

Toll Facilities

Workplace

Safety Study

Report to Congress



August 2010

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| 16. Abstract This document presents the findings of a study undertaken to investigate issues surrounding worker and motorist safety in the vicinity of toll collection facilities. The study was undertaken in direct response to Section 1403 of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) legislation, and was focused on accomplishing two main objectives: (1) to study the safety of highway toll collection facilities for workers and motorists through data, and through interviews and observations; and (2) to identify recommendations for improving toll facility safety – in the form of safety strategies for consideration by toll agencies. The study involved a review of existing literature, a survey of toll operators, site visits to 7 agencies, interviews with 21 agencies, a workshop with representatives from 20 agencies, and an analysis of available worker injury and motorist crash data. Together these activities provided a better understanding of the safety of toll collection facilities and allowed for identification of a wide range of strategies that toll agencies can consider implementing when looking to improve safety at their toll plazas. The study team obtained records on workplace injuries from 15 agencies (approximately 2,600 records) and records on crashes from 7 agencies (over 10,000 records). However, the data was not broad enough nor consistent enough from one agency to the next to allow significant industry-wide conclusions to be drawn. As a result, a key recommendation of this study is that standardized reporting procedures be implemented across the country whereby tolling agencies would document accidents and injuries occurring in the vicinity of toll plazas in a consistent and comparable manner. The report also recommends that a centralized database be created and maintained to store and organize this data in a searchable format. Based on the accident and injury data collected and the agency interviews conducted, the study did not find evidence to suggest that toll collector fatalities are a frequent occurrence at toll plazas. | | | |
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Glossary of Acronyms

| | |
|-------------|--|
| ANSI | American National Standards Institute |
| AVI | Automatic Vehicle Identification |
| CCTV | Closed-Circuit Television |
| CO | Carbon Monoxide |
| ETC | Electronic Toll Collection |
| FHWA | Federal Highway Administration |
| FMCSA | Federal Motor Carrier Safety Administration |
| GHSA | Governors Highway Safety Association |
| IBTTA | International Bridge Tunnel and Turnpike Association |
| IES | Illuminating Engineering Society |
| MMUCC | Model Minimum Uniform Crash Criteria |
| MUTCD | Manual on Uniform Traffic Control Devices |
| NCHRP | National Cooperative Highway Research Program |
| NHTSA | National Highway Traffic Safety Administration |
| NYS Thruway | New York State Thruway |
| OSHA | Occupational Safety and Health Administration |
| PANY/NJ | Port Authority of New York and New Jersey |
| PPE | Personal Protective Equipment |
| SAFETEA-LU | Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users |

Executive Summary

This report describes a study undertaken to investigate issues surrounding worker and motorist safety in the vicinity of toll collection facilities. The study was undertaken in direct response to Section 1403 of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) legislation, and is focused on accomplishing two main objectives:

- (1) To study the safety of highway toll collection facilities for workers and motorists through data, and through interviews and observations.
- (2) To identify recommendations for improving toll facility safety – in the form of safety strategies for consideration by toll agencies.

The study involved a review of existing literature, a survey of toll operators, site visits to 7 agencies, interviews with 21 agencies, a workshop with representatives from 20 agencies, and an analysis of available worker injury and motorist crash data. Together these activities provided a better understanding of the safety of toll collection facilities and allowed for identification of a wide range of strategies that toll agencies can consider implementing when looking to improve safety at their toll plazas.

The study was guided by a panel of stakeholders from a variety of industries relevant to this project, who graciously provided their time and energies throughout the life of the study. The panel worked together to set the scope for this project and actively provided feedback, guidance, and direction where appropriate. The panel members included representatives from the International Bridge, Tunnel and Turnpike Association (IBTTA), the Pennsylvania Turnpike Commission, the New York State Thruway Authority, the International Brotherhood of Teamsters, the Occupational Health and Safety Administration (OSHA), the American Association of State Highway and Transportation Officials (AASHTO), and the Federal Highway Administration (FHWA). A full list of the individual panel members can be found in Appendix A.

The study team worked with 15 agencies to collect data on worker injuries occurring at toll plazas. The team obtained records for a total of 2,662 worker injuries, and based on these injury records, it can be observed that:

- 12 percent of injuries involved some sort of interaction with a vehicle, although it is important to note that it appears that the majority of the injuries in the database that involved a vehicle did not involve any direct contact between the vehicle and the worker.
- The most common cause of injury was a fall, slip, or trip (28 percent). Other common injuries were those resulting from being struck by an object (11 percent), and from pulling, lifting, or pushing an object (9 percent).
- The most common types of injuries were cuts, scrapes, or abrasions followed by strains (these comprised 22 percent and 18 percent of all injury types, respectively).
- The most common body parts injured were the knee and the back, with the knee making up 12 percent of the injuries and the back making up 11 percent of the injuries.

The study team worked with seven agencies to collect data on vehicular accidents occurring in the vicinity of toll plazas (for the purposes of this study, this was defined as any incident occurring between the start of the upstream transition zone and the end of the downstream transition zone). The team obtained records for a total of 10,322 vehicular accidents. While it was possible to examine several trends in the data, the data was not broad enough or consistent enough to allow significant industry-wide conclusions to be drawn or to fully examine trends. The team did perform some analysis on an agency-by-agency basis for those agencies with strong data collection and archiving, but the findings of these analyses cannot necessarily be said to be representative for the Nation's toll facilities as a whole.

In order to compare data across toll facilities to make industry-wide observations and conclusions, the study team recommends that standardized reporting procedures be implemented for both accident and injury data, and that a centralized database be created and maintained to store this data and organize this data in a searchable format. This would allow data to be compared across toll facilities to make industry-wide observations and conclusions.

From the accident and injury data and agency interviews the study did not find evidence to suggest that toll collector fatalities are a frequent occurrence at toll plazas. The accident and injury records obtained through this study did not include any fatalities, and the project team learned of only one fatality through agency interviews.

