginia City/County Level Data						
PPP Project		Elizabeth River Tunnel	I-495	I-95	Pocahontas Pkwy	Dulles Greenway
Locality		Portsmouth city	Fairfax city	Stafford county	Richmond city	Loudon County
Total Crashes	2015	NA	NA	NA	NA	NA
	2014	1,162	700	2,036	4,835	4,281
	2013	1,220	615	2,048	4,970	4,186
	2012	1,421	648	1,924	4,835	4,164
	2011	1,321	650	1,978	4,598	4,066
Injuries	2015	NA	NA	NA	NA	NA
	2014	809	440	875	2,799	2,123
	2013	847	227	819	2,804	1,917
	2012	929	243	958	2,799	1,837
	2011	870	205	898	2,723	1,869
Fatalities	2015	NA	NA	NA	NA	NA
	2014	5	0	12	16	12
	2013	3	2	8	12	13
	2012	3	5	15	16	18
	2011	2	2	9	17	11
Annual Vehicle Miles Traveled (AVMT)	2015	NA	NA	NA	NA	NA
	2014	563,452,690	174,614,175	1,548,879,690	1,781,219,345	2,587,912,780
	2013	594,251,025	178,817,150	1,553,785,290	1,727,773,855	2,535,825,820
	2012	613,773,780	182,721,555	1,567,950,210	1,793,661,830	2,492,055,385
	2011	613,307,675	182,988,370	1,494,622,805	1,781,426,300	2,489,965,395

Table 3.14 Virginia non-PPP project-level benchmark data collection

Public Project Level Data						
Project		I-66 (From Exit 55 to Exit 73)	I-395 (From Exit 1C to Exit 10A)	DullesAccessRoad (From Exit 9B to Exit 18)	I-95 Part I (From Same location to PPP project)	I-95 Part II (From Exit 81A to 128A)
Total Crashes	2015	620	662	44	1737	741
	2014	617	561	51	2067	642
	2013	576	599	38	1877	684
	2012	532	533	39	1403	584
	2011	518	532	58	1432	649
Injuries	2015	253	228	28	610	260
	2014	274	181	26	778	238
	2013	260	211	16	706	266
	2012	274	227	32	620	260
	2011	219	222	41	679	321
Fatalities	2015	1	0	0	1	4
	2014	0	0	1	7	3
	2013	2	0	0	3	5
	2012	0	2	0	4	2
	2011	1	2	1	4	10
Annual Vehicle Miles Traveled (AVMT)	2015	611,010,000	571,590,000	558,450,000	565,020,000	578,160,000
	2014	286,160,000	257,544,000	279,006,000	282,583,000	279,006,000
	2013	371,533,500	397,156,500	405,697,500	273,312,000	397,156,500
	2012	656,270,000	709,195,000	698,610,000	709,195,000	751,535,000
	2011	1,140,260,000	1,076,020,000	1,092,080,000	1,140,260,000	1,092,080,000

3.2.1.4 Indiana, Colorado, Illinois, and Puerto Rico

The Indiana Officer's Standard Crash Report, completed by local and state law enforcement officers, requires over 200 data items for each collision reported. The safety statistics are available from the state Annual Crash Facts books and are used to inform the public as well as state and national policy-makers on matters of roadway safety and to serve as the analytical foundation of traffic safety program planning and design in Indiana. Table 3.15 summarizes the status of data collection at the state level.

Table 3.15 Indiana state-level benchmark data collection

Indiana Statewide Data				
Year	Total Crashes	Injuries	Fatalities	Annual Vehicle Miles Traveled (AVMT)
2015	NA	NA	NA	NA
2014	205532	48441	743	81,406.32M
2013	193013	46077	777	79,362.68M
2012	188841	47937	779	78,646 M
2011	188126	45993	750	77,456 M

The Colorado State Patrol evaluates the safety of Colorado roads by monitoring the fatality rate in the state. The traffic statistics are available at https://www.colorado.gov/pacific/csp/traffic-safety-statistics and https://www.codot.gov/library/traffic/safety-crash-data/fatal-crash-data-city-county. The state-level safety data are presented in table 3.16.

Table 3.16 Colorado state-level benchmark data collection

Colorado Statewide Data				
Year	Total Crashes	Injuries	Fatalities	Annual Vehicle Miles Traveled (AVMT)
2015	NA	NA	548	NA
2014	100936	9785	488	46,855,000,000
2013	101011	9657	482	46,968,000,000
2012	100881	9965	474	46,769,000,000
2011	101107	9581	447	46,606,000,000

Illinois DOT offers a wide variety of data summaries and reports about motor vehicle crashes. The website (http://www.idot.illinois.gov/transportation-system/safety/IllinoisRoadway-Crash-Data) provides access to crash data summary reports, fact sheets, and interactive tools based on topics. Table 3.17 summarizes the status of data collection at the state level.

Table 3.17 Illinois state-level benchmark data collection

Illinois Statewide Data				
Year	Total Crashes	Injuries	Fatalities	Annual Vehicle Miles Traveled (AVMT)
2015	NA	NA	NA	NA
2014	296049	84652	924	105.03 B
2013	285477	85031	991	105.48 B
2012	274111	83768	956	104.46 B
2011	281788	84172	918	103.37 B

The National Highway Traffic Safety Administration website (http://wwwnrd.nhtsa.dot.gov/departments/nrd-30/ncsa/STSI/43_PR/2014/43_PR_2014.htm) summarizes traffic safety performance measures for Puerto Rico. The data are shown in table 3.18.

Table 3.18 Puerto Rico data collection

Puerto Rico Statewide Data				
Year	Total Crashes	Injuries	Fatalities	Annual Vehicle Miles Traveled (AVMT)
2015	NA	NA		
2014	4,835	2,799	304	14,564,000,000
2013	4,970	2,804	344	18,588,000,000
2012	4,835	2,799	366	18,588,000,000
2011	4,598	2,723	361	18,588,000,000

The local-level safety data for Indiana, Colorado, Illinois, and Puerto Rico are presented in table 3.19.

Table 3.19 PPP locality-level benchmark data collection for Indiana, Colorado, Illinois and Puerto Rico

City/County Level Data					
PPP Project		Indiana Toll Road	Northwest Pkwy	Chicago Skyway	PR-5 & PR-22
Locality		North Indiana, IN	Broomfield county, CO	Chicago city, IL	Puerto Rico
Total Crashes	2015	NA	NA	NA	NA
	2014	NA	1,037	82,744	4,835
	2013	NA	1,104	79,384	4,970
	2012	NA	1,187	77,537	4,835
	2011	NA	1,097	77,926	4,598
Injuries	2015	NA	NA	NA	NA
	2014	NA	107	19,765	2,799
	2013	NA	124	20,199	2,804
	2012	NA	115	20,440	2,799
	2011	NA	111	20,422	2,723
Fatalities	2015	NA	NA	NA	NA
	2014	20	1	118	304
	2013	21	2	130	344
	2012	27	4	145	366
	2011	34	4	119	361
Daily Vehicle Miles Traveled (DVMT)	2015		NA	NA	NA
	2014	2,206,607,500	426,363,800	NA	14,564,000,000
	2013	1,926,470,000	406,376,035	7,178,589,000	18,588,000,000
	2012	1,984,140,000	397,103,575	7,127,674,000	18,588,000,000
	2011	1,833,030,000	391,498,635	7,208,792,000	18,588,000,000

As with Texas and Virginia, the authors established a non-PPP project-level benchmark by collecting data from a set of comparable public highways in Colorado on the basis of a survey. The non-PPP project-level benchmark data are shown in table 3.20.

Table 3.20 Colorado non-PPP project-level benchmark data collection

Public Project Level Data							
Project		SH470A I70	SH470B I-25	SH470W I-70	SH025A (194-228)	SH070A (259-289)	SH036 (45-57)
Total Crashes	2015	NA	NA	NA	NA	NA	NA
	2014	612	267	13	4034	2108	890
	2013	695	238	10	3472	1799	709
	2012	717	212	7	3143	1698	606
	2011	673	167	3	3093	1539	605
Injuries	2015	NA	NA	NA	NA	NA	NA
	2014	241	112	3	1027	648	259
	2013	234	89	2	947	625	207
	2012	46	32	0	222	141	47
	2011	49	23	0	223	159	41
Fatalities	2015	NA	NA	NA	NA	NA	NA
	2014	0	4	0	6	8	0
	2013	1	0	0	4	16	2
	2012	6	2	0	5	3	2
	2011	0	2	0	8	6	0
Daily Vehicle Miles Traveled (DVMT)	2015	NA	NA	NA	NA	NA	NA
	2014	775,560,278	498,255,251	11,223,750	2,417,090,605	1,228,165,052	437,929,044
	2013	739,361,702	371,932,868	10,774,800	2,309,754,821	1,180,891,508	418,921,129
	2012	702,941,176	365,517,241	10,020,000	2,179,330,000	1,123,830,000	446,130,000
	2011	701,041,667	371,111,111	9,990,050	2,230,510,000	1,121,420,000	444,830,000

Among the 17 target projects, the analysis at the state-level benchmark included five states that had data at the different state, locality, and project levels. These five states were Florida, Texas, Virginia, Colorado, and Illinois. For the locality-level benchmark, eleven counties/cities were included from the five states, including one in Florida, four in Texas, three in Virginia, two in Colorado, and one in Illinois. These localities were where the PPP projects were built. for the public non-PPP highways benchmark, 17 highways were included: four in Texas, seven in Colorado, and six in Virginia. These public, non-PPP highways were also in the same localities of the PPP projects. Finally, there were nine PPP projects, including one in Florida, three in Texas, three in Virginia, one in Colorado, and one in Illinois. These nine PPP projects were the ones that had a reasonable amount of data to conduct the analysis described below. Note that the PPP projects considered for the analysis included elven projects that included the Indiana Toll Road and the PR-22/PR-5 in Puerto Rico, but those two projects and their corresponding cities and states had to be removed because no data were available from the corresponding offices.

3.2.2 PPP Roadway Safety Data (Second Part of Task 3)

Unlike the benchmark safety data, no similar online database was available related to PPP project safety data. Therefore, this research took the initiative to contact state departments of transportations (DOTs) and PPP private contractors, and we also administered surveys to request and collect PPP project safety data.

Although the uses of PPP are on the rise, PPP has not been widely implemented in the U.S. transportation sector. According to the FHWA Innovative Project Delivery Program (2016), there are only 26 roadway PPP projects either under construction or in operation in the U.S. Therefore, even though our sample size included only 17 PPP projects, the sample, to some extent, could still represent the PPP population in the U.S. However, some of the 17 target projects had not opened to the public during the research period and therefore the traffic safety data were unavailable. For example, construction on the I-4 Ultimate, in Florida, started in 2015 and will finish in 2019; the SH 183 Managed Lanes, in Texas, will be completed in 2018; the Presidio Parkway finished construction in October 2015; and the Elizabeth River Tunnel was expected to be completed in 2017. On the other hand, some projects were bought back by the public agency because of financial issues and were no longer PPP projects, such as SR 125, in California. Such projects, therefore, were excluded from the PPP roadway data collection.

Of the selected 17 projects, 11 projects were in the operation phase and maintained by the private sector. A survey was administered to collect safety and traffic flow (AADT or VMT) data for these projects. In addition, for the sake of gaining more PPP project-level safety data, the authors also sent surveys to some other PPP projects that had been in operation for a certain time but were not included in the target project group, including the Dulles Greenway in Virginia and the Sea-To-Sky Highway and William R Bennett Bridge in British Columbia, Canada. In all, 13 data requests were sent out, and just one replied and provided the requested data. Table 3.21 summarizes the PPP project-level safety data collection.

Table 3.21 PPP project safety data collection

PPP Project Level Data												
PPP Project		LBJ635	North Tarrant Express	SH130	I-495	I-95	Dulles Greenway	I-595	Chicago Skyway	Northwest Pkwy	STS	William Bridge
State		TX	TX	TX	VA	VA	VA	FL	IL	CO	BC	BC
Total Crashes	2015	27	14	94	1,179	26	129	NA	NA	34	143	14
	2014	NA	3	56	1,079	NA	127	16	68	26	136	13
	2013	NA	NA	71	873	NA	84	NA	83	26	137	13
	2012	NA	NA	37	1,099	NA	121	NA	78	19	143	16
	2011	NA	NA	15	1,314	NA	109	NA	77	26	112	18
Injuries	2015	12	5	39	323	12	10	NA	NA	2	70	4
	2014	NA	2	35	328	NA	13	16	25	1	66	8
	2013	NA	NA	23	274	NA	13	NA	28	2	63	2
	2012	NA	NA	3	351	NA	11	NA	21	2	62	11
	2011	NA	NA	11	428	NA	13	NA	15	1	62	12
Fatalities	2015	0	0	5	0	0	0	NA	NA	0	1	0
	2014	NA	0	1	2	NA	0	0	0	0	2	0
	2013	NA	NA	4	0	NA	2	NA	1	0	2	0
	2012	NA	NA	0	1	NA	0	NA	0	1	2	0
	2011	NA	NA	0	0	NA	0	NA	0	0	3	0
Daily Vehicle Miles Traveled (DVMT)	2015	934,765,000	616,850,000	NA	754,379,080	445,336,500	260,891,050	NA	NA	48,775,680	479,798,669	1,529,304,375
	2014		97,025,760	124,129,930			247,543,730	41,007,750	301,674,690	43,397,040	506,293,727	1,452,791,250
	2013			136,973,550			240,440,830	NA	292,911,770	38,365,880	486,055,754	1,423,527,375
	2012			133,073,525			236,817,840	NA	294,917,445	34,958,240	469,950,056	1,384,873,875
	2011			NA			237,241,970	NA	281,824,895	33,048,560	445,788,297	1,381,150,875

A number of obstacles were encountered during the data collection:

1. As mentioned previously, a number of projects had recently started operation in 2015, which gave little time to collect and process safety data, and other projects had not opened to the public.
2. A number of projects, such as the I-495 Managed Lanes and I-95 Express lanes, had agreements for managed lanes only, not a whole toll road. In some states, however, data collection for AADT or VMT did not separate the data between the free lanes and the managed lanes.
3. It was difficult to collect data from either the private sector or the highway agency. For example, the Chicago Skyway and Puerto Rico DOT did not respond to requests for data.

These factors limited the collection of data to the number of projects and to a limited number of years, the most usable of which tended to be 2014.

3.3 Data Collection for PPP Safety Contractual Terms (the First Part of Task 3)

This study adopted a comprehensive search to collect relevant PPP procurement documents from the target PPP projects. Such procurement documents included but were not limited to Requests for Qualification (RFQ), Requests for Proposal (RFP), Technical Requirements / Provisions, Comprehensive Agreements, and other supplementary documents. The main sources of the PPP procurement documents were FHWA's PPP project files, target state DOTs' websites, target projects' websites, and the author's own database. Table 3.22 summarizes the contractual data collection status of the 17 target projects selected in Task 1.

Table 3.22 Project document collection status

Project	Document			
	RFQ	RFP or Technical Requirement	Comprehensive Agreement	Others
I-4 Ultimate	✓	✓	✓	
Port of Miami Tunnel	✓	✓	✓	
I-595 Improvements	✓	✓	✓	
SR 125		✓	✓	
The Presidio Parkway	✓	✓	✓	
SH 183 Managed Lanes	✓	✓	✓	
LBJ 635		✓	✓	Compensation term; Performance and Measurement table baseline
North Tarrant Express	✓	✓	✓	Compensation term
SH 130		✓	✓	Compensation term
Elizabeth River Tunnels		✓	✓	
I-495 Express Lanes		✓	✓	Guaranty of Performance
I-95 Express Lanes		✓	✓	Form of O&M Agreements; Performance Requirements; Security requirements for critical infrastructure facilities
Pocahontas Parkway		✓	✓	
Chicago Skyway		✓	✓	
Indiana Toll Road	✓	✓	✓	
PR-22 and PR-5	✓	✓	✓	Desirability & Convenience study
Northwest Parkway	✓		✓	

Chapter 4 Research Method

4.1 Introduction

For the first goal of the research, the safety data collected in tasks 2 and 3 were analyzed to determine whether there was a relationship between the safety performance, indices, and collision or crash averages of state roads and PPP projects. Using the safety information collected in Task 2, the averages or benchmarks were established at the state level, local level, and non-PPP project level. Using the PPP safety information collected in Task 3, data were analyzed at the PPP project level. Statistical tools were consulted in this regard in order to check the differences, analogies, and the statistical significances of the results. Note that this research should be considered an initial step toward future analysis that would cover more PPP projects than the number available to the current research. In addition, future research would perhaps segregate the state safety data into groups, *e.g.,* in clustered analysis, which would recognize the design-bid-build system, design-build system, and other traditional systems, along with the historical maintenance records for the highways. Well-maintained roads under the traditional systems would play a role in a comparison to PPP safety data.