The most significant finding of the study with regard to the safety of toll plazas is that tolling authorities across the country are implementing a wide range of safety strategies with success, and it appears that many of these strategies could be effective if implemented by other agencies. These strategies, which span a wide range of issues, and tackle a wide range of safety challenges, were identified through a survey, telephone interviews, and site visits. They were then vetted with representatives from 20 of the Nation's toll agencies in a facilitated workshop setting to obtain feedback from individuals in the field on the perceived effectiveness of each strategy and of any concerns and/or constraints that they may see or have with any particular strategy. As the operating conditions, culture, etc., are different at each agency and even at each toll plaza in some cases, the strategies are presented not as recommendations, but as ideas for agencies to consider when seeking ways to improve safety for workers and motorists at their toll collection facilities.

The findings in this document are organized according to four categories. The first two categories focus directly on the issues called for in the legislation:

- *Design of toll facilities* - this includes the effect of design or construction of the facilities on the likelihood of vehicle collisions with the facilities; the safety of crosswalks used by toll collectors in transit to and from toll booths; the use of warning devices, such as vibration and rumble strips, to alert drivers approaching the facilities; and the use of traffic control arms in the vicinity of the facilities.
- *Enforcement practices* – this includes the extent of the enforcement of speed limits in the vicinity of the facilities; the use of cameras to record traffic violations in the vicinity of the facilities; and law enforcement practices and jurisdictional issues that affect safety in the vicinity of the facilities.

The final two categories present additional information that was uncovered during this study that is still very relevant to the topic of highway safety at toll plazas, but that does not directly address the requirements of the legislation:

- *Maintenance practices* – this includes strategies focused on reducing the occurrence of incidents and injuries related to maintenance activities in and around toll plazas.
- *Human factors issues* – this includes strategies focused on reducing the incidence of vehicles stopping or backing up in high-speed lanes, mitigating sensory overload, and mitigating driver inattention.

Beyond these four categories, the study also uncovered information about other safety challenges at toll plazas that are not highway-related – such as *ergonomics*, *worker exposure to the environment*, and *worker risk of assault*. These additional findings are presented in Appendix F. In addition to this, information on workshop participants’ thoughts on all of the strategies (both those presented in Chapter 4 and those presented in Appendix F) can be found in Appendix H.

1 Introduction

1.1 Background

Toll facilities play a vital role in meeting the Nation's transportation needs. In general, they offer high levels of service, well-maintained roadways, and a relatively safe environment – with toll authorities placing significant focus and resources on reducing risks to customers and workers alike. However, these facilities are not without their safety challenges. Traditionally, toll agencies have relied upon fare collection techniques that require vehicles to rapidly decelerate from freeway speeds, navigate sometimes confusing plaza facilities, undertake manual (or increasingly automatic) fare transactions, and then accelerate and merge back to mainline traffic conditions. These maneuvers present a unique situation in roadway operations and introduce safety challenges both to the traveling public and to those workers who support the fare collection operation.

To combat this problem as well as others, more and more agencies are evolving to open road tolling (ORT). By a strict definition, open road tolling refers to fully automated electronic tolling in an “open road” environment, allowing vehicles to travel at full speeds when passing through toll collection points. Under this definition, customers must either possess an electronic transponder, or be assessed toll charges via license plate recognition technology. By this strict definition, safety is improved as there is inherently lower exposure: there are fewer worker-vehicle interactions since there is no plaza, and fewer vehicle-vehicle conflicts since less traffic is traveling through a plaza; also, noise and emissions are lessened due to the reduction in vehicles starting and stopping.

Beyond this strict definition of ORT, a number of agencies have implemented what might best be termed hybrid ORT operations: that is, they include a combination of mainline, full-speed electronic toll collection along with fully-separated cash lanes. Typically, cash-paying customers must exit the roadway or shift to a separated toll plaza in order to make cash payment at a traditional, staffed plaza.

Historically, all customers were required to stop at plazas to pay cash tolls and were then required to merge back to highway speeds, thus disrupting the overall traffic flow. With the introduction of electronic toll collection (ETC) systems in a mixed-mode collection facility, the problem of flow disruption has been exacerbated by the combination of some vehicles stopping to pay cash with others traveling freely through toll booths with technology electronically registering their payments. Downstream of the toll plazas, all of these vehicles must then merge to resume highway speeds. Certainly, electronic toll collection has improved overall mobility (and can improve safety when used exclusively as opposed to being used along with cash collection),¹ but it has also raised significant new safety concerns that were previously non-existent.

¹ An NTSB report published 4/18/06 concluded that “traditional toll plazas...create traffic backups that present a safety hazard; the conversion of traditional plazas to electronic toll collection systems should greatly reduce such hazards and improve safety on toll roads.” In a response to the NTSB report, the FHWA noted the increasing popularity of toll supported roadways and the need for consistent toll plaza traffic control strategies. These issues are addressed in the report, “*State of the Practice and Recommendations on Traffic Control Strategies at Toll Plazas*,” which can be found online at <http://mutcd.fhwa.dot.gov/rpt/tcstoll/index.htm>.

Many toll facilities were built before the establishment of the Interstate Highway System, and most are owned, operated, and maintained by autonomous public agencies, semi-public agencies, or private entities. As a result, guidance on national standards for uniform traffic control at toll facilities does not currently exist.² With so many different types of entities managing toll roads and with so many independent design approaches and no existing national standards, individual agencies have developed their own innovative approaches and solutions to improve worker and driver safety while ensuring smooth and efficient operations.

In light of the evolving toll collection methods and operational characteristics at toll plazas, and in direct response to Section 1403 of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) legislation, a panel of stakeholders undertook a study of toll facility safety, and this report presents the findings of the study.

1.2 Study Objectives

The study was undertaken to accomplish two main objectives:

- (1) To study the incidence of accidents and injuries in the vicinity of highway toll collection facilities.
- (2) To study the safety of toll collection facilities for workers and motorists – and to document strategies for improving toll plaza safety.

The study was designed to meet the requirements of the SAFETEA-LU legislation, but also to provide additional detail that was not specifically identified in the legislation. Worker safety is the main focus of the legislation, but the scope of this study also includes the study of vehicular safety at toll facilities since this is a matter of national interest and since it is difficult to completely separate the two.

The goal of the study is not to develop standards, but rather to document the state of the practice in toll facility safety and to share information on effective practices for improving worker and motorist safety in the vicinity of toll plazas. As such, this report is intended to serve as the Report to Congress and also as a set of safety strategies for direct consideration by toll facility agencies to improve the safety of the plazas that they operate. Key findings from this report have been summarized in a shorter companion document entitled “Strategies for Improving Safety at Toll Collection Facilities.”

1.3 Requirements of the SAFETEA-LU Legislation

The legislation behind this study can be found in SAFETEA-LU, and is stated as follows:

² The current edition of Manual on Uniform Traffic Control Devices (MUTCD) (2003, Revision 1) does not contain provisions for traffic control devices at toll plazas or toll-managed facilities. However, elements of the manual are used by some agencies where appropriate. Further, a chapter on tolling is under consideration for future proposed rulemaking for the MUTCD.

SEC. 1403 - TOLL FACILITIES WORKPLACE SAFETY STUDY

(a) In General

The Secretary shall conduct a study on the safety of highway toll collection facilities, including toll booths, to determine the safety of the facilities for the toll collectors who work in and around the facilities, including consideration of:

- (1) The effect of design or construction of the facilities on the likelihood of vehicle collisions with the facilities.
- (2) The safety of crosswalks used by toll collectors in transit to and from toll booths.
- (3) The extent of the enforcement of speed limits in the vicinity of the facilities.
- (4) The use of warning devices, such as vibration and rumble strips, to alert drivers approaching the facilities.
- (5) The use of cameras to record traffic violations in the vicinity of the facilities.
- (6) The use of traffic control arms in the vicinity of the facilities.
- (7) Law enforcement practices and jurisdictional issues that affect safety in the vicinity of the facilities.
- (8) The incidence of accidents and injuries in the vicinity of toll booths.

(b) Data Collection

As part of the study, the Secretary shall collect data regarding the incidence of accidents and injuries in the vicinity of highway toll collection facilities.

(c) Report

Not later than 1 year after the date of enactment of this Act, the Secretary shall submit to the Committee on Transportation and Infrastructure of the House of Representatives and the Committee on Environment and Public Works of the Senate a report on the results of the study, together with recommendations for improving toll facilities workplace safety.

(d) Funding

- (1) Authorization of appropriations – There is authorized to be appropriated to carry out this section, out of the Highway Trust Fund (other than the Mass Transit Account), \$500,000 for fiscal year 2006.
- (2) Contract authority – Funds authorized to be appropriated by this section shall be available for obligation in the same manner and to the same extent as if the funds were apportioned under chapter 1 of title 23, United States Code, except that the Federal share of the cost of the project shall be 100 percent, and the funds shall remain available until expended and shall not be transferable.”

1.4 Technical Panel

The study was guided by a panel of stakeholders from a variety of industries relevant to this project including representatives from the International Bridge, Tunnel and Turnpike Association (IBTTA), the Pennsylvania Turnpike Commission, the New York State Thruway Authority (NYS Thruway), the International Brotherhood of Teamsters, the Occupational Health and Safety Administration (OSHA), the American Association of State Highway and Transportation Officials (AASHTO), and the Federal Highway Administration (FHWA). The panel worked together to set the scope for the study and has actively provided guidance and direction throughout the completion of the study. A complete list of the individual panel members can be

found in Appendix A. The study team thanks the panel for their leadership, guidance, and support.

1.5 Roadmap to the Report

Following the introduction, this report first presents background information on the methodology used to conduct the study (*Section 2*). The report then presents the findings of the study in terms of the two major objectives for determining the safety of toll facilities, as required by the legislation (in *Sections 3 and 4*). *Section 3* presents the findings of a review of accident and injury data while *Section 4* presents a summary of the findings that address the objective of gaining a better understanding of the safety of toll plazas. The report concludes with a summary of the findings presented in *Section 5*.

Appendices provide further documentation on the study activities as follows: *Appendix A* provides a list of the panel members and the agencies that participated in the study; *Appendices B through E* provide the detailed findings of each of the various data gathering activities; *Appendix F* provides information on additional safety strategies that were identified throughout this study that are not highway-related and *Appendix G* provides the ratings from the agency workshop held as part of this study. Finally *Appendix H* summarizes workshop participants' thoughts on each of the strategies uncovered throughout the course of this study.

2 Study Methodology

To address the first objective of this effort, which was to study the incidence of accidents and injuries in the vicinity of highway toll collection facilities, the team gathered and analyzed available data on accidents and injuries. The approach to this activity is presented later in this section, and the findings of the data analysis are presented in *Section 3, Findings – Characteristics of Accidents and Injuries Occurring at Toll Plazas*.

To address the second objective of this study, which was to study the safety of toll collection facilities for workers and motorists – and to document strategies for improving toll plaza safety, the team again leveraged the literature review and survey to get a sense for safety practices being used across the country. In addition to this, the team conducted a series of telephone interviews with agencies to obtain additional detail on these practices, and also visited a select group of agencies in person. All practices noted through the course of these activities were then synthesized into a series of “strategies,” and the team then validated these strategies in a workshop setting with a panel of 20 representatives from among the Nation’s toll agencies.³ The approach to the telephone interviews, site visits, and workshop is presented later in this section, and the synthesized findings of these activities are presented [in the form of strategies to improve safety at toll plazas] in *Section 4, Findings – Factors Affecting Safety at Toll Plazas* and in *Appendices F and H*.

2.1 Literature Review

To begin this study, the team performed a literature review to document existing information about applicable standards and practices of highway toll collection facilities with regard to safety. The findings of the literature review are provided for reference in Appendix B.

2.2 Agency Survey

The next information-gathering activity conducted as part of this study was a nationwide survey of toll agencies. The survey was designed to gather high-level information about perceived factors that contribute to crashes and worker injuries at toll collection facilities, to gather information that would be helpful to the study team in identifying agencies that have accident and injury data, and to aid the study team in selecting the most representative agencies for inclusion in the subsequent site visits.

The IBTTA distributed the survey electronically to its 40 active toll agency members in the United States, and out of the 40 distributed surveys, 27 toll agencies responded, for a response rate of 67.5 percent. The survey instrument and survey findings are provided in Appendix C.