To address the second goal, contractual safety data collected in Task 3 were analyzed for how safety was managed and accounted for, *e.g,* safety measures, specifications, and safety payments and incentives. A content and comparative analysis was done, and lessons learned were also established for contractual safety practices in PPP projects.

4.2 Analysis of Roadway Safety Data (Task 4)

Task 4 aimed to identify whether PPP roads demonstrate better safety performance than publicly operated roads. The analysis was tailored to address the objective while dealing with the limitations of the database. The collected safety data, including fatalities, injuries, and total crashes were regarded as initial data. As mentioned earlier, to reduce distortions in the roadway safety results, exposure to traffic was taken into consideration. Therefore, traffic flow in terms of AADT and VMT was factored in to generate safety indicators/rates, including fatality rates (fatalities per 100 million VMT), injury rates (injuries per million VMT), and accident rates (total crashes per million VMT). The three safety indicators/rates were then categorized into four groups:

1. PPP highways (nine operational PPP projects),
2. localities/cities (11 counties/cities of the selected PPP projects),
3. comparable non-PPP public projects (17 highways in the same localities as the PPP projects in Texas, Colorado, and Virginia; the states with more accessible data), and
4. states (five states with the selected PPP projects).

Statistical analysis was performed on the data to check the differences, analogies, and statistical significances of the groups. The analysis was done in four phases:

1. a broad group comparison of the annual means/averages of the safety rates (fatality, injury, and crash rates) of each group for 2011 to 2014.
2. individual project comparisons in which the annual safety rates of each PPP project were compared to those of local, non-PPP highway projects, each project’s locality/city, and its state,
3. individual project comparisons in which the average over the available years from 2011 to 2015 was compared to that of non-PPP highway projects, each project’s locality/city, and its state, and
4. tests of the hypothesis that the PPP group safety performance would be better than that of the state-level group, locality/city-level group, and the non-PPP project-level group.

Three hypotheses were tested, and the R statistical application was used for this purpose.

4.3 Analysis of Contractual Safety Terms (Task 5)

A content analysis of the collected procurement and contract document was conducted to investigate how safety was managed and accounted for in current U.S. PPP projects. The relevant contractual terms, including but not limited to safety-related payments, roadway safety performance measurements, and safety specifications in the selected PPP projects, were identified and analyzed in this task.

A set of steps was implemented for the analysis. First, the introduction chapter in the Concession Agreement of each PPP project was reviewed. Almost all of the selected projects contained a section named “contract document.” This section listed all the documents related to the contract. Therefore, by referring to the list, this study could ensure that all the necessary documents related to the selected project were collected. By checking this document list, this study ensured that the collected documents were complete and enough for analysis. For example, for the I-4 Ultimate project, a new PPP roadway project in Florida, this study first checked Chapter 1.4 – Contract Document (p.18) in the Concession Agreement. The completed document package of the I-4 Ultimate project consisted of Concession Agreement Volume I, Supplemental Agreements with Respect to Volume I, Alternative Technical Concepts, Amendments with Respect to Project Commitments, Project Commitments, Amendments with Tespect to Volume II (Technical Requirements), Volume II (Technical Requirements), Amendments with Respect to Volume III (Additional Mandatory Standards), Volume III (Mandatory Standards), Appendix 2 (Concessionaire’s Proposal Commitments), Special Provisions, Technical Special Provisions, Revisions to the Plans, Plans, Design Standards and Governing Regulations, and Standard Specifications.

Second, the collected document package of each project was divided into four categories, including the bidding document (Appendix A), contract document – Part I Design and Operation (Appendix B), contract document – Part II Safety Incentives and Payments (Appendix C), and contract document – Part III Safety Incidents or Accidents (Appendix D) . The analysis was based on these four categories, and a set of questions was designed for each category to fully understand the usage of contractual safety terms for roadway safety management in PPP projects. These questions have been summarized as follows:

In bidding documents:

1) Is roadway safety one of the project's significant objectives?
2) Is safety one criterion to evaluate PPP proposals?
3) Will the project assign any evaluation points or other measuring system to roadway safety in the bidding documents?

In Contract Document – Part I Design and Operation

1) Are there any contractual terms containing special structural design or extra roadway elements to improve roadway safety?
2) Are there any contractual terms containing extra or special operational requirements to improve roadway safety?
3) Are there any contractual terms containing a request for installation of any devices to collect roadway safety data?

In Contract Document – Part II Safety Incentives and Payments

1) Does the project contract contain incentive payments to improve safety?

2) Does the project contract contain safety payments?
3) Does the project contract include traditional sections for general roadway safety precautions?
4) Have the contract documents provided historical safety records/data of the project or the locality of the project?
5) Have the contract documents provided any compensations / reimbursements for safety improvement?
6) Have the contract documents included any deductions for unsatisfactory safety performance?

In Contract Document – Part III Safety incidents or accidents:

1) Do the contract documents require the project concessionaire to collect (record and manage) roadway safety data?
2) Do the contract documents require the project concessionaire to report the collected roadway safety data?
3) Do the contract documents require the highway agency to record and report roadway safety incidents or accidents?
4) Do the contract documents require an independent agency or third party to record and report roadway safety incidents or accidents?
5) Do the contract documents require the project concessionaire to manage the roadway incidents or accidents?
6) Do the contract documents require the project concessionaire to carry out roadway emergency maintenance after accidents?

7) Do the contract documents require the project concessionaire to carry out capital work in response to repeated accidents?

Finally, a comprehensive search of all the contract documents of each target project was carried out. The search keywords included but were not limited to “safety,” “traffic management,” “data collection,” “payment,” “incentive/reward,” “deduction,” and “crash/accident.” In this step, all contractual terms with one or more of these specific keywords were considered to meet the requirements of this study, and a careful look at the marked contents was conducted. As an example, the search findings of the I-4 Ultimate project are summarized as follows:

- In its RFQ, the project adopted an availability payment mechanism, described as follows: “The periodic payments made by FDOT to the Concessionaire upon opening of the Project to traffic in its final configuration. Entitlement to the Availability Payment will generally be based on the availability of the project to vehicular traffic and Concessionaire’s conformance with other operation and maintenance criteria established in the Concession Agreement” (p.7).
- In the Concession Agreement, the contents related to the keywords were as follows::
  1) Article 6.2.1 General Obligation, one of concessionaire’s general obligations was to carry out the O&M works within the applicable O&M limits in accordance with any safety compliance order and the safety plan (p.50).
  2) Article 6.8.2.3 required that the concessionaire should perform and comply with the provisions of Technical Volumes concerning Emergencies, Incident Response, Safety and Security, including implementing all procedures, plans, protocols and requirements set forth in Section 4 of the Technical Requirements and the Emergency management plan.

3) Article 7.4 Monetary Deductions assessed for certain noncompliance mentioned, "Potential harm and detriment to Users, which may include additional wear and tear on vehicles and increased costs of congestion, travel time and accidents" (p.65).
4) Article 9, Safety Compliance stated, "Concessionaire shall implement all safety compliance as expeditiously as reasonably possible following issuance of the safety compliance order" (p.80).
5) Article 12 related to Payments to concessionaire (p.100), and Appendix 22 included Bonus Work Elements (BWE) and BWE payments. However, no traffic safety incentives were mentioned in the contract.
6) Article 19.2.3 described the remedies for failure to meet safety standards or performance safety compliance, but the "safety" refers to construction safety, not traffic safety.
7) Appendix 3 (Periodic Payment, final acceptance payments and final acceptance payment adjustments) and Appendix 6 (Payment Mechanism) summarized the formulas to calculate an availability payment (annually and quarterly) and unavailability adjustments. However, no safety aspect was considered.

- In the Technical Requirements, the contents related to the keywords were as follows:

1) In the general project objectives, one term mentioned "timely facility management and capacity improvements to maintain adequate service levels," but there was no direct requirement for improving traffic safety performance.
2) In the beginning description of the O&M, it mentioned that "the operations and maintenance criteria have stringent requirements with respect to safety, operation activities, and maintenance activities as required in order to provide a safe environment for the public's use of the facilities" (p.351).

3) In Section 4 (Operation and Maintenance Requirements), Chapter 1.8 Safety, stated, "Concessionaire shall follow all safety requirements of the Contract Documents, including those outlined in the National Electric Safety Code (NESC) and the Occupational Safety and Health Administration (OSHA). Concessionaire is solely responsible for the safety of all its personnel and shall be solely responsible for maintaining the safety required and providing safety equipment and procedures for the protection of employees and the public throughout the OM limits" (p.363).
4) In Section 4, Chapter 3.9 Traffic Operations stated, "FDOT will be responsible for monitoring safety and operations issues on the project. Concessionaire shall conduct awareness meetings with traffic operations staff every 3 months to review any safety or operations issues on the project. FDOT will conduct traffic safety studies, review crash data annually and identify crash patterns. Concessionaire should coordinate with FDOT and also shall request approval from FDOT for revisions and modifications to speed limits" (p.393).
5) In Section 4, Chapter of Operation Requirements (p.385) included, "concessionaire shall be responsible for operating the project with the main objectives of maximizing safety, reliability and roadway availability."
6) In Section 4, Table 4.1 to 4.4 provided the specific requirements for operation (p.410). However, there were no terms related to particular traffic safety performance.

- In Volume III, Additional Mandatory Standards, section 1.3.7 Safety included the collection of crash data. Crash data were analyzed to determine high crash roadway sections, the types of crashes that occurred, and the associated economic loss per year associated with those roadway sections on I-4 within the project study area. The crash summary included information on location, the number of fatalities/injuries, crash rate, safety ratios, and economic loss. Safety ratio was defined as the ratio between the actual crash rate and the critical crash rate. The actual crash rate is a function of the roadway section length multiplied by the annual number of vehicles in relation to the number of crashes. The critical crash rate is a function of the roadway section length, the traffic volume, and the statewide average crash rate for similar roadway facilities. A safety ratio equal to or greater than one (1.00) indicates that the facility is experiencing more crashes than would be typically anticipated on this type of facility. The higher the safety ratio, the greater the hazard. However, this safety ratio was used only for identifying high hazard locations. There were no connections between the safety ratio and compensations paid to private contractors.

4.4 Case Study: Proactive Mechanisms for Safety Improvement

Public agencies should have a range of options or explore new ones to enforce operating or achieving higher standards, exemplified by lowering the number of crashes, fatalities, and injuries in PPP projects. A number of options are described below using real PPP project examples or international PPP practices.

4.4.1 Sea To Sky (STS) Highway

4.4.1.1 Project Description

The Sea-to-Sky (STS) Highway is a 95-km section of Highway 99 between West Vancouver and Whistler, BC. In order to improve the safety, reliability, and capacity of the existing STS highway, in 2005, a 25-year design-build-finance-operate (DBFO) concession agreement was signed between the British Columbia Ministry of Transportation (BCMOT) and the S2S Transportation Group (S2S). The concessionaire S2S included a) Macquarie, the financial advisor; b) Peter Kiewit Sons Co., the project design/build contractor; c) JJM

Construction Limited, a British Columbia road builder; d) Hatch Mott MacDonald (HMM), a transportation consultant; e) Miller Paving, the highway operator; and f) Capilano Highway Services, a provider of maintenance and operations. A maximum $600 million capital commitment was approved in 2003 for improving the STS highway, and the improvements were completed by 2009. The improvements were expected to achieve BCMOT's long-term roadway goals for accommodating population and economic growth, increasing traveling demand, and increased goods movement in the project communities. The major objective for the STS Improvement project consisted of 1) improving the safety of the highway, 2) improving its reliability (*e.g,*. travel time predictability), 3) enhancing the ability of the highway to satisfy increasing traveling demand, 4) following strict project completion time and budget control, and 5) actively managing traffic flows during construction phase (BCMOT 2005).

4.4.1.2 Payment Mechanism

The contract adopted a performance-based payment for the STS. No traditional capital payment (milestone payments during construction) were involved in the payment mechanism of the STS Project (Abdel Aziz 2015). According to the Schedule 10 – Payments, the payment mechanism used in STS comprised the following parts: 1) total performance payments, 2) availability payments and non-availability deductions, 3) operation and maintenance performance deduction, 4) vehicle usage payment, 5) performance incentive payments, and 6) end-of-term payments. Figure 4.1 is a snapshot of a summary table from the Value-for-Money Report of the STS Project, which shows the expected performance payment to the concessionaire S2S for each contract year.

PAYMENT COMPONENTS UNDER DBFO ($ Millions) (Nominal dollars assuming two per cent inflation and Provincial Base Case Traffic Forecast)								
Contract Year	Year Ended 31-March	DBFO Availability Payments	DBFO Volume Usage Payments	DBFO Performance Incentive Payments	DBFO End of Term Payment	MoT Design Build Contracts	MoT + DBFO Total Payments	Non-Risk Adjusted PSC
1	2006 and prior	6.6	0.0	0.7	0.0	56.4	63.7	87.8
2	2007	14.0	0.0	1.0	0.0	7.8	22.8	25.0
3	2008	18.7	0.0	1.3	0.0	10.9	30.9	45.0
4	2009	28.7	0.0	1.9	0.0	13.2	43.8	57.9
5	2010	49.5	5.2	1.1	0.0	15.0	70.8	60.4
6	2011	52.3	10.1	1.0	0.0	16.8	80.2	60.1
7	2012	52.7	9.9	1.0	0.0	16.8	80.4	60.1
8	2013	53.1	10.0	1.1	0.0	16.8	81.0	60.4
9	2014	53.5	10.1	1.1	0.0	16.8	81.5	60.8
10	2015	53.9	10.1	1.1	0.0	16.8	81.9	61.1
11	2016	54.4	10.2	1.1	0.0	16.8	82.5	61.5
12	2017	54.8	10.2	1.1	0.0	16.9	83.0	66.0
13	2018	55.2	10.3	1.1	0.0	16.9	83.5	62.2
14	2019	55.7	10.4	1.1	0.0	16.9	84.1	68.5
15	2020	56.1	10.4	1.1	0.0	16.9	84.5	69.4
16	2021	56.6	10.5	1.1	0.0	16.9	85.1	69.8
17	2022	57.1	10.6	1.1	0.0	16.9	85.7	70.4
18	2023	57.6	10.7	1.1	0.0	16.9	86.3	71.0
19	2024	58.1	10.7	1.1	0.0	16.9	86.8	71.7
20	2025	58.6	10.8	1.2	0.0	16.9	87.5	72.3
21	2026	59.1	10.9	1.2	0.0	16.9	88.1	75.1
22	2027	59.6	11.0	1.2	0.0	16.9	88.7	75.9
23	2028	60.2	11.1	1.2	0.0	16.9	89.4	76.9
24	2029	60.7	11.2	1.2	0.0	16.9	90.0	82.9
25	2030	61.3	11.3	1.2	50.0	16.9	140.7	98.5
Total		**1,248.1**	**215.7**	**28.4**	**50.0**	**440.7**	**1,982.9**	**1,670.7***

Figure 4.1 The Value for Money Report of the STS project

The total performance payment ("TPP_n") in contract year *n* would be determined by the following function:

$$Tpp_n = AP_n + VUP_n + PIP_n + IA_n - ACR_n + EOTP \quad \text{Eq. 4.1}$$

where:

TPP_n = Total performance payment for contract year n

AP_n = Availability payment for contract year n calculated in accordance with a non-availability deduction

VUP_n = Vehicle usage payment for contract year n

PIP_n = Performance incentive payments for contract year n

IA_n = Insurance adjustment

ACR_n = Asset condition retention for contract year n in accordance with paragraph 3 of Part 4 of the Schedule 10 of the STS Project

$EOTP$ = The end-of-term payment

The vehicle usage payment accounted for 10 percent to 15 percent of the TPP_n, which aimed to incentivize the concessionaire to achieve the project objectives of improving highway reliability and capacity as well as increasing current traffic volume.

As the major payment type used in the STS Project, the share of the availability payment was over 80 percent of the TPP_n. A set of performance measures was established to evaluate the availability of the transportation facility and the performance of the O&M services (Abdel Aziz 2007a). Through an availability payment, the government aimed to maximize the project's lane availability, minimize traffic disruptions, and ensure a well-maintained condition of the facility. A non-availability deduction mechanism was also included in the availability payment. Three major deduction payments adopted in the STS Project were unavailability deduction for lane closures, the traffic delay deduction, and performance deductions for non-conformity with O&M standards.