2.3 Accident/Injury Data

To further understand the safety of toll plazas, the team sought to collect and analyze 5 years of vehicular crash and worker injury data from a representative sample of toll agencies from across the United States. Initially, the study team sought data from agencies representing a mix of

³ A complete list of the workshop participants can be found in Appendix A.

facility types, lane types, geographic locations, amount of truck traffic, union vs. non-union, etc. However, as the study progressed it became evident that such a level of diversity could not be achieved given the relatively small number of agencies that collect and maintain this kind of data in a readily-accessible format. Consequently, the team elected to solicit data from all agencies that reported in their survey response that they have electronic data available. It should be noted that the team did also explore the possibility of using national databases including the National Highway Transportation Safety Administration's (NHTSA's) Fatality Analysis Reporting System (FARS). Unfortunately it is not possible to identify collisions occurring in the vicinity of a toll plaza from the FARS since the database does not include a field to denote whether a crash occurred within the vicinity of a toll plaza.

In collecting data on vehicular accidents, the team asked that agencies include data for any crashes occurring *in the vicinity of a toll plaza* (for the purposes of this study, this was defined as those incidents occurring between the upstream transition zone and the downstream transition zone). The team made a similar request for worker injury data. However, in a few cases, the responding agencies were unable to isolate the injury data in this way.

In total, the team received vehicular crash data from 7 agencies (totaling to 10,322 incidents), and worker injury data from 15 agencies (totaling to 2,662 incidents). The study team analyzed the data to determine trends, which can be found in *Section 3, Findings – Characteristics of Accidents and Injuries Occurring at Toll Plazas*.

2.4 Agency Site Visits

The team visited seven agencies to directly obtain information about safety practices and procedures at toll facilities and to observe facility operations. To select sites, the team first developed a list of site selection criteria, aiming to include facilities that span the range of characteristics that represent the wide variety of toll agencies across the United States. The selection criteria included:

- Consideration of geographic region.
- Availability of data to the study team.
- Variety in types of facilities (e.g., road, tunnel, bridge, or combination).
- Traffic volume.
- Percent of truck traffic.
- Facility characteristics (e.g., electronic toll collection, open road tolling, etc.).

After considering all sites that had expressed interest in a visit in their survey response, the team, along with the project panel, narrowed the list down to the following seven agencies:

- Florida Turnpike.
- Golden Gate Bridge (California).
- New York State Thruway.
- Pennsylvania Turnpike.
- Port Authority of New York / New Jersey (PANY/NJ).

- Denver E-470 (Colorado).
- Illinois Tollway.

Two team members attended each site visit, and each visit occurred over a 1-to-2 day period depending on the number and diversity of the facilities that the agency operates. During the visits the study team emphasized the need to meet with a variety of agency staff involved in different aspects of the toll operation, including those involved with enforcement, training, toll facility management, toll collection, safety, operations, and design. During each of the site visits the team interviewed a wide range of staff including the following:

- Representatives who deal with enforcement issues at one or more plazas (speeding, violations, etc.).
- Staff responsible for facility management or facility operations.
- Toll collectors (both union and non-union where applicable).
- Those who directly supervise toll collectors.
- Maintenance staff who perform work in the immediate vicinity of the plaza (including electrical work, construction, and other repairs).
- Those responsible for training toll collectors and/or maintenance staff.
- Those involved with plaza design.
- Those responsible for safety programs at the agency (where applicable).

The detailed findings of the site visits can be found in Appendix D.

2.5 Agency Interviews

The team also conducted phone interviews with agencies to obtain additional information on safety strategies being used across the country to improve worker and traffic safety. The team had the following three goals in mind when conducting these interviews: (1) to obtain information about specific safety strategies to assist in preparing the Report to Congress; (2) to obtain information about innovative safety strategies from toll agencies that did not respond to the survey; and (3) to obtain more detailed information about innovative safety strategies reported on surveys returned from toll agencies.

In contacting agencies to request focused interviews, the team contacted the same IBTTA points of contact who had received the original survey. The seven toll agencies that participated in site visits were excluded from the interview process since the team had already gathered in-depth information about their safety strategies. A total of 40 toll agencies were contacted by study team members via e-mail requesting phone interviews. Twenty-one agencies responded to the e-mail and agreed to grant interviews. Of the 21 interviews that were conducted, 5 of these were agencies who had not previously responded to the survey.

In most cases interviews were conducted with someone from the agency's Operations section. Phone calls typically lasted 30 to 45 minutes and team members found interview participants to be extremely willing to share detailed information about the strategies they had implemented to increase safety at their toll plazas. Many toll agencies submitted exhibits, such as pictures,

copies of posters, safety presentations, etc., to the study team to assist even further with the study. The detailed findings of the agency interviews can be found in Appendix E.

2.6 Agency Workshop

As the final step in the information gathering phases of this study, the team conducted a consensus-building workshop to gather feedback from toll agency staff across the country on the safety strategies that had been identified through the survey, telephone interviews, and site visits. In recognition of the fact that the characteristics of each agency and even of each plaza can dictate what strategies would be practical to implement and what strategies would be the most effective, the primary goal of the workshop was to gather feedback on each of the strategies identified from individuals who are familiar with day-to-day operations at plazas across the country. Another goal of the workshop was to gather information on any additional strategies that the team might not have uncovered through the data gathering activities leading up to the workshop.

At the workshop, the team presented each of the strategies that had been identified, one at a time, and then, for each strategy, encouraged participants to offer feedback regarding: (1) their perceptions of the effectiveness of the strategy; (2) thoughts they have on any constraints that they see with that strategy (i.e., any circumstances under which a particular strategy may not be effective for whatever reason); and (3) to provide their “bottom line” opinion of the strategy (e.g., they may feel that the strategy would be very effective but they would not consider implementing it due to cost implications).

The workshop included individuals representing a wide range of toll agencies across the country. A full list of the workshop attendees, as well as the ratings from the workshop participants, can be found in Appendix G. Information on workshop participants’ thoughts on each of the strategies can be found in Appendix H.

3 Findings – Characteristics of Accidents and Injuries Occurring at Toll Plazas

To address the first objective of this effort, which was to study the incidence of accidents and injuries occurring in the vicinity of highway toll collection facilities, the team gathered and analyzed available data on accidents and injuries occurring in the vicinity of toll plazas. This section presents the findings of the accident and injury data analysis.