To ensure that project assets would be in acceptable condition at contract expiration, the STS Project implemented an end -of-term payment in the TPP_n. The total amount of the end-of-term payments was $31.1 million, and the government adopted an inspection process on which a monthly retention would be assessed (Abdel Aziz 2007a).

The TPP_n in any contract year *n* could not exceed the annual affordability ceiling for that contract year *n*; however, the performance incentive payments, consistimg of a safety performance payment (SPP_n) and a traffic management payment (TMP_n), was not within the government maximum payment requirement. These performance incentive payments were regarded as a pure bonus for the STS highway to encourage the concessionaire to meet or exceed required standards.

The next section provides a detailed description of the implementation of safety performance payment in the performance incentive payments.

4.4.1.3 Safety Payment

The design of a payment mechanism for a PPP should reflect the government's specific objectives in the project (Treasury 2003). Traffic safety was an important objective and was paid significant attention during project planning. Therefore, a safety incentive payment was included as part of the performance incentive payments in the contract payment mechanism. The concessionaire was entitled to this incentive payment only if the highway safety performance exceeded the provincial safety performance record for comparable highways on a three-year rolling average basis. The contract also stated that for the first two contract years, when the three-year rolling average would be unavailable, the respective one- and two-year averages would be used for calculation. Since the safety performance would be measured and compared on an annual basis, the incentive payment would be paid annually rather than monthly as in some other projects. Three categories of accidents were used to measure project safety performance, including fatalities, injuries, and property damage. For the STS highway, the safety incentive payment was a pure incentive payment, and it was not within the government annual affordability ceiling for the project (Abdel Aziz 2007a).

The total amount for the safety incentive payment in the base data was $1,000,000. An adjusted formula considering the actual safety performance was used to calculate the final payment compensating concessionaire. The safety performance payment (SPP_n) in contract year *n* was calculated as follows:

$$SPP_n = SPP_0 * \left[1 + F * \left(\frac{CPI_n}{CPI_0} - 1\right)\right] * SPPR_n \quad (4.2)$$

where:

$SPPn_0$ = The safety performance payment in contract year *n*

SPP_0 = The safety performance payment in based date prices, being $1,000,000

F = Indexation factor of 0.35

$SPPR_n$ = The safety performance payment reduction percentage in contract year *n*

CPI_n = The Consumer Price Index in contract year *n*

CPI_0 = The Consumer Price Index in the project's based date

The safety performance payment reduction percentage (SPPR*n*) in contract year *n* was calculated by reference to the actual safety performance compared to the relevant average number of accidents for comparable highways in accordance with the following formula:

$$SPPR_n = 3 - \frac{2*AAN_n}{PAN_n} \quad (4.3)$$

where:

AAN_n = The actual average number of accidents on the STS highway in contract year *n*

PAN_n = The provincial average number of accidents in contract year *n*

An $SPPR_n$ calculated with the above function that was less than or equal to zero would mean that the safety performance provided by the concessionaire failed to exceed the Provincial average. In that case, no safety performance payment would be paid to the concessionaire in that contract year. An $SPPR_n$ equal to or greater than 1.0 would mean that the safety performance was acceptable. In this case, the $SPPR_n$ would be deemed to be 1.0, and the full safety performance payment would be payable in that
contract year.

The Province provided the concessionaire with the relevant safety statistics for determining the provincial average number of accidents. The statistics were derived from independent sources, such as Highway Accident Statistics (HAS) and Royal Canadian Mounted Police (RCMP) records. The relevant provincial average number (PAN_n) was calculated as the benchmark to evaluate safety performance of the STS highway through the following formula:

$$PAN_n = \sum_{ac} AACRK_n * LK \tag{4.4}$$

where:

PAN_n = The provincial average number of accidents for contract year *n*

$AACRK_n$ = The average accident category rate per lane kilometer

LK = The number of lane kilometers for the STS Highway

Figure 4.2 presents the relationship between the ratio of AAN to PAN and the corresponding SPPR. The range of SPPR is from 0 to 3. If the highway's number of accidents was 50 percent more than the provincial average (AAN/PAN=1.5), then the SPPR would equal 0, and the concessionaire would get no safety incentive. If the number of accidents was the same as the provincial average (AAN/PAN=1), then the concessionaire would get a full-base incentive payment ($1,000,000); if the highway's number of accidents was 10 percent less than the average, then the concessionaire would get 120 percent of the base incentive pay. This relationship would continue until the highway had zero accidents, and the concessionaire would get the maximum 300 percent of the base payment.

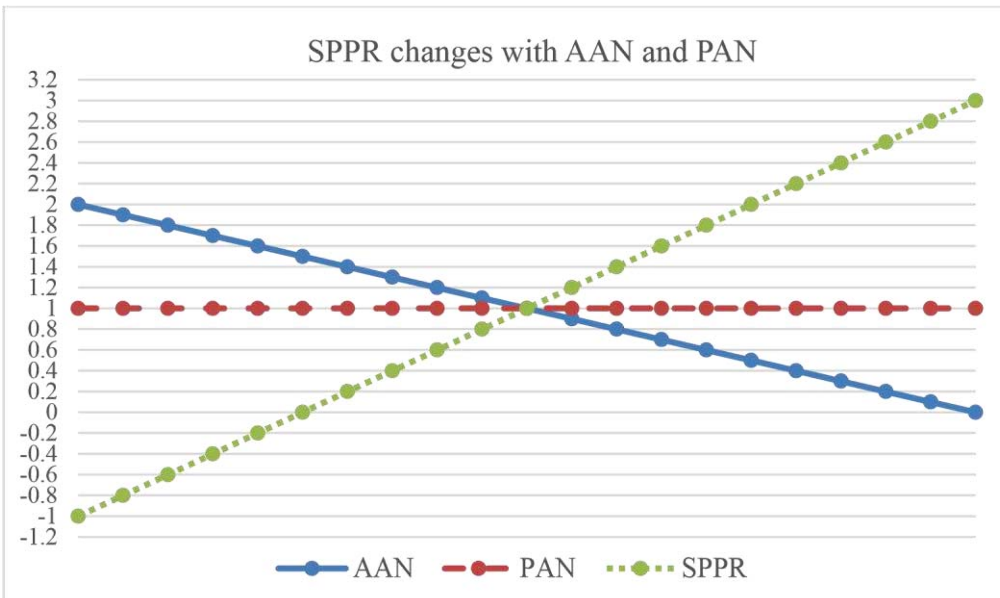


Figure 4.2 The mechanism of the SPPR formula

4.4.2 William R. Bennett Bridge in British Columbia

4.4.2.1 Project Description

The original Okanagan Lake Bridge, as part of Highway 97, linked the City of Kelowna on the east side of Okanagan Lake to the west side of the lake. The existing bridge, which crossed the 120-kilometer long lake, failed to satisfy increasing traffic demands from the communities and also had a high accident rate. A 30-year concession agreement was finalized in 2005 between

SNC-Lavalin and the Province for delivery and long-term operation of a new project, the William R. Bennett Bridge. The concessionaire, SNC-Lavalin, was responsible for designing, constructing, operating, maintaining, and rehabilitating the new bridge. Additionally, the concessionaire needed to decommission the existing Okanagan Lake Bridge as soon as the new bridge was open. The new bridge would form part of Highway 97, linking Okanagan Lake between Kelowna and Westbank, at a location immediately adjacent and parallel to the existing Okanagan Lake Bridge. A set of objectives was established by the British Columbia Ministry of Transportation, including 1) to meet immediate and mid-term traffic demand; 2) to reduce the total estimated capital cost by achieving PPP value for money; 3) to secure the usable 75-year design life of the bridge; and 4) to improve the long-term safety performance of the bridge (BCMOT 2005).

Figure 4.3 Map of the Okanagan Bridge area from the Value for Money report (BCMOT)

4.4.2.2 Payment Mechanism

The Province made annual payments to SNC-Lavalin based totally on performance. No minimum performance payments and no portion of the performance payments were guaranteed. The payment mechanism of the William R. Bennett Bridge consisted of a traffic volume payment (usage payment), a lane availability payment, safety performance payment, users satisfaction payment, and a set of performance deductions. These payments were not started until the bridge was open to the public. Therefore, no traditional capital payments were included in this project. The total payment made to the concessionaire, called the enhanced service performance payment for the William R. Bennett Project, was calculated in accordance with the function below:

$$ESPP_n = TVP_n + LAP_n + SPP_n + USP_n - PD_n \tag{4.5}$$

where:

$ESPP_n$ = the enhanced service performance payment for contract year n

TVP_n = Traffic volume payment for contract year *n*

LAP_n = Lane availability payment for contract year *n*

SPP_n = Safety performance payment for contract year *n*

USP_n = Users satisfaction payment for contract year *n*

PD_n = Performance deductions for contract year *n*

For the enhanced service performance payment (total payment), the traffic volume payment (usage payment) accounted for about 25 percent to 30 percent, which was approximately double that of other similar projects (Abdel Aziz 2007a). Through a high traffic volume payment, the Province aimed to ensure that the concessionaire would optimize traffic capacity for the new bridge and ensure that the payment would cover the potential high O&M costs caused by the increasing traffic volumes. However, traffic bands and shadow toll used for calculating the traffic volume payment were allowed to be adjusted for the occurrence of a “traffic volume change event,” which was defined in the contract as government-sponsored capital works (e.g., construction of a second crossing), construction or removal of interchanges and interchanges and intersections, or widening or narrowing of roads on the main bridge highway (Abdel Aziz 2007a).

The lane availability payment was another major payment used for the William R. Bennett Bridge Project and accounted for approximately 60 percent of the total payment. This payment was structured to maximize lane availability and to ensure the reliability of the new bridge. Lanes were identified as "unavailable" except for expected closures. The unavailability deductions were included in calculating the overall lane availability payment.

Unlike the STS Highway, for which where the safety performance payment was regarded as a pure bonus, the safety performance payment for the William R. Bennett Bridge was a core payment within the overall payment. Adjustments were made to the safety performance payment for the William R. Bennett Bridge project on the basis of a table of accident severity ratio and accident frequency. This payment is discussed in detail in the next section.

The users satisfaction payment was set to be within 1 percent of the total payment . The base payment was adjusted annually according to results of a user satisfaction survey.

4.4.2.3 Safety Payment

As with the STS Highway Project, the Province measured the project's safety performance on a three-year rolling average basis. For the first two contract years, for which the three-year average was not available, a respective one- and two-year average was used. The safety performance payment (SPP_n) was calculated as follows:

$$SPP_n = SPPB * SPPR_n * [1 + (IF_{SPP} * PPI_n)] \tag{4.6}$$

where:

SPPB = Safety performance payment base. If contract year *n* is less than one year, this amount will be reduced in proportion to the number of days in the relevant contract year relative to 365.25.

$SPPR_n$ = The applicable safety performance payment ratio is determined in accordance with severity ratios and accident frequencies (figure 4.4).

IF = Indexation factor

PPI = Performance price index in contract year *n*, which consists of the labor index, the fuel index, and the residual index.

		Accident Frequency				
		0-7	8-15	16-22	23-30	>30
Severity Ratio	0-20%	DEL.	DEL.	DEL.	DEL.	DEL.
	20.01-40%	DEL.	DEL.	DEL.	DEL.	DEL.
	40.01-60%	DEL.	DEL.	DEL.	DEL.	DEL.
	60.01-80%	DEL.	DEL.	DEL.	DEL.	DEL.
	80.01-100%	DEL.	DEL.	DEL.	DEL.	DEL.

Figure 4.4 The applicable safety performance payment ratio

The three categories of accidents used to measure project safety performance were similar to those for the STS Highway Project, including fatalities, injuries, and property damage. The severity Rratio used in figure 4.4 was calculated as “the sum of the number of fatal accidents and the number of injury accident divided by the total number of accidents.” The severity ratio or the accident frequency or both set out in the table were to be re-calibrated every five years in accordance with changes of traffic volumes and overall safety performance on British Columbia highways. The benchmark would also be modified if police accident reporting standards materially changed. In the recalibration, some other safety data sets, such as a reference group of highways located within the area of the Okanogan Lake Bridge and a group of highways within British Columbia that were considered similar to the Okanogan Lake Bridge, would be used to compare with the police reported crashes on the William R. Bennett Bridge to assess the accuracy of police reported crashes.

4.4.3 The International PPP Market

According to Vassallo et al. (2009), in some European countries, including in Spain, Hungary, Norway, Finland, Portugal, and the United Kingdom, positive incentives based on explicit road safety indicators have become normal practice and continue to be improved in the most recent PPP contracts. Generally, the incentives in the PPP contracts of these countries can be divided into two types: incentives related to the project period and incentives related to monetary compensation. The first type can be found in the latest PPP toll roads in Spain. In these PPP projects, the concessionaire can be granted one or two additional years of operation of the road if the safety performance is better than the average of a comparator set of roads. Incentives related to monetary compensation include linking the assessment of safety performance to bonuses and penalties, which is similar to the STS Highway and William Bennet Bridge in B.C. For example, the United Kingdom widely implemented an “active management payment mechanism” in its PPP projects. A safety performance adjustment, as one element of the payment mechanism, is made to the PPP concessionaire’s compensation on the basis of the number of injuries, fatalities, or accidents that occur on the project in comparison to a benchmark determined from the safety performance of a comparator set of roads. Another way to provide incentives for improving safety in the UK is that the contractor is recompensed by receiving 2 percent of the economic cost of each traffic accident avoided in comparison to the previous project year

(https://wpqr4.adb.org/lotusquickr/copmfdr/PageLibrary482571AE005630C2.nsf/0/1F17A0493E8D6AC448257C12001FCA3F/$file/C ase%20Studies%20(combined))_Richard%20Foster.pdf).

Chapter 5 Results

5.1 Overview

The research results are presented separately on the basis of two major goals of the research. In Section 5.2, the results of an analysis of roadway safety data are discussed, and the findings helped us to generate conclusions about the relationship between roadway safety and the project delivery system. In Section 5.3, the results of a content analysis of the collected procurement and contract documents are discussed. The findings enabled the research team to explore the existence of, and the similarities and differences among, the safety-related contractual terms of the target projects and to establish an understanding of roadway safety management in current U.S. PPP market.

5.2 Roadway Safety Performance

5.2.1 Phase 1 – Broad Groups Comparison

As outlined in the research methodology, safety data were categorized into four groups: a state group, locality/city group, non-PPP projects group, and PPP projects group. Table 5.1(a) to table 5.1(c) show descriptive statistics for the fatality rate, the injury rate, and the accident rate indicators, respectively.

The injury rate for the PPP group was lower than that of the other three groups. The non-PPP comparable local highways showed a rate slightly higher than that of the PPP group. The range or gap increased significantly in comparison to those of the state and locality groups. This was true for all the statistics, including the minimum, the quartiles, the median, and the mean. It is also clear that the standard deviation of the PPP group was less than those of the other groups. On the basis of the descriptive analysis, it is fair to say that the injury and crash rates for the PPP group were better than those of the other state, locality, and comparable public highway groups. The fatality rate followed a similar, but not exact, trend for most years, except 2013.

Table 5.1 Descriptive statistics of safety rates by data groups, years 2011-2014.