The study team obtained data on 10,322 vehicular crashes representing 7 agencies, and data on 2,662 worker injuries representing 15 agencies. A summary of the records for both vehicular crashes and worker injuries and the time periods for which data was made available to the study team is shown in Tables 3-1 and 3-2 below. The amount of data provided by each agency for vehicular crashes varied significantly, with one agency providing as few as 15 records and another providing as many as 5,114 records; as a result, it is important to note that data from only two agencies comprises 88 percent of the vehicular crash records in the database.

The findings of the accident and injury data analysis are presented in the following sections.

Table 3-1. Worker Injury Data

| Agency | Period Covered | Number of Records |
|---------------|-------------------------------|--------------------------|
| Agency 2 | January 2000 – July 2006 | 646 |
| Agency 3 | January 2005 – July 2006 | 12 |
| Agency 4 | January 2002 – December 2006 | 4 |
| Agency 6 | February 2002 – December 2006 | 59 |
| Agency 7 | January 2002 – February 2005 | 80 |
| Agency 8 | July 2001 – September 2006 | 29 |
| Agency 9 | January 2004 – December 2006 | 87 |
| Agency 10 | January 2005 – September 2006 | 183 |
| Agency 11 | January 2006 – November 2006 | 15 |
| Agency 12 | January 2001 – November 2006 | 191 |
| Agency 13 | January 1996 – October 2006 | 139 |
| Agency 14 | January 2001 – December 2003 | 615 |
| Agency 15 | January 1975 – December 1990 | 9 |
| Agency 16 | January 1997 – December 2006 | 399 |
| Agency 17 | January 2000 – November 2006 | 194 |
| Total | | 2,662 |

Table 3-2. Vehicular Crash Data

| Agency | Period Covered | Number of Records |
|--------------|---------------------------------|-------------------|
| Agency 1 | January 2005 – December 2006 | 665 |
| Agency 2 | June 2001 – May 2006 | 3,955 |
| Agency 3 | April 2002 – August 2006 | 16 |
| Agency 4 | January 2003 – December 2006 | 73 |
| Agency 5 | September 1994 – September 2006 | 484 |
| Agency 6 | January 2006 – November 2006 | 15 |
| Agency 7 | January 2001 – December 2006 | 5,114 |
| Total | | 10,322 |

3.1 Worker Injuries

3.1.1 Analysis

The worker injury data provided to the team generally included fields for location, date, time, and, in most cases, a general description that allowed the study team to categorize the data. The descriptions were useful in determining the cause of the injury, the specific resulting injury, and the resulting body parts that were injured.

Some agencies' data provided information on the time of day that the injury occurred. Table 3-3 suggests that, for these agencies, injuries increase in the morning rush hour period and remain higher throughout the midday and afternoon before dropping off again in the late evening. This is also likely the portion of the day when the highest numbers of toll collectors are working and when traffic volumes are greatest.

Table 3-3. Number of Injuries by Hour/Time of Day

| Hour | Number of Injuries | % of Injuries |
|---------------------|--------------------|---------------|
| 12:00 AM - 1:00 AM | 15 | 2.2% |
| 1:00 AM - 2:00 AM | 6 | 0.9% |
| 2:00 AM - 3:00 AM | 11 | 1.6% |
| 3:00 AM - 4:00 AM | 12 | 1.8% |
| 4:00 AM - 5:00 AM | 11 | 1.6% |
| 5:00 AM - 6:00 AM | 21 | 3.1% |
| 6:00 AM - 7:00 AM | 46 | 6.9% |
| 7:00 AM - 8:00 AM | 44 | 6.6% |
| 8:00 AM - 9:00 AM | 40 | 6.0% |
| 9:00 AM - 10:00 AM | 38 | 5.7% |
| 10:00 AM - 11:00 AM | 50 | 7.5% |
| 11:00 AM - 12:00 PM | 42 | 6.3% |
| 12:00 PM - 1:00 PM | 25 | 3.7% |
| 1:00 PM - 2:00 PM | 40 | 6.0% |
| 2:00 PM - 3:00 PM | 36 | 5.4% |
| 3:00 PM - 4:00 PM | 24 | 3.6% |
| 4:00 PM - 5:00 PM | 24 | 3.6% |
| 5:00 PM - 6:00 PM | 33 | 4.9% |
| 6:00 PM - 7:00 PM | 41 | 6.1% |
| 7:00 PM - 8:00 PM | 21 | 3.1% |

| Hour | Number of Injuries | % of Injuries |
|---------------------|--------------------|---------------|
| 8:00 PM - 9:00 PM | 19 | 2.8% |
| 9:00 PM - 10:00 PM | 25 | 3.7% |
| 10:00 PM - 11:00 PM | 28 | 4.2% |
| 11:00 PM - 12:00 AM | 17 | 2.5% |
| Total | 669 | |

An additional analysis was performed to look at the number of toll collector injuries that involved a vehicle. From the data provided, 224 of 1,931 (12 percent) injuries involved a vehicle, although it is important to note that it appears that the majority of the injuries in the database that involved a vehicle did not actually involve direct contact between the vehicle and the worker.

Another variable that was investigated was the major causes of injuries. These are presented in Table 3-4 below. The data are sorted by percentage and indicate that the most common causes of injuries are general falls, slips, and trips (27.8 percent); being struck by an object (11.1 percent); and pulling, lifting, and pushing an object (9.1 percent).

Table 3-4. Number (and Proportion) of Injuries by Cause

| Cause | Number of Injuries | % of Injuries |
|---|--------------------|---------------|
| Fall/Slip/Trip - General | 600 | 27.8% |
| Struck by Object | 240 | 11.1% |
| Pull/Lift/Push | 197 | 9.1% |
| Exposure (chemicals, fumes, smoke, weather, etc.) | 159 | 7.4% |
| Hit body part on object | 154 | 7.1% |
| Repetitive Motion | 131 | 6.1% |
| Fall/Slip/Trip - Slick surface (ice, oil, etc.) | 120 | 5.6% |
| Handling Objects | 77 | 3.6% |
| Reaching | 75 | 3.5% |
| Insect Bite/Sting | 60 | 2.8% |
| Physical interaction with driver | 56 | 2.6% |
| Opening/Closing Toll Booth Door/Window | 55 | 2.5% |
| Pothole | 26 | 1.2% |
| Fainting | 8 | 0.4% |
| Stress | 8 | 0.4% |
| Fall/Slip/Trip - Construction Area | 3 | 0.1% |
| Foot Entanglement | 3 | 0.1% |
| Other | 189 | 8.7% |
| Total | 2,161 | |

The study team also analyzed injury data by the type of injury as shown in Table 3-5 . Based on the data analyzed, the most common injury types are cuts, scrapes, and abrasions (22.0 percent), strains (17.9 percent), pains (11.0 percent), and sprains (10.7 percent).

Table 3-5. Number (and Proportion) of Injuries by Type of Injury

| Injury | Number of Injuries | % of Injuries |
|---------------------|--------------------|---------------|
| Cut/Scrape/Abrasion | 420 | 22.0% |
| Strain | 342 | 17.9% |

| Injury | Number of Injuries | % of Injuries |
|---------------------------|---------------------------|----------------------|
| Pain | 211 | 11.0% |
| Sprain | 205 | 10.7% |
| Bruising | 188 | 9.8% |
| Twist | 79 | 4.1% |
| Burning/Irritated/Itching | 76 | 4.0% |
| Swelling | 35 | 1.8% |
| Insect Bite/Sting | 33 | 1.7% |
| Soreness | 31 | 1.6% |
| Fracture | 30 | 1.6% |
| Headache | 21 | 1.1% |
| Puncture | 17 | 0.9% |
| Pulled Muscle | 16 | 0.8% |
| Trouble breathing | 14 | 0.7% |
| Burn | 10 | 0.5% |
| Multiple | 8 | 0.4% |
| Stress | 8 | 0.4% |
| Other | 167 | 8.7% |
| Total | 1,911 | |

The study team also analyzed the data to determine what part of the body is most commonly injured as shown in Table 3-6. The most common body parts injured include the knee (11.9 percent), back (10.8 percent), head (8.3 percent), and hand (8.1 percent).

Table 3-6. Number (and Proportion) of Injuries by Body Part Injured

| Body Part Injured | Number of Injuries | % of Injuries |
|--------------------------|---------------------------|----------------------|
| Knee | 326 | 11.9% |
| Back | 296 | 10.8% |
| Head | 226 | 8.3% |
| Hand | 221 | 8.1% |
| Finger | 214 | 7.8% |
| Shoulder | 211 | 7.7% |
| Arm | 179 | 6.5% |
| Ankle | 159 | 5.8% |
| Leg | 148 | 5.4% |
| Elbow | 113 | 4.1% |
| Wrist | 111 | 4.1% |
| Foot | 106 | 3.9% |
| Eye | 98 | 3.6% |
| Neck | 90 | 3.3% |
| Torso | 70 | 2.6% |
| Hip | 56 | 2.0% |
| Internal Organ | 47 | 1.7% |
| Mouth | 28 | 1.0% |
| Groin | 15 | 0.5% |
| Multiple | 3 | 0.1% |
| Palm | 3 | 0.1% |
| Other | 16 | 0.6% |
| Total | 2,736 | |

3.1.2 Conclusions

Based on an analysis of records for 2,662 worker injuries representing 15 agencies, it can be observed that:

- The most common causes of injuries are general falls, slips, and trips (28 percent); being struck by an object (11 percent); and pulling, lifting, and pushing an object (9 percent).
- The most common injury types are cuts, scrapes, and abrasions (22 percent); strains (18 percent); pains (11 percent); and sprains (11 percent).
- The most common body parts injured include the knee (12 percent), back (11 percent), head (8 percent), and hand (8 percent).

In terms of what else can be seen from the data, it is interesting to note that 12 percent of the workplace injuries were designated as “involving a vehicle,” although it appears that the majority of these injuries did not involve direct contact between the vehicle and the worker. Instead they may have involved a motorist pulling the collector’s hand while passing through the plaza. This does indicate, however, that the interaction between vehicles and workers plays a critical role when it comes to worker safety.

While it was possible to examine these trends in the injury data, these findings can only be said to be general observations. The data obtained during this study was not broad enough or consistent enough to draw significant industry-wide conclusions or to fully examine trends. Therefore the findings of this analysis cannot necessarily be said to be representative for the Nation’s toll facilities as a whole.

3.2 Vehicular Crashes

3.2.1 Analysis

Crash data collected during the study represented 10,322 vehicular crashes occurring between 1994 and 2006. The majority of the data represents crashes occurring between 2001 and 2006, although one agency provided data going back to 1994. As different agencies provided data for different time periods, it is not possible to discern meaningful yearly trends from the data.

Although the data supplied were not in a standard format, many agencies collected similar data elements. The most common fields included in the crash data were:

- Accident location.
- Date and time.
- Crash type (at a minimum indicating whether the accident caused property damage only, or an injury or fatality).

Data fields that were less common but present in some of the datasets included:

- Weather conditions at the time of the accident.
- Number of vehicles involved.
- Type of vehicles involved.

- Cause of the accident.
- Accident type (e.g., sideswipe, rear-end, etc.).
- Violation committed.
- Number of injuries.
- Number of fatalities.
- Police crash report number.
- General comments.

About half of the crash records included time of day of the crash; an analysis of this by hour is shown in Table 3-7 below. Not surprisingly, the greatest number of crashes in the database occurred between 7:00 AM and 6:00 PM, which is likely the period of highest traffic volume at these facilities.

Table 3-7. Number of Crashes by Hour

| Hour | Number of Crashes | % of Injuries |
|---------------------|-------------------|---------------|
| 12:00 AM - 1:00 AM | 81 | 1.7% |
| 1:00 AM - 2:00 AM | 45 | 1.0% |
| 2:00 AM - 3:00 AM | 47 | 1.0% |
| 3:00 AM - 4:00 AM | 45 | 1.0% |
| 4:00 AM - 5:00 AM | 53 | 1.1% |
| 5:00 AM - 6:00 AM | 60 | 1.3% |
| 6:00 AM - 7:00 AM | 152 | 3.3% |
| 7:00 AM - 8:00 AM | 267 | 5.8% |
| 8:00 AM - 9:00 AM | 325 | 7.0% |
| 9:00 AM - 10:00 AM | 268 | 5.8% |
| 10:00 AM - 11:00 AM | 218 | 4.7% |
| 11:00 AM - 12:00 PM | 283 | 6.1% |
| 12:00 PM - 1:00 PM | 235 | 5.1% |
| 1:00 PM - 2:00 PM | 272 | 5.9% |
| 2:00 PM - 3:00 PM | 299 | 6.4% |
| 3:00 PM - 4:00 PM | 307 | 6.6% |
| 4:00 PM - 5:00 PM | 340 | 7.3% |
| 5:00 PM - 6:00 PM | 350 | 7.5% |
| 6:00 PM - 7:00 PM | 288 | 6.2% |
| 7:00 PM - 8:00 PM | 178 | 3.8% |
| 8:00 PM - 9:00 PM | 134 | 2.9% |
| 9:00 PM - 10:00 PM | 144 | 3.1% |
| 10:00 PM - 11:00 PM | 129 | 2.8% |
| 11:00 PM - 12:00 AM | 116 | 2.5% |
| Total | 4,636 | |