(a) Fatality rate

Year	Groups	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.	S.D.
2014	State Level Benchmark	0.86	0.88	1.04	1.09	1.24	1.42	0.24
	Locality Level Benchmark	0.00	0.46	0.88	0.69	0.88	1.05	0.37
	Non-PPP Project Benchmark	0.00	0.00	0.25	0.54	0.80	3.33	0.81
	PPP	0.00	0.00	0.00	0.15	0.10	0.81	0.30
2013	State Level Benchmark	0.92	0.94	1.03	1.10	1.25	1.39	0.21
	Locality Level Benchmark	0.49	0.60	0.85	0.93	1.12	1.81	0.40
	Non-PPP Project Benchmark	0.00	0.00	0.28	0.36	0.48	1.35	0.40
	PPP	0.00	0.09	0.38	0.75	0.73	2.92	1.11
2012	State Level Benchmark	0.92	0.96	1.01	1.12	1.27	1.44	0.22
	Locality Level Benchmark	0.72	0.80	1.01	1.23	1.25	2.74	0.62
	Non-PPP Project Benchmark	0.00	0.23	0.45	0.76	0.71	3.99	1.09
	PPP	0.00	0.00	0.00	0.55	0.32	2.86	1.15
2011	State Level Benchmark	0.89	0.94	0.96	1.06	1.25	1.27	0.18
	Locality Level Benchmark	0.44	0.69	0.81	0.89	1.08	1.65	0.35
	Non-PPP Project Benchmark	0.00	0.00	0.36	0.38	0.63	1.16	0.37
	PPP	0.00	0.00	0.00	0.13	0.00	0.67	0.30

Table 5.1 continued. (b) Injury rate

Year	Groups	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.	S.D.
2014	State Level Benchmark	0.21	0.71	0.78	0.73	0.81	1.12	0.33
	Locality Level Benchmark	0.25	0.82	1.28	1.19	1.35	2.52	0.64
	Non-PPP Project Benchmark	0.07	0.13	0.26	0.34	0.48	1.10	0.27
	PPP	0.01	0.02	0.07	0.12	0.17	0.39	0.14
2013	State Level Benchmark	0.21	0.70	0.81	0.72	0.81	1.10	0.32
	Locality Level Benchmark	0.31	0.88	1.27	1.23	1.33	2.81	0.68
	Non-PPP Project Benchmark	0.04	0.14	0.24	0.32	0.47	1.01	0.26
	PPP	0.00	0.05	0.07	0.08	0.12	0.17	0.06
2012	State Level Benchmark	0.21	0.70	0.80	0.72	0.83	1.04	0.31
	Locality Level Benchmark	0.29	0.72	1.21	1.19	1.33	2.87	0.68
	Non-PPP Project Benchmark	0.00	0.10	0.13	0.22	0.16	0.87	0.25
	PPP	0.01	0.03	0.05	0.06	0.07	0.13	0.04
2011	State Level Benchmark	0.21	0.71	0.80	0.69	0.81	0.95	0.29
	Locality Level Benchmark	0.28	0.84	1.21	1.21	1.36	2.83	0.68
	Non-PPP Project Benchmark	0.00	0.09	0.13	0.22	0.16	0.90	0.25
	PPP	0.01	0.03	0.05	0.06	0.05	0.14	0.05

Table 5.1 continued. (**c**) Accident rate

Year	Groups	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.	S.D.
2014	State Level Benchmark	1.48	1.71	1.92	2.02	2.15	2.82	0.51
	Locality Level Benchmark	1.31	1.59	1.65	2.00	2.12	4.01	0.83
	Non-PPP Project Benchmark	0.13	0.51	0.79	1.05	1.67	2.91	0.79
	PPP	0.01	0.18	0.33	0.31	0.47	0.60	0.22
2013	State Level Benchmark	1.51	1.65	1.82	1.97	2.15	2.71	0.48
	Locality Level Benchmark	1.32	1.53	1.68	2.08	2.55	3.44	0.79
	Non-PPP Project Benchmark	0.09	0.45	0.88	0.99	1.50	2.69	0.71
	PPP	0.01	0.28	0.32	0.35	0.48	0.68	0.23
2012	State Level Benchmark	1.48	1.53	1.76	1.91	2.16	2.62	0.48
	Locality Level Benchmark	1.23	1.39	1.73	2.44	3.21	6.12	1.49
	Non-PPP Project Benchmark	0.14	0.45	0.64	0.87	1.36	1.98	0.57
	PPP	0.01	0.27	0.29	0.32	0.46	0.54	0.19
2011	State Level Benchmark	1.19	1.54	1.91	1.91	2.17	2.73	0.59
	Locality Level Benchmark	1.32	1.36	1.68	2.03	2.61	3.55	0.83
	Non-PPP Project Benchmark	0.15	0.43	0.52	0.80	1.36	1.91	0.58
	PPP	0.01	0.25	0.27	0.36	0.46	0.79	0.29

To further explain the behavior of the safety rates of the four groups over the years, figure 5.1 illustrates the mean for safety performance over the study period, 2011 to 2014. As presented in figure 5.1(a), the fatality rate of the PPP group was lower than the fatality rates of the state-level and locality-level benchmarks in each year from 2011 to 2014. Therefore, a hypothesis could be made that the safety performance of PPP projects would be better than the fatality rate benchmarks of the state and locality levels. In comparing the PPP group with the non-PPP project-level benchmark, however, it is hard to make a similar hypothesis. This is because in 2013, the PPP group had a higher fatality rate than the non-PPP project-level benchmark, and in the other years, the fatality rates of the PPP group were also close to the those of non-PPP project-level benchmark.

As shown in figure 5.1(b) and figure 5.1(c), the injury rates and crash rates of the PPP group were far lower than the state- and locality-level benchmarks in each year from 2011 to 2014. The PPP group also had a lower injury rate and crash rate than the non-PPP project-level benchmark in each year. Therefore, in terms of injury rate and crash rate, the hypothesis could be made that the safety performance of PPP would be better than the state-, locality-, and non-PPP project-level benchmarks.

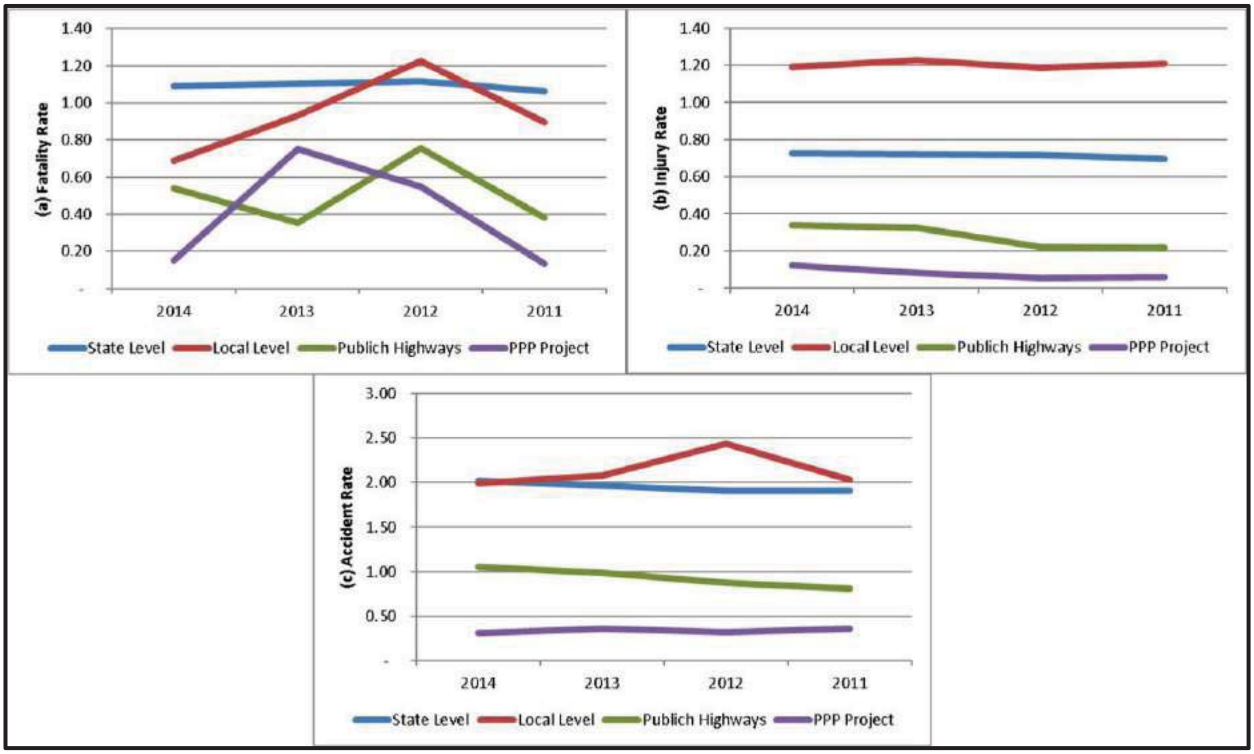


Figure 5.1 Fatality, injury, and accident rates for the state, locality, public highways, and PPP projects, mean performance over 2011 to 2014.

The main limitation in this research was the incomplete database. Of the PPP projects that responded to the data collection request, four of them were newly open to the public in 2014 or 2015, including LBJ 635, the North Tarrant Express, I-495, and I-95. Safety data before 2014 were unavailable for these four projects. In addition, many the state DOTs had not yet published their Annual Crash Facts reports or other kinds of roadway safety statistics for 2015. Thus, the 2015 benchmarks were missing for most of the PPP projects. Therefore, this analysis was tailored to address the research objective while dealing with the limitation of the database. For that reason, the other three phases of analysis were performed as explained below.

5.2.2 Phase 2 - Analysis of Individual PPP Projects to Their Benchmarks Year by Year

Unlike the broad group analysis shown in figure 5.1, which made overall group comparisons, in this phase, each PPP project was compared only with its local area benchmarks.

This was done for select projects that had reasonable/sufficient data for comparison. For example, the SH 130 PPP project was compared with the Texas state-level benchmarks, the Travis County locality-level benchmark, and the comparable non-PPP highways near this project. Within the same area, it was reasonable to assume that the unobserved factors that potentially impact roadway safety were similar, such as weather and driving behaviors. Therefore, the results would suffer less interference from unobserved factors. However, as mentioned above, because of the limitation of the database, only three PPP projects, including SH 130, the Dulles Greenway, and the Northwest Parkway, had relatively complete data from 2011 to 2014. Figure 5.2 to figure 5.4 present comparisons between each of the three PPP projects and their corresponding annual benchmarks.

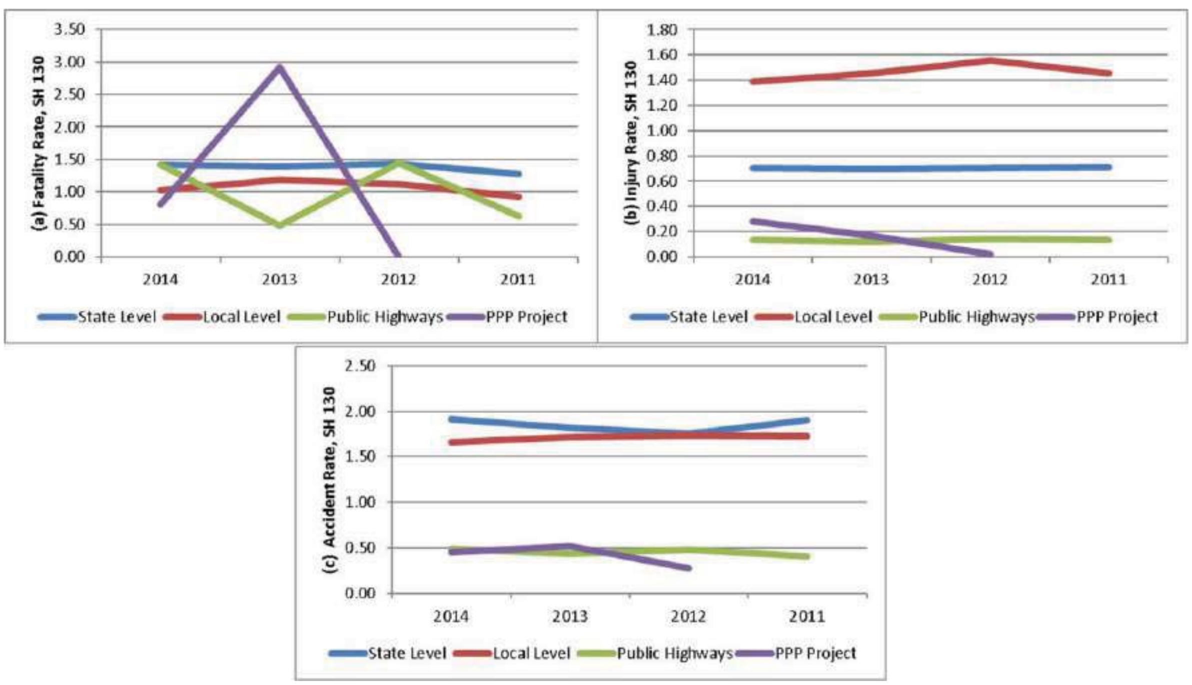


Figure 5.2 SH 130 project vs. the corresponding benchmarks from 2011 to 2014

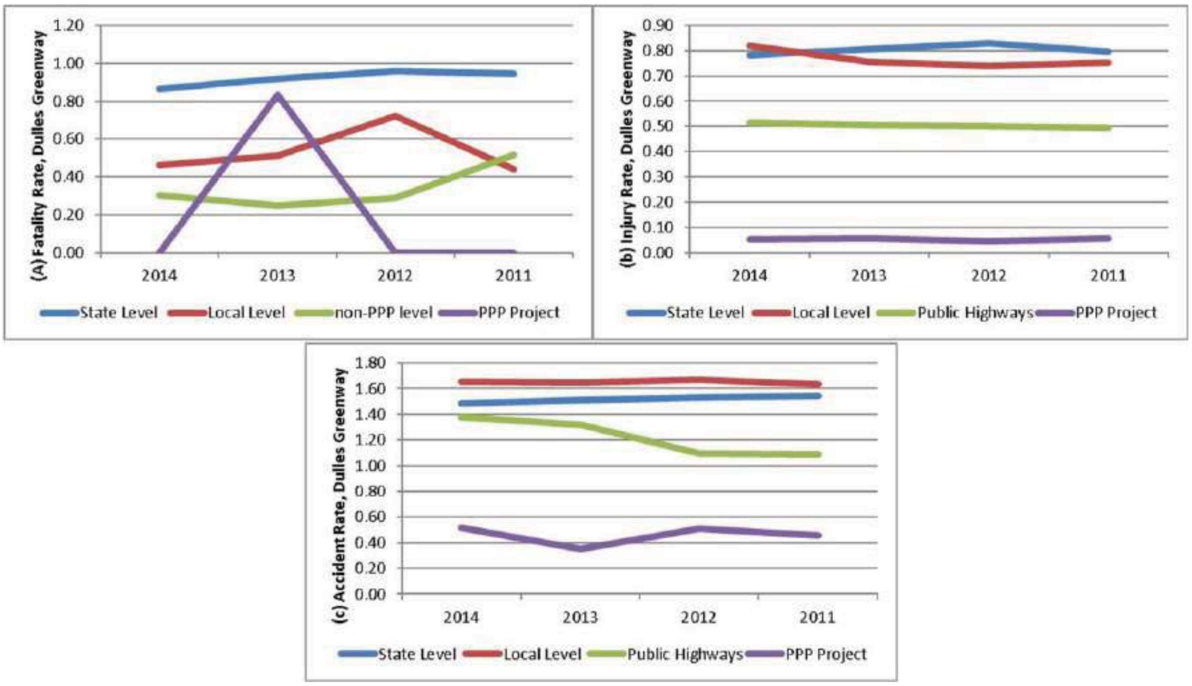


Figure 5.3 Dulles Greenway project vs. the corresponding benchmarks from 2011 to 2014

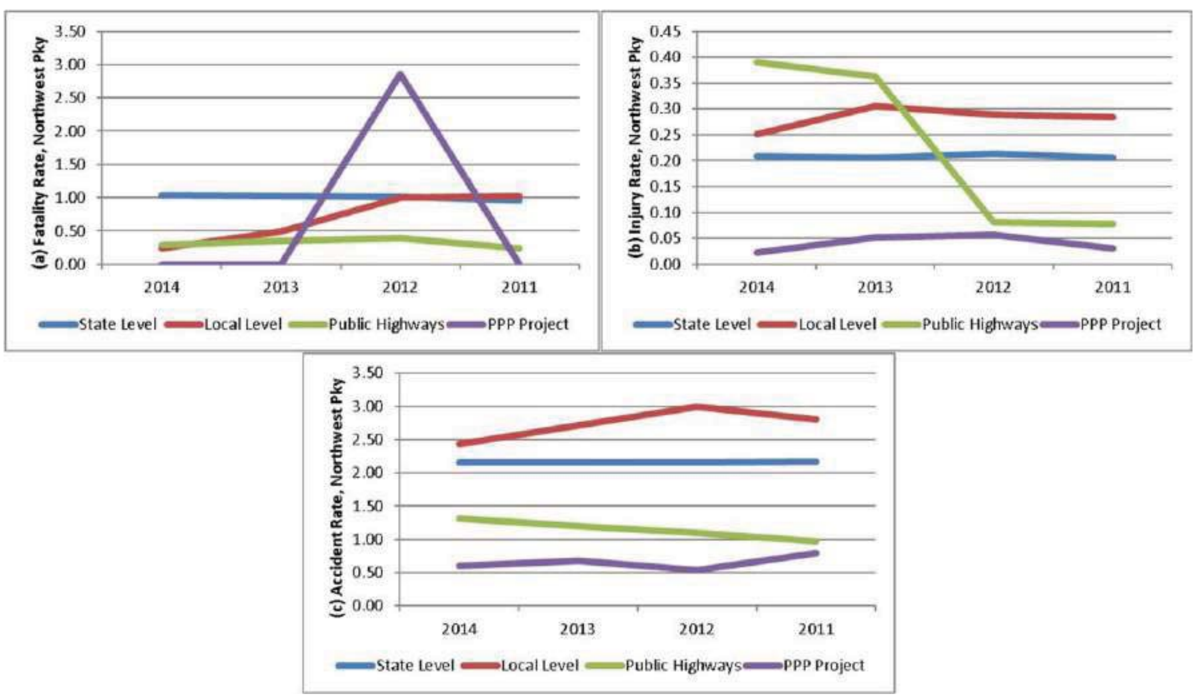


Figure 5.4 Northwest Parkway project vs. the corresponding benchmarks from 2011 to 2014

The analysis results, as presented in figure 5.2 to figure 5.4, can be described as follows. For the fatality rate, all of these three PPP projects showed an inconsistent performance. For instance, the fatality rates of Project SH 130 in 2012 and 2014 were lower than its benchmarks, but the project had a higher fatality rate in 2013. This was also the case for the Dulles Greenway and Northwest Parkway projects. For the Dulles Greenway, the fatality rate in 2013 was higher than the locality-level and non-PPP public highways benchmarks. For the Northwest Parkway, the fatality rate in 2012 was much higher than all the benchmarks of the three other levels. One possible reason for the inconsistent performance is that because the total number of fatalities was small, the change of a single unit (death) would have a very large effect on calculation of the final fatality rate.

For the injury rate and the accident rate, all three PPP projects had more consistent performance. For SH 130, both its injury rate and crash rate were much lower than the stat- and locality-level benchmarks but very close to the non-PPP public highways benchmark. For Dulles Greenway, its injury rate and crash rate were much lower than the benchmarks of the three other levels. Like the Dulles Greenway project, the injury rate and crash rate of the Northwest Parkway were also lower than the benchmarks of its three corresponding levels. Note that the injury rate of the non-PPP project-level benchmark for the Northwest Parkway project increased greatly after 2013. One explanation for the increase is that the Colorado public agency changed the reporting system in 2013, potentially making the data collection different than those in previous years.

5.2.3 Phase 3 - Analysis of Historical Means of Individual PPP Projects and the Benchmarks

In this phase, the research used the historical average safety performances from 2011 to 2015 to compare each PPP project with its corresponding average benchmarks. For those projects for which data were only available for some particular years, this study then took the average of those certain years. For example, for SH 130, safety performance was only available from 2012 to 2014. A three-year average performance was then used to compare with the corresponding general benchmarks. By doing this, those new PPP projects that had only one or two years of data could also be compared with the historical average benchmarks (see figure 5.5).

Note that because of the limitation of the database, we could not establish a causal model to determine, from a statistical point of view, whether PPP had an impact on roadway safety performance. In this study, we only implemented statistics to observe whether safety performances differed between PPP projects and their locality averages. A content analysis was used to explore the potential reasons for any differences or similarities in the statistical analysis.

Figure 5.5 shows that for some new PPP projects, such as LBJ 635, North Tarrant Express, and I-95, the average fatality rates, the average injury rates, and the average crash rates were far below the corresponding state-level, locality-level and non-PPP public highways-level benchmarks. This means these new PPP projects had better safety performance than their localities. One reason may be that these projects were recently open to the public. With new facilities, good road conditions, high design and operational standards, and relatively low traffic flow, it is reasonable that these three projects had better safety performance than their benchmarks.

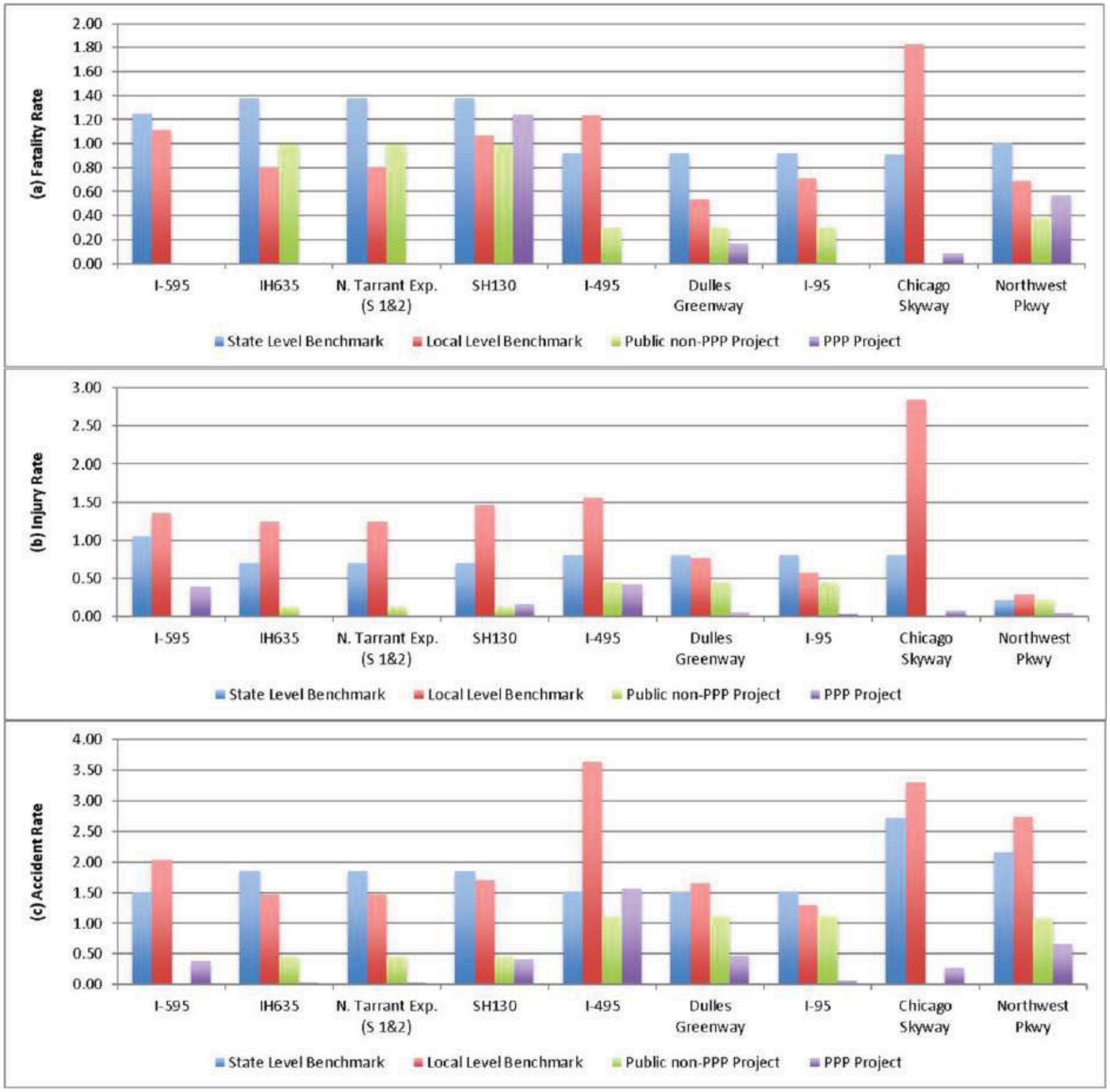


Figure 5.5 Single PPP project vs. the corresponding benchmarks: the historical average

For other PPP projects, generally, their safety performances were also much better than their state- or locality-level benchmarks. One reason is that some existing roads in the localities were old, and their design standards were below those of more recently built roads. Note that, for SH 130, this study found that its fatality rate was less than the state-level benchmark but slightly higher than the locality benchmark and the comparable project-level benchmark. This was consistent with previous findings.

5.2.4 Phase 4 - Comparison between the PPP Group and the Benchmark Groups

This phase of the analysis aimed to test the hypothesis to identify whether there were any differences between the safety performance of the benchmarks and that of the PPP projects. This phase compared the PPP group with the state-level, the locality-level, and the non-PPP public highways project-level benchmark groups. More than the General Descriptive Analysis phase, this phase used more involved statistical methods to check the significance of the results. The three hypotheses are summarized below:

1. **Null Hypothesis:** The safety performance of PPP group is equal to the safety performance of the state-level benchmark.

   Alternative Hypothesis: The safety performance of PPP group is better than the safety performance of the state-level benchmark.
2. **Null Hypothesis:** The safety performance of PPP group is equal to the safety performance of the locality-level benchmark.

   Alternative Hypothesis: The safety performance of PPP group is better than the safety performance of the locality-level benchmark.
3. **Null Hypothesis:** The safety performance of PPP group is equal to the safety performance of the non-PPP project-level benchmark.

   Alternative Hypothesis: The safety performance of PPP group is better than the safety performance of the non-PPP project-level benchmark.

Because the sample sizes of all the four groups were less than 30, the central limit theorem could not be employed. Therefore, we could not directly assume that the safety performances of the four groups were subject to the normal distribution. In fact, a preliminary test using the Chi-square goodness of fit showed that none of the four groups followed a normal distribution. Therefore, this study considered using the Mann-Whitney U Test to identify the difference of group means. This is a non-parametric test, and it does not necessarily require the population to follow a normal distribution. The analysis data covered the years from 2011 to 2014. The comparison results are presented in table 5.2 to table 5.4.

Table 5.2 M-W U Test for the difference of means - PPP roads and the state-level benchmark

(a) Fatal Rate				
Wilcoxon rank sum test with continuity correction Alternative hypothesis: true location shift is not equal to 0				
	2014	2013	2012	2011
W value	40	25	25	25
P-value	0.001339	0.04107	0.03793	0.00485
(b) Injury Rate				
Wilcoxon rank sum test with continuity correction Alternative hypothesis: true location shift is not equal to 0				
	2014	2013	2012	2011
W value	38	30	30	25
P-value	0.005155	0.003914	0.002165	0.005963
(c) Crash Rate				
Wilcoxon rank sum test with continuity correction Alternative hypothesis: true location shift is not equal to 0				
	2014	2013	2012	2011
W value	40	30	30	25
P-value	0.000777	0.003985	0.002165	0.003968

Table 5.3 M-W U Test for the difference of means - PPP roads and the locality benchmark

(a) Fatal Rate				
Wilcoxon rank sum test with continuity correction Alternative hypothesis: true location shift is not equal to 0				
	2014	2013	2012	2011
W value	63	47	55	48
P-value	0.004034	0.03601	0.01464	0.002629
(b) Injury Rate				
Wilcoxon rank sum test with continuity correction Alternative hypothesis: true location shift is not equal to 0				
	2014	2013	2012	2011
W value	70	60	66	50
P-value	0.0006115	0.0006278	0.0005256	0.001289
(c) Crash Rate				
Wilcoxon rank sum test with continuity correction Alternative hypothesis: true location shift is not equal to 0				
	2014	2013	2012	2011
W value	72	60	66	50
P-value	0.0003081	0.0006601	0.0005294	0.0013

In terms of the comparison between the PPP group and the state-level and locality-level benchmarks, this study found that, in each year from 2011 to 2014, the p values related to the fatality rates, injury rates, and crash rates were all less than the 0.05 significance level. In other words, we can say with 95 percent confidence that the fatality rate, injury rate, and crash rate of the PPP groups from 2011 to 2014 were lower than the state-level and locality-level benchmarks. Therefore, at the 0.05 significance level, the first two null hypotheses could be rejected, and it could be concluded that the PPP projects had better safety performance than their state- or locality-level benchmarks.

Table 5.4 M-W U Test for the difference of means - PPPs and the public highways benchmark

(a) Fatal Rate				
Wilcoxon rank sum test with continuity correction Alternative hypothesis: true location shift is not equal to 0				
	2014	2013	2012	2011
W value	68	32	55	38
P-value	0.0539	0.6661	0.03999	0.1879
(b) Injury Rate				
Wilcoxon rank sum test with continuity correction Alternative hypothesis: true location shift is not equal to 0				
	2014	2013	2012	2011
W value	75	65	59	47
P-value	0.02026	0.003631	0.01736	0.04043
(c) Crash Rate				
Wilcoxon rank sum test with continuity correction Alternative hypothesis: true location shift is not equal to 0				
	2014	2013	2012	2011
W value	81.5	60	61	45
P-value	0.005433	0.01383	0.009104	0.06297

In terms of the comparison between the PPP groups and the non-PPP public highways project-level benchmark, as shown in table 5.4, the p values of the fatality rate in years 2011, 2013, and 2014 were higher than the 0.05 significance level. In this case, it could not be concluded that the fatality rate of the PPP group was lower than the non-PPP project-level benchmark. However, most of the p values of injury rate and crash rate in each year were less than the 0.05 significance level, except for 2011. This means that we can say with 95 percent confidence that the injury and crash rates of the PPP group were lower than the non-PPP project-level benchmark. Therefore, for the fatality rate, the third null hypothesis could not be rejected, but for injury and crash rates, it could be concluded that at the 0.05 significance level, PPP projects would have better safety performance than the non-PPP projects.

5.3 Safety-Related Contractual Terms in the Target PPP Projects

For the content analysis, the procurement and contract documents of the 17 target PPP projects were carefully reviewed, and the results are summarized in table 5.5

Table 5.5 Content analysis: investigating questions

Document	Questions	YES(s)[1]	NO(s) or NM (s)[2]
Bidding Materials	a. Whether roadway safety is one project significant goal?	13	4
	b. Weather safety is one criteria to evaluate PPP proposals	9	8
	c. Will the project assign any evaluation points or other measuring systems to roadway safety?	6	11
	d. What the weight of roadway safety in proposal evaluation	2	15
Contract Document – Part I: Design & Operation	a. Are there any contractual terms containing special structural design or extra roadway elements to improve roadway safety?	7	10
	b. Are there any contractual terms containing extra or special operational requirements to improve roadway safety?	11	7
	c. Are there any contractual terms containing request of installation of any devices to collect roadway safety data?	4	13
Contract Document – Part II: Safety Incentives and Payments	a. Whether the project contract contains incentive payments to improve safety?	0	17
	b. Whether the project contract contains safety payments?	0	17
	c. Whether the project contract includes traditional sections for general roadway safety precautions?	17	0
	d. Have the contract documents provided historical safety records/data of the project or the locality of the project?	2	15
Contract Document – Part III: Safety Incident and Accidents	a. Whether the contract documents require the project concessionaire to collect (record and manage) roadway safety data?	4	13
	b. Whether the contract documents require the project concessionaire to report the collected roadway safety data?	1	16
	c. Whether the contract documents provide for the highway agency to record and report roadway safety incidents or accidents?	16	1
	d. Whether the contract documents provide for independent agency or third party to record and report roadway safety incidents or accidents?	1	16
	e. Whether the contract document require the project concessionaire to manage the roadway incidents or accidents?	17	0
	f. Whether the contract documents require the project concessionaire to carry out roadway emergency maintenance after accidents?	14	3
	g. Whether the contract documents require the project concessionaire to carry out capital work in response to repeated accidents?	11	6

1 YES(s): Projects would be marked as "Yes" only if containing certain contractual provisions that can answer the proposed questions. 2 NO(s) or NM(s): If projects not containing any contractual provisions related to the proposed questions, this study would mark the answers for such projects as "No or Not Mentioned."