It was also possible to explore the frequency of crashes based on the number of vehicles involved. Table 3-8 shows that the majority of crashes in the database (75.4 percent) involved 2 vehicles. Only 21.4 percent involved a single vehicle and very few (3.1 percent) involved 3 or more vehicles.

Table 3-8. Number of Crashes by Vehicles Involved

| Number of Vehicles Involved | Number of Crashes | % of Injuries |
|-----------------------------|-------------------|---------------|
| 1 | 866 | 21.4% |
| 2 | 3,049 | 75.4% |
| 3 | 105 | 2.6% |
| 4 | 20 | 0.5% |
| 5 | 1 | 0.0% |
| 6 | 0 | 0.0% |
| 7 | 0 | 0.0% |
| 8 | 1 | 0.0% |
| Total | 4,042 | |

Looking at the data for a single agency (Agency 2), it is possible to analyze the locations of crashes with respect to the toll plaza. Of 406 crash records that reported the crash location, approximately half occurred at the plaza itself (212 or 52.2 percent). Of the remaining crashes, 151 (or 37.2 percent) occurred upstream of the plaza, and 43 (or 10.6 percent) occurred downstream of the plaza.

Looking at the data for another single agency (Agency 7) it is possible to gain insight into the types of crashes occurring at their facilities (representing two large plazas). These are summarized in Table 3-9. Nearly all of the crashes were sideswipes (75.6 percent) or rear end crashes (16.4 percent).

Table 3-9. Number of Crashes by Type (Agency 7 only)

| Crash Type | Number of Crashes | % of Crashes |
|------------------------|-------------------|--------------|
| Angle Collision | 125 | 2.4% |
| Backing | 166 | 3.2% |
| Damaged While Parked | 1 | 0.0% |
| Fixed Object | 47 | 0.9% |
| Head On (Two Vehicles) | 5 | 0.1% |
| Object Lying in Road | 4 | 0.1% |
| Other | 28 | 0.5% |
| Overtaking | 2 | 0.0% |
| Pedestrian | 7 | 0.1% |
| Ran Off Road | 2 | 0.0% |
| Rear End | 839 | 16.4% |
| Right-turn | 2 | 0.0% |
| Sideswipe | 3,867 | 75.6% |
| Turned Over in Road | 3 | 0.1% |
| Unknown | 16 | 0.3% |
| Total | 5,114 | |

3.2.2 Conclusions

Based on analysis of 10,322 crash records obtained from 7 toll agencies, it can be seen that multi vehicle accidents are much more common than single vehicle accidents (75 percent of crashes involved 2 vehicles, while only 21 percent involved a single vehicle). In terms of where accidents most often occur in the vicinity of a toll plaza, only one agency provided this level of detail in their record-keeping, but the data from this agency showed that approximately half of all

accidents occurring in the vicinity of a toll plaza (52 percent) occur at the plaza itself while 37 percent occur upstream of the plaza, and 11 percent occur downstream of the plaza. In terms of the most common crash types, again only a single agency provided this level of detail; for this agency a majority of the crashes were sideswipes (76 percent), with the next most-common crash-type being rear-end collisions (16 percent).

While the team examined several trends in the data as just presented, the crash data was not broad enough or consistent enough to allow significant industry-wide conclusions to be drawn or to fully examine trends. Therefore, the findings of this analysis cannot be said to be representative for the Nation's toll facilities as a whole.

3.3 Study Limitations and Recommendations for Archiving of Data in the Future

This section presents both limitations of the data analysis portion of the study as well as suggestions for future data archiving of accidents and injuries at toll plazas.

3.3.1 Study Limitations

As a whole, there simply was not enough data available in a consistent format to develop concrete conclusions. While the team examined several trends in the data, the data obtained was not broad enough or consistent enough to allow significant industry-wide conclusions to be drawn or to fully examine trends. Analyses were performed on an agency-by-agency basis for those agencies with strong data collection and archiving, but the findings of these analyses cannot necessarily be said to be representative for the Nation's toll facilities as a whole.

An example of the limitations of the data is that reporting thresholds (i.e., what level of accident or injury severity is reported in their database) varied significantly by agency, so the number of incidents documented varied independent of safety factors or facility characteristics, making it difficult to make comparisons across agencies and facilities to determine contributing factors.

A limitation specific to the crash records is that while the fields in the injury records were typically short descriptions providing enough detail to allow for categorization and comparison across agencies, the crash data were primarily defined by discrete variables, and these variables differed from agency to agency. As a result, comparing data across agencies was not desirable as it would have required interpretation of these discrete data fields which could lead to misinterpretation of the results.

Another issue with the crash records was that the amount of data provided by each agency for vehicular crashes varied significantly, with one agency providing as few as 15 records and with another providing as many as 5,114 records. As a result, data from only two agencies comprises 88 percent of the vehicular crash records in the database, making it impossible to draw industry-wide conclusions.

These are just some of the many challenges that the study team faced as a result of the limited electronic data archiving currently in practice across the country. The team recommends that agencies consider more consistent reporting in the future. This is discussed in further detail in the following section.

3.3.2 Recommendations for Data Archiving Moving Forward

In order to facilitate comparison of data across toll facilities to make industry-wide observations and conclusions in the future, the study team recommends that standardized reporting procedures be implemented for both accident and injury data, and that a centralized database be created and maintained to store and organize this data in a searchable format. This would allow data to be compared across toll facilities to make industry-wide observations and conclusions. The team recommends that OSHA record-keeping requirements and the Model Minimum Uniform Crash Criteria (MMUCC) Guideline be considered in developing any standards.