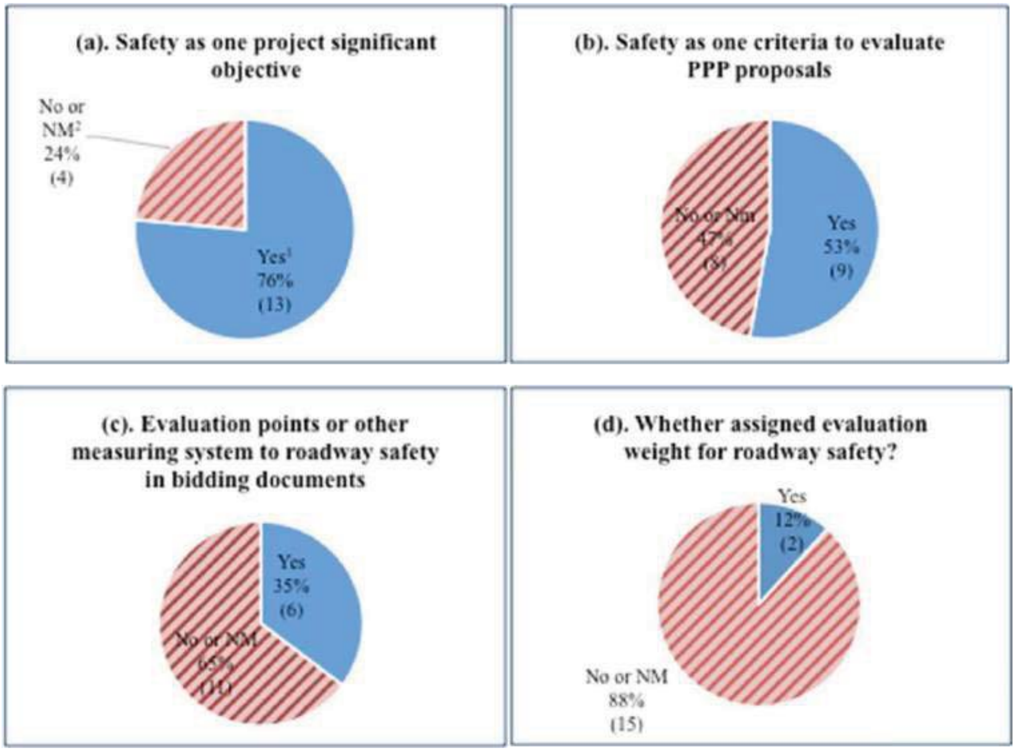
5.3.1 Bidding Documents

This section details the analysis of the bidding documents, including RFQs, RFPs, and parts of the concession agreements. The proposal evaluation criteria in the RFQ and RFP of each project were given more attention during the review. Table 5.6 summarizes the review of bidding documents for all selected 17 target projects. On the basis of the proposed questions in the previous chapter, this phase aimed to investigate whether roadway safety was considered an explicit objective in current PPP projects and how these bidding evaluation criteria reflected safety considerations.

Table 5.6 Review of the bidding documents

Project	Safety as one project significant objective	Safety as one criteria to evaluate PPP proposals	Evaluation Points or other measuring system to roadway safety	What the weight of roadway safety in proposal evaluation
I-4 Ultimate	YES	NO	NO	NM
Port of Miami	YES	NO	NO	NM
I-595	YES	YES	NO	NM
SR 125	NM	NO	NO	NM
Presidio Parkway	YES	YES	YES	NM
SH 183 Managed Lanes	YES	YES	YES	10%
LBJ 635 Managed Lanes	NO	NO	NO	NM
North Tarrant Express	YES	YES	NO	NM
SH 130 (Seg. 5 & 6)	NO	NO	NO	NM
Elizabeth River Tunnel	YES	YES	YES	NM
I-495 Express Lanes	YES	YES	NO	NM
I-95 Express Lanes	YES	NO	NO	NM
Pocahontas Parkway	YES	YES	YES	10%
Chicago Skyway	NO	NO	NO	NM
Indiana Toll Road	YES	YES	YES	NM
PR-5 and PR-22	YES	YES	YES	NM
Northwest Parkway	YES	NO	NO	NM

The investigation of the procurement documents emphasized two parts: 1) whether roadway safety was considered to be a significant goal in the project, and 2) how well the safety considerations were reflected in the bidding evaluation criteria. The results are shown in figure 5.6.



1 Projects marked as "Yes" only if containing certain contractual provisions that can answer the proposed questions. 2 NO(s) or NM(s): If projects not containing any contractual provisions related to the proposed questions, this study would mark the answers for such projects as "No or Not Mentioned".

Figure 5.6 Safety considerations in the bidding documents

In terms of safety objectives, as shown in figure 5.6(a), most of the target projects explicitly included safety as an important goal. Note that all of the 17 target projects contained separate chapters on safety to ensure that the projects met the safety standards required by the federal government (National Highway Traffic Safety Administration, NHTSA). Therefore, when answering the proposed questions of "a. whether safety is one project significant objective," only those projects that explicitly included safety as one of the project objectives were marked as "Yes." A total of 13 projects (76 percent) included such terms in their project objectives. For example,

- In the I-595 Improvements project, Florida, the contract required in the RFP Volume II that “the primary objectives throughout the Term of The Project are: … Maintain a high level of quality and safety provisions in the engineering, construction, maintenance and operations services provided by the Concessionaire …”
- In the Presidio Parkway project, California, the contract required in the RFP that “Sponsors’ goals for the Project are as follows: … B) Improve the operation or safety of the Presidio Parkway; … D) Improve the seismic, structural and traffic safety on Presidio Parkway…”
- In the SH 183 project, Texas, the contract required in the RFQ Section 2.1 – Description of the Project Objectives and Proposed Contracting Opportunity – that “ … (v) Implementing safe construction, operation and maintenance…”
- For the Elizabeth River Tunnel, Virginia, the contract required in the Solicitation for Conceptual (SFC) that “A successful project will satisfy the following transportation objectives: Increase capacity, reduce congestion and provide safety and efficient operations …”
- For the I-495 HOT Lanes, Virginia, the contract required in the Concession Agreement that “… (a) There is a public need for timely development and/or operation of transportation facilities within the State to address the needs identified by the appropriate state, regional, or local transportation plan by improving safety, reducing congestion, increasing capacity, and/or enhancing economic efficiency and that such public need may not be wholly satisfied by existing methods of procurement in which qualifying transportation facilities are developed and/or operated; …”

- For the I-95 HOV/HOT Lanes, Virginia, the contract required in the Technical Requirement that "a. The Concessionaire's management approach shall provide all components of an effective and efficient management system, including communication and reporting; documentation of Work; supervision of Work personnel and activities; all tools, facilities, and materials; environmental protection and mitigation; safety of Work personnel; and any other management elements needed to produce and document a quality, safe, efficient, and operable Project that complies with Good Industry Practice. "
- In the Pocahontas Parkway (Route 895) project, Virginia, the contract required in the Concession Agreement that "… (c) Authorizing private entities to acquire, construct, improve, maintain, and/or operate one or more transportation facilities may result in the availability of such transportation facilities to the public in a more timely or less costly fashion, thereby servicing the public safety and welfare; …"
- For the Indiana Toll Road, the contract required in the RFP Introduction part that "… The State's primary objective is to maximize value the State, while maintaining the high safety standards and service levels of the Toll Road."
- In the PR-5 and PR-22 projects, Puerto Rico, the contract required in the RFQ that one of the primary objectives the Authority and the Puerto Rico Highways and Transportation Authority (PRHTA) should seek would be to achieve "improving the toll roads' safety standards, service levels and roadway quality."
- For the Port of Miami Tunnel, the contract required in the RFP that one of the primary objectives of the Project be "to improve traffic safety in downtown Miami by removing the Port of Miami traffic, trucks and buses, from the congested downtown street network."

Although some other projects did not explicitly mention safety in their project objective sections, the contracts still contained a set of provisions related to improving safety performance. For example:

- In the Northwest Parkway project, Colorado, roadway safety was not mentioned as one project goal to be achieved in the Project Objective section of its RFQ. However, the project developed detailed Operation Standards in Schedule 2 of the Concession Agreement, which required, "The Concessionaire must operate and maintain the Parkway in a safety and reliable manner during the Term of Agreement. The Concessionaire must adhere to a specific set of operating standards (the "Operating Standards") relating to the operation, maintenance and rehabilitation of the Parkway and must undertake certain capital improvements to the Parkway during the Term …" And the wholly "Operating Standards" can be found in the Northwest Parkway Concession Agreement Schedule 2.
- For the I-4 Ultimate project, Florida, there was no direct requirement for improving traffic safety performance in the general project objectives, but in Volume III Additional Mandatory Standards, the Purpose Section stated that the developer should upgrade the safety and mobility of the existing I-4 roadway.
- For the LBJ 635, and other Texas projects, although they did not have a clear objective for safety, there were lots of requirements for the concessionaire to improve and ensure project safety (e.g., a safety plan).

In terms of selection criteria, although 13 of the 17 selected projects explicitly considered safety as one of the project objectives, four of them did not specifically include safety in their evaluation criteria. As shown in figure 5.6(b), about half of the selected projects (9 out of 17) included safety as one of the project objectives and also contained safety in their evaluation criteria. These projects included I-595 Improvements, the Presidio Parkway, SH 183, North Tarrant Express, the Elizabeth River Tunnel, I-495 Express Lanes, the Pocahontas Parkway, Indiana Toll Road, and PR-22 / PR-5. In these projects, a common method was to include safety management as an element to evaluate the technical capability of the bidding team. For example, for the Indiana Toll Road and PR-22 / PR-5, safety was treated as one subject under Technical Capability in the evaluation criteria. For the Indiana Toll Road, the document stated that the "Team must demonstrate their ability to address and resolve safety issues, specifically, the team should have a) knowledge of highway safety techniques and methodologies; b) experience in emergency response support; and c) background in relevant traffic engineering standards, specifications, policies, practices, and processes." In these projects, safety was categorized as part of technical capability. However, a fewer number of projects specifically assigned evaluation points or rating weights to safety; this is presented in figure 5.6(c) and figure 5.6(d). Usually, the evaluation weights were assigned only for a team's technical capability as a whole. In the 17 target projects, only two of them clearly assigned evaluation points for safety. These included the following:

- For the Pocahontas Parkway project, the evaluation criteria were primarily based on two sections: the Technical Proposal and the Price Proposal. The Technical Proposal had a weight of 30 percent, and the Price Proposal had a weight of 70 percent. Safety as one sub-section in the Technical Proposal had a 10 rating weight out of 100. Figure 5.7 is a snapshot of the Technical Proposal Evaluation Factors for the Pocahontas Parkway.
- For the SH 183 Managed Lanes project, Safety Qualification was considered to be a separate evaluation instead of a sub-section under technical capability. Safety Qualification was assigned a 10 percent rating weight in the Chapter of Evaluation

Process and Criteria in the RFQ. Additionally, the criteria explicitly required the proposers to provide previous safety records or other materials to demonstrate their safety qualifications. However, this qualification was primarily related to construction safety rather than the traffic operational safety. Figure 5.8 is a snapshot of the Qualifications Evaluation Criteria and Weighting for SH 183 Managed Lanes.

5.1 Technical Proposal Evaluation Factors

5.1.1 The Technical Proposal will be evaluated by Transurban based upon the proposal criteria listed under Sections 4.2 and 4.3 of this RFP, with the respective subsections being assigned the following weights:

Sub-Sections		Rating Weight
4.2	Qualifications and Experience	30
4.3.1 and 4.3.2	Design Factors and Utility Relocation Coordination	10
4.3.3 and 4.3.4	Geotechnical and Construction Factors	25
4.3.5	Schedule	25
4.3.6 and 4.3.7	Quality Assurance/ Quality Control and Safety	10
4.3.8	DBE/SWAM	Pass/Fail
TOTAL		**100 points**

Figure 5.7 Part of the Technical Proposal Evaluation Factors for the Pocahontas Parkway

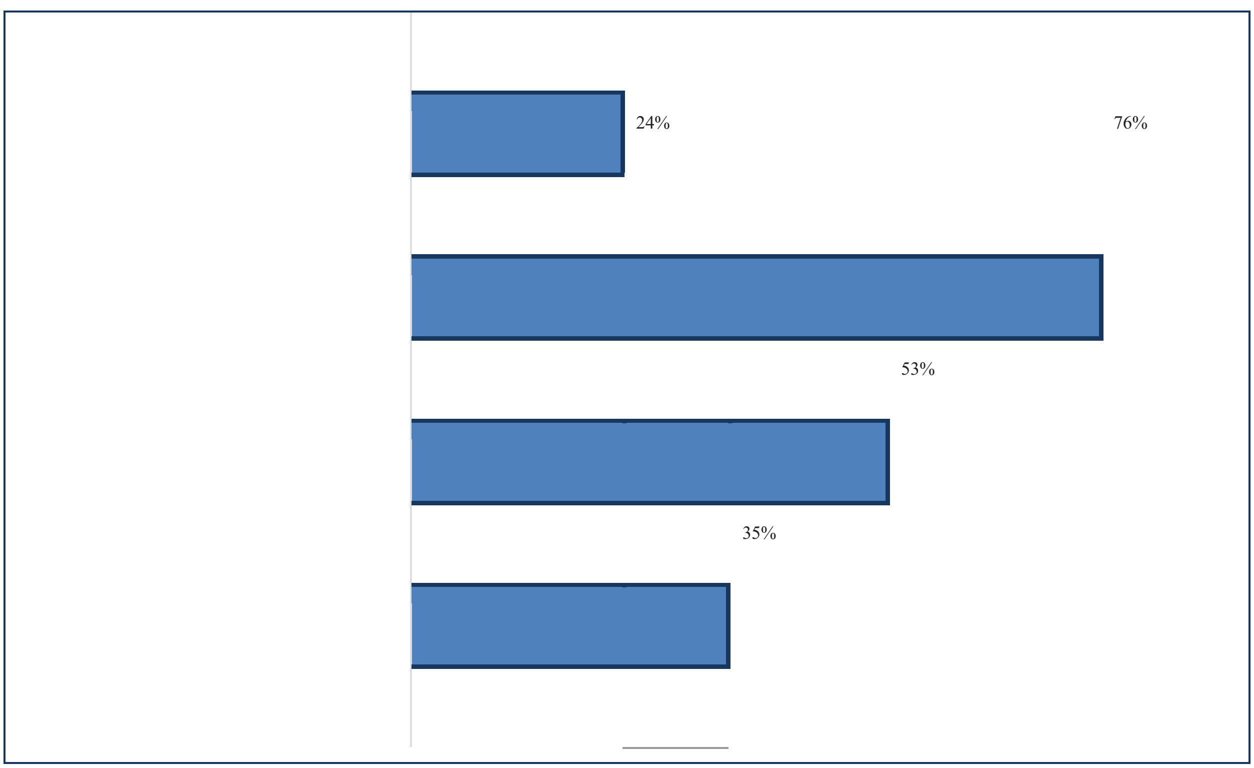
5.3 Qualifications Evaluation Criteria and Weighting

Each responsive QS passing all of the "pass/fail" qualification requirements set forth above in Part A, Section 5.2 will be evaluated and scored according to the criteria set forth below. TxDOT will evaluate responsive QSs according to the criteria in this Part A, Section 5.3. The relative weighting or importance of the evaluation criteria within each category is described in Part A, Sections 5.3.1 through 5.3.5 below and is summarized below;

- Technical Qualifications and Capability (35% Weighting)
- Statement of Technical Approach (10% Weighting)
- Project Finance Qualifications and Capability (35% Weighting)
- Conceptual Project Finance Discussion (10% Weighting)
- Safety Qualifications (10% Weighting).

Figure 5.8 Part of the Qualifications Evaluation Criteria and Weighting for SH 183 Managed Lanes

In summary, although most PPP transportation projects considered safety to be an important project goal, a much smaller proportion clearly reflected safety objectives in their selection criteria. This is clearly noted, as percentages decreased from 76 percent to 53 percent to 35 percent and finally to 12 percent (see figure 5.9). For instance, the I595 Improvements project, the Presidio Parkway, the Elizabeth River Tunnel, I-495 Express Lanes, Indiana Toll Road, and PR-22 and PR-5 projects had similar contracts to include safety as part of their evaluation criteria for the technical capacity, but none of them assigned any weighting points specifically for safety. Even if some projects, such as SH 183 Managed Lanes, considered safety qualifications to be a separate criterion and explicitly assigned weights for it, there was no clear definition to distinguish roadway safety, with an emphasis on operation and maintenance, from construction safety, with emphasis on construction.



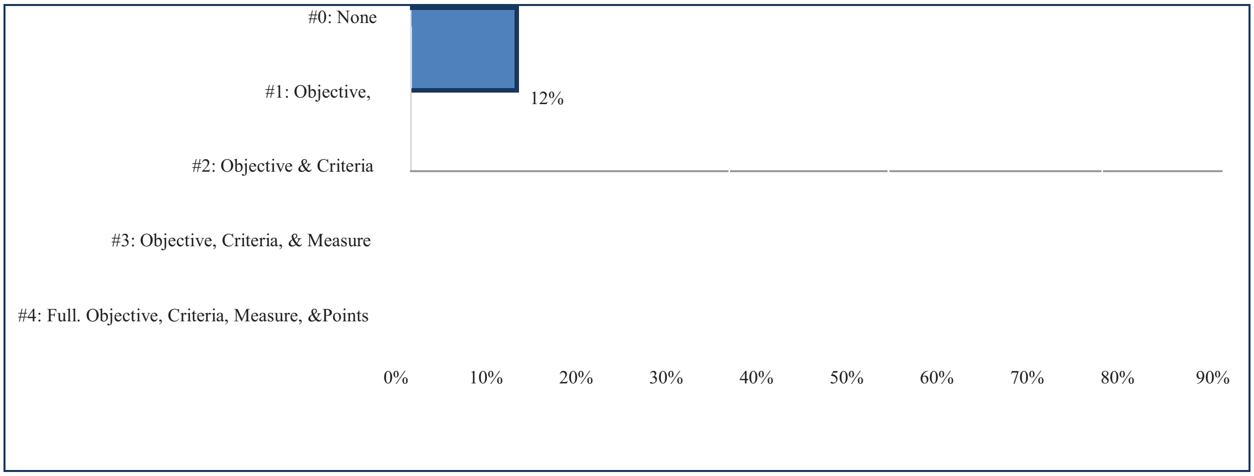


Figure 5.9 Relative safety considerations

5.3.2 Contractual Document Part I: Design and Operation

This analysis aimed to investigate whether PPP agreements included any special terms, beyond what are traditionally included in transportation contracts, in respect to structural design and operational requirements to improve roadway safety. The technical requirements of the PPP transportation projects commonly contained a set of safety-related contractual terms in the design stage, construction stage, and operation and maintenance stage, such as the road slope, lighting, and materials. Additionally, the concession agreements of all target projects required their concessionaires to provide a comprehensive safety plan. However, because the safety-related terms in the technical requirements and safety plans in comprehensive agreements were very similar among the target projects, they were considered to be traditional terms in this study. The results of the review for contractual documents related to the design and operation of all 17 target projects are summarized in table 5.7.

Table 5.7 Review of the contract documents part I: design and operation

Project	Special structural design or extra roadway elements to improve roadway safety	Extra or Special operational requirements to improve roadway safety	Request of installation of any devices to collect roadway safety data

I-4 Ultimate	NO	YES	NO
Port of Miami	YES	YES	NO
I-595	YES	NO	NO
SR 125	NM	NM	NM
Presidio Parkway	NO	YES	NO
SH 183	NO	YES	YES
LBJ 635	YES	YES	YES
North Tarrant Express	NO	NO	NO
SH 130 (Seg. 5 & 6)	YES	YES	NO
Elizabeth River Tunnel	NO	YES	YES
I-495	NO	NO	NO
I-95 Express Lanes	YES	YES	YES
Pocahontas Pkwy	NO	NO	NO
Chicago Skyway	YES	NM	NM
Indiana Toll Road	YES	YES	NO
PR-5 and PR-22	YES	YES	NO
Northwest Pkwy	NO	YES	NO

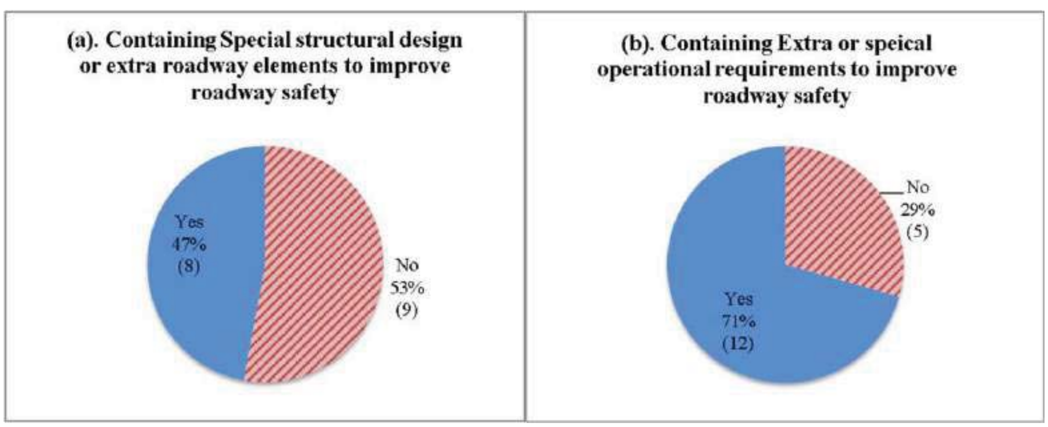


Figure 5.10 Special design and operation safety terms in the target projects

In terms of special design or extra roadway elements for safety improvement, as shown in figure 5.10 (a), 8 of the 17 (47 percent) target projects contained at least one contractual design term that differed from the traditional contractual template. These special design-related provisions were heterogeneous and varied from project to project. For example, the I-595 Improvements project required that a custom design should meet or exceed all of the operational, aesthetic, safety, and access requirements for toll maintenance personnel provided by the standard signature gantry, which was a set of particular design requirements in the agreement. The LBJ 635 project adopted a geotechnical instrumentation program to monitor the safety and adequacy of the design and construction approach. The I-95 Express Lanes project required that a reliability assessment be made for safety purpose, and furthermore, the project required an operational analysis to demonstrate that the concessionaire's revised design did not have a significant adverse impact on the safety and operation of the existing facility. The Indiana Toll Road project developed a particular traffic plan, named Safety Initiative, for roadway safety improvements. The PR-5 / PR-22 project implemented a program called "the accelerated safety upgrades" to improve performance and safety conditions.

In terms of operation, as presented in figure 5.5(b), 12 of the 17 (71 percent) target projects included special or extra provisions to improve roadway safety. In comparison to the design-related provisions, these operation-related provisions had more similarities among projects and could be divided into two categories. One was to require concessionaires to conduct periodic safety inspection to monitor safety conditions. For example, the I-4 Ultimate project required that concessionaire conduct awareness meetings with traffic operation staff every three months to review any safety or operations issues. Some other projects also required concessionaires to assign particular safety staff to be responsible for safety management. For example, the SH 130 project required the concessionaire to set up a safety committee to hold quarterly meetings to review safety history and devise and implement new safety improvement measures. In addition to conducting a safety inspection, the category included a requirement for the concessionaire to regularly update safety plans. Some projects also required concessionaires to remove and replace the existing signage, lights, or other safety equipment in a timely manner.

In terms of the installation of devices for safety data collection, in the 17 selected projects, four projects clearly required their concessionaires to collect safety data, which is summarized in the fourth column of table 5.7. These projects were SH 183, LBJ 635, the Elizabeth River Tunnel, and the I-95 Express Lanes. For example, in the I-95 Express Lanes documents, the Technical Requirement 4.4.2 Data Collection stated, "the Concessionaire shall store all data and make the data accessible to the Department in accordance with the Agreement." However, for most of other selected projects, although a data collection section was included in the technique requirement, no requirements or provisions for traffic or safety data were clearly made.

As a result of the review of contractual terms related to the design and operations phases, we found that all of the selected PPP projects contained many common contractual terms in the design phase and operations phase to ensure roadway safety, such as a set of minimum requirements in design (*e.g.,* soil cut and slope design), and snow removal or ice control in operation. Beyond these traditional contractual terms, we found that eight of the 17 selected projects contained some extra provisions for improving safety in the design phase. These projects with extra or special design adopted very different ways to protect roadway safety. However, the extra or special operational requirements adopted to improve roadway safety were relatively more common around many of the selected projects. These extra provisions can be divided into two major categories. One of them required the concessionaires to conduct periodic safety inspection, and also, some projects required that a particular safety manager be assigned to monitor safety performance. These projects included the I-4 Ultimate project, SH 183 Managed

Lanes, LBJ 635, the Elizabeth River Tunnel, the Northwest Parkway, and SH 130. Another type of provision required the concessionaire to update the safety plans on the basis of historic safety performance. This happened in the Presidio Parkway project, Indiana Toll Road, and PR-5 and PR-22 projects. Finally, we noticed that although only four projects clearly required their concessionaire to install necessary devices for data collection, most of the 17 selected projects mentioned in their emergency plans that the concessionaire should report traffic accidents in a timely manner. This is discussed more in the following section.

5.3.3 Contractual Document Part II: Safety Incentives and Payments

For this phase, we reviewed the provisions regarding payment mechanisms, rewards, and deductions in the concession agreements and other complementary documents. As suggested by the proposed questions described previously, this section is divided into three parts for discussion, including 1) whether the selected projects contained safety payments or safety incentives; 2) whether the selected projects contained traditional sections for general roadway safety precautions; and 3) whether the selected projects required the use of historical safety records/data of the project or of the locality for safety analysis.

Table 5.8 Review of the contract documents part II: safety incentives and payments

Project	Incentive payments to improve safety	Particular Safety Payment	Traditional roadway safety precautions – compensations for safety improvement or deductions for safety incompliance	Historical safety records of the project or the locality of the projects
I-4 Ultimate	NO	NO	YES	YES
Port of Miami	NO	NO	YES	YES
I-595	NO	NO	YES	NO

SR 125	NO	NO	YES	NO
Presidio Parkway	NO	NO	YES	NO
SH 183	NO	NO	YES	NO
LBJ 635	NO	NO	YES	NO
North Tarrant Express	NO	NO	YES	NO
SH 130 (Seg. 5 & 6)	NO	NO	YES	NO
Elizabeth River Tunnel	NO	NO	YES	NO
I-495 Express Lanes	NO	NO	YES	NO
I-95 Express Lanes	NO	NO	YES	NO
Pocahontas Pkwy	NO	NO	YES	NO
Chicago Skyway	NO	NO	YES	NO
Indiana Toll Road	NO	NO	YES	NO
PR-5 and PR-22	NO	NO	YES	NO
Northwest Parkway	NO	NO	YES	NO

The investigation in this section aimed to identify the usage of monetary incentives for managing safety performance in PPP transportation projects. Through the review of the concession agreements and other documents regarding payment mechanisms for all selected 17 projects, we found that all the selected projects implemented mechanisms to improve roadway safety in different ways, but not necessarily through a particular payment type or incentives tied to safety performance indicators. In literature review, this study found that safety payments or safety incentives were innovative payment mechanisms that tied the monetary compensation to the traffic safety performance provided by the concessionaire. According to the analysis of all provisions regarding the payment mechanisms of the 17 target projects, this study found that none of the projects included any payment mechanism that linked a monetary compensation to traffic safety performance. The reasons could be as follows:

- As a relatively new delivery system in the United States, most of the existing PPP projects focused on the aspects of project financing and risk allocation, with less or scarce attention on other areas such as roadway safety.
- The PPP payment mechanisms used in the early U.S. projects were almost dominated by toll revenues rather than a comprehensive payment mechanism.
- According to a NHTSA traffic safety report, many issues exist with current safety performance measures, such as the large cost of database maintenance and inaccurate data. These issues have hindered public agencies in evaluating operations quality on the basis of project performance. Additionally, there is no effective framework or guidelines that provide instructions for linking safety performance to a payment mechanism.

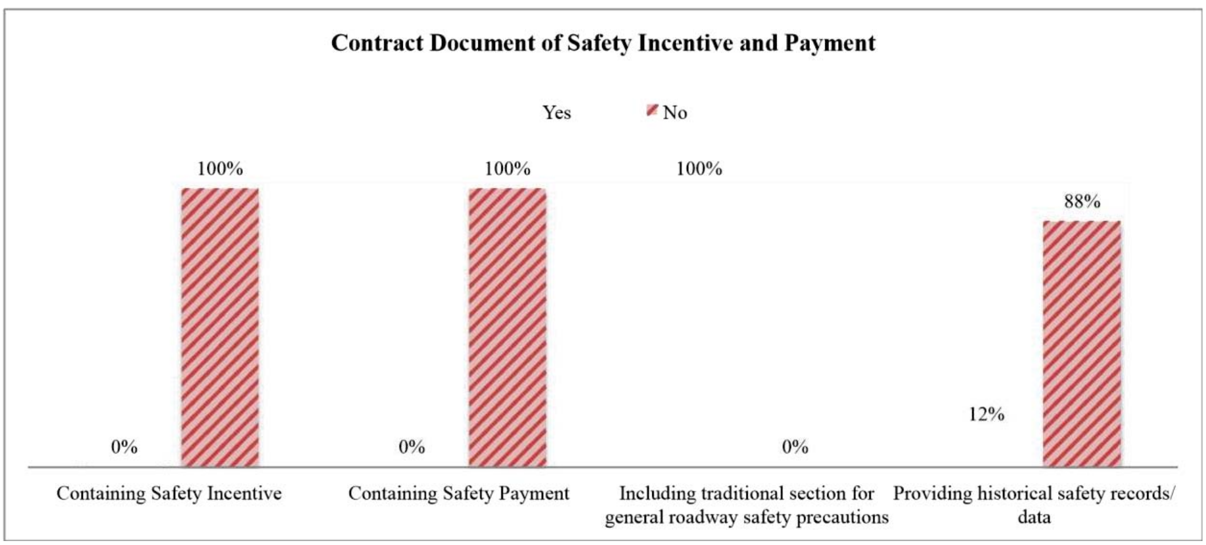


Figure 5.11 The implementation of safety payments or incentives in target projects

We also investigated whether the selected projects contained traditional provisions with regard to roadway safety precautions. If yes, we would further investigate whether these terms potentially related to a compensation or deduction. The results are summarized in the fourth column of table 5.9.

As shown in figure 5.11, all target projects contained traditional provisions regarding roadway safety precautions. Two contractual chapters, Safety Compliance and Remedies for Failure to Meet Safety Standards or perform Safety Compliance, were widely applied to all PPP projects. In addition to the terms that required the concessionaire to comply with the safety plan and safety standards, these two chapters also included some terms potentially related to safety deductions or compensation. For example, the I-4 Ultimate project required that if the concessionaire failed to comply with safety standards or any other regulations, the public agency had the right to take actions directly to ensure the safety and quality of the project, and the concessionaire would be responsible for all the expenses and potential losses due to such actions. However, these provisions cannot be regarded as a concept of safety payment. One reason is that the “safety” mentioned in most of the provisions did not clearly refer to the roadway or traffic safety. None of the 17 projects required the evaluation of any safety performance measure (*e.g.,* number of crashes, injuries, or fatalities). None provided any safety payment or safety incentive or deduction for substandard safety performance.

According to figure 5.11, few projects required the use of historical safety records to assess roadway safety performance. The results have are in the fifth column of table 5.7. In these 17 projects, only two projects—the I-4 Ultimate project and the Port of Miami Tunnel—mentioned that traffic data should be utilized for analysis in their technical requirements. However, the Port of Miami Tunnel required using only AADT to establish a revised traffic operational analysis. This analysis was primarily used for congestion management instead of improving traffic safety. The I-4 Ultimate project was the only one of the 17 target projects that included traffic safety analysis in its contracts by using historical safety records. In Volume III Additional Mandatory Standards, section 1.3.7 Safety, it required the concessionaire to adopt the safety ratio as an index to evaluate roadway safety performance. One such provision was, “The safety ratio is defined as the ratio between the actual crash rate and the critical crash rate. The actual crash rate is a function of the roadway section length times the annual number of vehicles in relation of the number of crashes. The critical crash rate is a function of the roadway section length, the traffic volume, and the statewide average crash rate for similar roadway facilities.” However, the contract mentioned that the safety ratio was only adopted for the purpose of identifying hazardous locations in the project. The safety ratio and analysis were not use to evaluate the safety performance provided by the concessionaire. In addition, there were no specific terms requiring the concessionaire to collect such safety data. Although the safety analysis adopted in the I-4 Ultimate project was not used for evaluating whether there would be any safety improvements through PPP, this project still shed light on implementing safety performance measures into a PPP contract.

As a result of this analysis, we found that all selected PPP projects adopted mechanisms to improve roadway in different ways, but not one through a payment or incentive tied to safety performance indicators. Although two monetary mechanisms were included in the traditional chapters of safety compliance and remedies for failure to meet safety standards or perform safety compliance, they could not be treated as a safety-related payment or incentive. We also found that safety performance measures and indicators were not applied widely to the selected PPP projects. The I-4 Ultimate project was the only target project that included a traffic safety analysis in its contract by using historical safety records. However, the analysis was used to identify hazardous locations instead of evaluating the safety performance of the concessionaire. Additionally, this analysis was not linked to any payments or deductions.

5.3.4 Contractual Documents Part III: Roadway Accident Management

We reviewed of the contractual terms regarding traffic accident/incident reports and management. The review mainly focused on two areas. One was related to safety data collection and incident reports, which is reflected in the first three questions in the columns 2 to 4 of table 5.9. Another area was related to emergency management and repair work, which is reflected in the last three questions in columns 5 to 7 of table 5.9.

Table 5.9 Review of the contract documents part III: roadway accident management

Project	Requiring the project concessionaire to collect roadway safety data	Requiring the project concessionaire to report safety data	Providing for the highway agency to record and report roadway safety incidents	Providing for Independent agency or third party to record and report roadway safety incidents	Requiring concessionaire to manage roadway incidents	Requiring concessionaire to carry out roadway emergency maintenance	Requiring concessionaire to carry out capital work for incident maintenance
I-4 Ultimate	NO	NO	YES	NO	YES	YES	YES
Port of Miami	NO	NO	YES	NO	YES	NO	YES
I-595	NO	NO	NO	NO	YES	YES	YES
SR 125	NO	NO	YES	NO	YES	YES	NM
Presidio Pkwy	YES	NO	YES	NO	YES	YES	YES
SH 183	NO	NO	YES	NO	YES	YES	YES
LBJ 635	YES	YES	YES	YES	YES	YES	NO
North Tarrant Ex	NO	NO	YES	NO	YES	NO	NO
SH 130	NO	NO	YES	NO	YES	YES	YES
Elizabeth River Tu	NO	NO	YES	NO	YES	YES	YES
I-495	NO	NO	YES	NO	YES	YES	YES
I-95	YES	NO	YES	NO	YES	YES	YES
Pocahontas Pkwy	NO	NO	YES	NO	YES	YES	YES
Chicago Skyway	NO	NO	YES	NO	YES	NM	YES
Indiana Toll Road	YES	NO	YES	NO	YES	YES	NM
PR-5 and PR-22	NO	NO	YES	NO	YES	YES	NM
Northwest Pkwy	NO	NO	YES	NO	YES	YES	NM

In terms of incident data collection, recording, and reporting, although some PPP projects had data collection chapters in their comprehensive agreements that contained provisions on collecting, storing, and reporting traffic data (*e.g.* ,AADT), no safety-related data were particularly mentioned in the data collection chapters of most of the selected projects. For instance,

- For the I-95 Express Lanes, the contract mentioned in the Data Collection Chapter that "a process of data collection will be established that includes, at a minimum, traffic data." Additionally, the contract required the concessionaire to store all data and make the data accessible to the department in accordance with the agreement. However, it must be pointed out that only traffic data collection was required (*e.g.,* AADT) and safety data were not specifically mentioned (*e.g.,* crashes, injuries, or fatalities).
- The Indiana Toll Road required the concessionaire to collect traffic data through the toll collection system. Although its Toll Collection Plan included procedures for addressing events and incidents associated with toll collection and operations, the collected data were to be used only for traffic demand analysis, and there was still no specific requirement for safety data collection.

Figure 5.12 shows the results of the review and analysis of the contractual terms regarding safety data collection and reporting and traffic accident/incident management. We found that collecting and keeping safety data (*e.g.,* number of accidents, crashes, fatalities, and injuries) was not a major requirement for the concessionaire. In fact, only four (24 percent) of the contracts required the concessionaire to collect data, and only one contract (6 percent) required the concessionaire to report safety data. The Presidio Parkway was the only project that required the developer to establish a self-monitoring program in order to ensure a safe and reliable roadway system, with the main objective of maximizing public safety, reliability, and roadway availability. On the other hand, the majority of the contracts (94 percent) required the public highway agency to carry out this task instead, *i.e.,* to record and report the roadway accidents. In only one project (6 percent), the LBJ 635 project, was a provision made to allow an independent agency to do this task. The Elizabeth River Tunnel was the only project that required the concessionaire to manage and control information identified through incident reports, noncompliance reports, and traffic reports to address quality improvement.

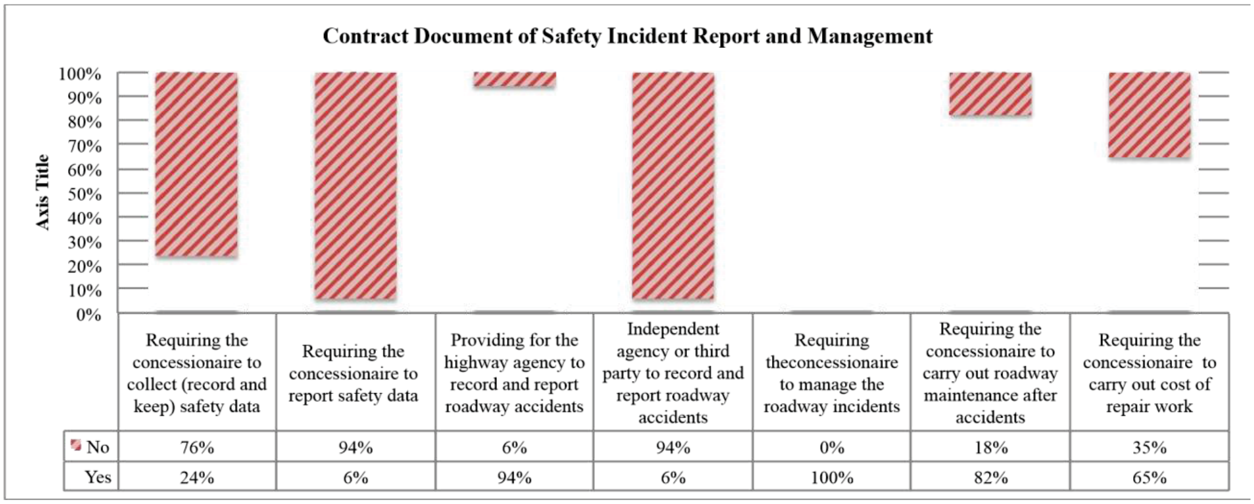


Figure 5.12 Safety incident report and management in target projects

While collecting and keeping safety data was not a major requirement, all 17 target projects included a set of requirements for incident response and put forward specific incident management/response plans in the contract. As shown in figure 5.12, most of the target projects required their concessionaires to immediately report any safety-related incidents to the public law enforcement agency.

Although almost none of the PPP projects included specific requirements for safety data collection and management in their data collection chapters, we found that all 17 projects included explicit requirements for incident response and put forward specific incident response/management plans in technical provisions, which potentially had contractual requirements regarding safety event reports. Therefore, we further investigated the incident response/management plans. In such plans, 16 of the 17 projects explicitly required their concessionaires to immediately report any safety-related incidents to the Department of Public Safety or other public law enforcement agency, and only the I-595 Improvement project had no explicit terms related to incident reporting. For instance, the Indiana Toll Road required "the concessionaire shall promptly notify the IFA (Indiana Finance Authority) of all emergencies, and promptly notify the IFA of all accidents and incidents occurring on or at the Toll Road." Other projects had a similar provision to require incident reporting in their contract. However, note that some of these projects did not clearly distinguish between traffic incidents and construction incidents. For example, the contract for the I-495 Express Lanes required that "the contractor should immediately report in writing any safety-related injury, loss, damage or accident arising from the Work." This provision referred to construction incidents rather than traffic incidents.

Although most of the selected PPP projects had particular provisions for incident reporting, almost none of them required concessionaires to be responsible for the management and analysis of safety data. The Elizabeth River Tunnels was the only project that required the concessionaire to "manage and control information identified through incident reports, noncompliance reports, and traffic reports to address quality improvement" in the research targets.

Sometimes, it is more effective to manage such safety data through a third party. On the one hand, it is more fair and objective for the safety data to be recorded and managed by a third party rather than by the concessionaire. If a payment mechanism is linked to traffic safety performance, then the project concessionaire may remove or ignore accident records intentionally in order to show good safety performance. On the other hand, the expense of data collection and management by a third party may be less than that by either the concessionaire or the public agency. However, we found that almost none of the 17 projects required an independent agency or a third party to collect, manage, and report traffic safety data. Of the 17 projects, only he LBJ 635 project suggested that a separate party could be engaged for data management. In the LBJ

635 contract, it mentioned that the “Developer may engage private security firms or employ passive security devices or technology to protect, collect, accumulate, transfer and deposit tolls and incidental charges or identify toll violations.” Although this provision was designed more for toll collection, it can be regarded as a foundation for including a third party to provide the service of collecting and managing traffic safety data.

In terms of incident management and repair works, unlike safety data collection and recording, all of the target projects required the concessionaires to develop a comprehensive emergency/incident management plan to immediately respond and manage roadway incidents. For example:

- The I-4 Ultimate project required that the concessionaire “shall perform and comply with the provisions of the Technical Volumes concerning emergencies, incident response, safety and security.”
- The Port of Miami Tunnel project required the concessionaire to provide a “First Response Team with required special equipment for incidents.”
- In the contract for the I-595 Improvement project, the “Concessionaire shall comply with all rules, directives and guidance of the US department of Homeland Security and comparable State agency and shall coordinate and cooperate with FDOT and all other governmental entities providing security, first responder and other public emergency response services in accordance with the Contract Document.”

Additionally, most (82 percent) of the 17 projects required the concessionaires to be responsible for maintenance and roadway repair after incidents. In some projects, particular provisions or procedures for emergency/incident repair were contained in the emergency/incident management plan, such as the I-4 Ultimate project, I-595 Improvement project, Presidio Parkway project, SH 183 Managed Lanes, LBJ 635 project, Elizabeth River Tunnel, I-495 Express Lanes, I-95 Express Lanes, Pocahontas Parkway, Chicago Skyway, Indiana Toll Road, PR-5&PR-22 project, and Northwest Parkway. However, in some other projects, the contract mentioned that the concessionaire did not have to assume all maintenance responsibility. For example, the Port of Miami Tunnel required that the emergency response procedure should be developed by the parties in conjunction with the government.

For capital work in response to accidents, 11 projects required the concessionaires to pay for the costs of repair work. However, some public agencies authorized concessionaires to pursue claims against any responsible third party for reimbursement of expenses incurred. For example,

- The contract for the I-4 Ultimate project stated, “when an incident/emergency causes damage to any element within the applicable O&M limits, FDOT authorizes Concessionaire to pursue claims against any responsible third party for reimbursement of expenses incurred.”
- For the Elizabeth River Tunnel, I-495, and I-95 projects, the contracts allowed the concessionaires to charge incident fees, but the amount of any such other incidental fees and charges would not exceed the amount reasonably necessary for the concessionaires to recover their reasonable out-of-pocket and document costs and expenses.

As a result of the review of contractual terms related to traffic accident/incident reporting and management, we found that projects in the same state commonly had similar contract models. For incident reporting and data collection, all of the 17 projects had an incident management plan in the contract, and most of them included explicit provisions requiring the concessionaire to report an incident immediately. However, some projects did not clearly distinguish between traffic incidents and construction incidents. Also, we found that although most of the selected PPP projects had particular provisions on incident reporting, almost none of them required concessionaires to be responsible for the management and analysis of safety data, and none of them required an independent agency or a third party to collect, manage, and report the traffic safety data. For incident maintenance and repair work, all of the 17 selected projects required that the concessionaire be responsible for maintenance and roadway repair after an incident. Eleven projects also required the concessionaire to pay for the capital costs of the repair work. However, some public agencies also authorized concessionaires to pursue claims against any responsible third party for reimbursement of expenses incurred.

Chapter 6 Discussion

6.1 Research Implications and Significance

Improvement in road safety is an important objective for all highway agencies. There are multiple ways to address safety improvement, and this research addressed a dimension that had not been addressed before. This research considered the type of project delivery system to check whether choosing one delivery system over another would have an effect on improving roadway safety. When a safety objective is ranked or rated high for a highway, particularly for roads that have high collision/accident rates, it is important for decision makers to understand what delivery system could be used to contribute to reducing collisions or improving the safety record. This research provides PPP contractual safety measures to use in managing safety in the long term.

Even though it would be expected that roadway safety would be improved by long-term maintenance in PPP contracts, there were few quantitative studies that supported this perception. This research shed light on quantifying PPP for improving road safety. The research outcomes have been presented in this technical report. State, city, and county managers or other stakeholders will find the outcomes useful in getting more information about the relationships between safety, maintenance, and delivery systems. This will help in setting priorities for road maintenance and in choosing delivery systems.

6.2 Limitations

Note that because of the limitations of the roadway safety database, this study was not about establishing a causal model to determine whether PPP impacts roadway safety performance. In this study, statistical tools were used only to identify whether there were any differences between the safety performance of PPP projects and those of their local average.

This research should be considered as an initial stage toward more substantial analysis that would segregate the states' safety data into groups, e.g., in clustered analysis, which would recognize the design-bid-build system, design-build system, and other traditional systems, along with historical maintenance records for highways. Well-maintained roads under traditional systems would play a role in comparing PPP safety data. According to he previous research, a number of exogenous variables have the potential to influence the roadway safety performance, but they are beyond the concessionaire's ability to manage, such as traffic flow (Abdel-Aty and Radwan 2000; Persaud et al. 2000; Hauer and Bamfo 1997), percentage of heavy goods vehicles (Hiselius 2004; Ramirez et al. 2009), and number of lanes and intersections (Ivan and O' Mara 1997; Milton and Mannering 1998; Noland and Oh 2004). In future research, with a more comprehensive database, a Poisson and Negative Binomial Regression model (Rangel et al. 2012), which includes more comprehensive predictor variables, could be used to establish causality. This model would provide a coefficient of PPP and the significance of coefficient from the statistical perspective to determine whether PPP is a factor affecting safety performance.

Chapter 7 Conclusions and Recommendations

7.1 Conclusions

This study helps to establish an understanding of the relationship between roadway safety and innovative project delivery systems in transportation sector in the U.S.

An analysis of safety data from PPP projects in this study showed that PPP projects have better safety performance than traditionally delivered highways in relation to injury rates and accidents rates. It was difficult to come the same conclusion for fatality rates.

The content analysis of the PPP contracts of target PPP projects indicated that PPP projects in the United States take a lenient or less than expected stance toward enforcing better roadway safety performance. By default, all studied projects had to account for the traditional requirements of safety as set by the states and the federal government. However, PPP projects did not seem to be any different in relation to safety, even during the operations phase. The analysis showed that safety was mentioned as an important objective in the procurement documents of most (76 percent) of the studied PPP projects. However, there was no special mechanism to implement that objective in the real conduct of the projects. Only about half of the projects (53 percent) mentioned safety as part of their proposal evaluation, and only two projects actually assigned points and weights to their safety requirements. In the PPP agreements, regular safety plans were required from private partners. However, extra design or construction safety parameters were requested in only eight of the studied 17 projects (47 percent). In the operations phase, the status was similar, as 12 of the 17 projects (71 percent) called for conducting inspections and updating roadway safety plans. The collection of roadway safety, traffic, and crash data was not a requirement except in four projects. The biggest example of this lenient approach was that contract compensation carried no link or relationship to the safety performance of the project. There were no safety incentives, safety payments, or other mechanisms used in this regard. In fact, no provisions were made to assess any safety performance indicators except for one project out of 17.

Knowing that most states have records of accidents, injuries, and fatalities, this research suggests that these states could use such data to benchmark the safety performance of potential PPP projects to help enforce better roadway safety on future PPP projects.

7.2 Recommendations

One of the objectives of using PPPs is to take advantage of private sector skills in the management of facilities and enterprises. Public highway agencies could use proactive systems that enforce and incentivize the private partners to attain higher roadway safety standards and performances. Public agencies trying to achieve such objective would be recommended to do the following:

- Assessing the safety objectives

  A highway agency must decide whether roadway safety is an essential objective. For example, if the locality of a proposed PPP transportation facility has high levels of accidents per mile or per 10,000 VMT, then safety should be an essential objective. If it was a basic/normal objective, then perhaps the traditional safety requirements would be sufficient.

- Procurement Stage

  If safety is an essential objective, then the procurement documents, RFQ, and RFP must reflect that safety will be part of the PPP proposal evaluation, and a number of points or weight will need to be set for the safety objective.

- Contract and Operation Stage

  If safety is an essential objective, then a link should be established between the private partner compensation and the achievement of the safety objectives. This could be done by using a safety incentive payment, a core safety payment, safety deductions as part of the performance and availability deductions, and compensation for the contractor for capital/maintenance safety improvements.

- Establishing a safety benchmark

  A highway agency would need to establish a minimum or average safety benchmark to use in making payments. For example, the agency would need to establish the average number of accidents/fatalities/injuries per mile or per 10,000 VMT on a number of comparable roads or for a city/county average. A formula would link the actual number of accidents/fatalities/injuries to the average benchmark to establish safety compensation to the private partner. The agency could be more sophisticated by incorporating the severity of the accident severity (e.g., percentage of fatalities to injuries) and the accident frequency.

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