The MMUCC Guideline was developed through a partnership between the Governors Highway Safety Association, the National Highway Traffic Safety Administration, the Federal Motor Carrier Safety Administration, and FHWA in response to a similar challenge. Nationwide analysis of crash data was being hindered due to the lack of uniformity between and within States. The purpose of the MMUCC is to provide a data set for describing motor vehicle crashes that will generate the information necessary to improve highway safety within each State and nationally. The MMUCC is a voluntary and collaborative effort to generate uniform crash data that are accurate, reliable, and credible for data-driven highway safety decisions.⁴

For consistency, the study team recommends that standardized crash data reporting procedures for toll facilities, if implemented, should follow the MMUCC guideline. The MMUCC guideline is very extensive and may take time to implement. Therefore, the study team recommends that data collected for a national toll facility crash database for vehicular crashes include the following MMUCC elements as a minimum (MMUCC data references are in parentheses next to each item):

- Location (C5).
- Date (C2).
- Time (C2).
- Crash type (C8).
- Weather (C11).
- Number of vehicles involved (CD2).
- Type of vehicles involved (V7).
- Apparent crash cause (C6).
- Violation committed (P13/P15).
- Number of injuries / fatalities (CD1/CD3/CD4/CD5/CD6).
- Annualized Average Daily Traffic (RL6).

In addition, in order to perform more detailed analyses of what the possible causes of crashes might be, the geometric and roadway/traffic characteristics (i.e., number of toll lanes, volume, lane widths, sign placement) would be required, and would need to be in an accessible, consistent manner. The FHWA is currently working on an initiative, called the Model Minimum

⁴ <http://www.mmucc.us/>

Inventory of Roadway Elements (MMIRE), that will identify the importance of roadway inventory and traffic data for safety programs and will define what critical roadway data variables are required in order to take advantage of current and future cutting-edge analytical tools and resources.⁵ The study team recommends that toll operators voluntarily participate in MMIRE data collection activities to have this data available for their own safety analyses, as well as national safety analyses.

As for the injury data, although the written descriptions included with the injury data made it easier for the study team to determine the various characteristics of the injury, the study team recommends that similar, consistent data be collected across agencies if national trends and comparisons are of interest. The study team recommends that the following data should be collected as a minimum for all workplace injuries occurring in the vicinity of toll plazas:

- Location.
- Date.
- Time.
- Involvement of a vehicle.
- Injury.
- Causes.
- Body parts affected.

⁵ For more information about MMIRE, contact the FHWA Office of Safety Research and Development or the FHWA Office of Safety.

4 Findings – Factors Affecting Safety at Toll Plazas

Through in-person and telephone interviews, the team gathered information regarding the key factors that can affect safety at toll plazas. This section presents these safety issues – and for each safety issue presents mitigation strategies that have been successfully used across the country. The findings are organized according to four categories. The first two categories focus directly on the issues called for in the legislation:

- *Design of toll facilities* - this includes the effect of design or construction of the facilities on the likelihood of vehicle collisions with the facilities; the safety of crosswalks used by toll collectors in transit to and from toll booths; the use of warning devices, such as vibration and rumble strips, to alert drivers approaching the facilities; and the use of traffic control arms in the vicinity of the facilities.
- *Enforcement practices* – this includes the extent of the enforcement of speed limits in the vicinity of the facilities; the use of cameras to record traffic violations in the vicinity of the facilities; and law enforcement practices and jurisdictional issues that affect safety in the vicinity of the facilities.

The final two categories present additional information that was uncovered during this study that is still very relevant to the topic of highway safety at toll plazas, but that does not directly address the requirements of the legislation:

- *Maintenance practices* – this includes strategies focused on reducing the occurrence of incidents and injuries related to maintenance activities in and around toll plazas.
- *Human factors issues* – this includes strategies focused on reducing the incidence of vehicles stopping or backing up in high-speed lanes, mitigating sensory overload, and mitigating driver inattention.

Beyond these four categories, the study also uncovered information about other safety challenges at toll plazas that are not highway-related – such as *ergonomics*, *worker exposure to the environment*, and *worker risk of assault*. These additional findings are presented in Appendix F. In addition to this, information on workshop participants’ thoughts on all of the strategies (both those presented here and those presented in Appendix F) can be found in Appendix H.

4.1 Design of Toll Facilities

This section presents information regarding ways in which toll agencies have responded to safety issues at toll plazas through design. This section includes a discussion of:

- The effect of design or construction of the facilities on the likelihood of vehicle collisions with the facilities.
- The safety of crosswalks used by toll collectors in transit to and from toll booths.
- The use of warning devices, such as vibration and rumble strips, to alert drivers approaching the facilities.
- The use of traffic control arms in the vicinity of the facilities.

4.1.1 The Effect of Design or Construction of the Facilities on the Likelihood of Vehicle Collisions with the Facilities

There are a number of issues that may increase the likelihood of vehicle collisions with toll facilities. These include:

- *Motorists selecting the improper lane at the plaza* – Agencies frequently experience problems with cash-paying customers accidentally entering ETC lanes. The accident data analyzed as part of this study showed that over one-third (approximately 37 percent) of crashes occur upstream of a plaza. Consistent with this, when asked what action causes vehicular accidents at plazas, the most common reason cited by toll operators was vehicles selecting the improper lane in advance of the plaza.
- *Motorists making unsafe lane changes / last-minute lane changes in advance of the plaza* - Unsafe lane changing can pose a serious safety problem at toll plazas. Often last minute lane changes occur simply because motorists are seeking out the shortest line – they commit to a lane but switch when they see cars moving more quickly in another lane.
- *Driver confusion and driver inattention* - Toll plazas are inherently confusing environments. A variety of elements at plazas can cause confusion, including merging vehicles, unfamiliar messages on signs, inconsistent lane configurations, and a wide variety of competing visual inputs. These issues are exacerbated by the fact that conditions change from agency to agency, from plaza to plaza, and even by time of day at some plazas. Not surprisingly, during the site visits, driver confusion was frequently cited as one of the primary observed reasons for vehicular crashes. Driver inattention has also become a significant problem at plazas, with many motorists talking on a cell phone when approaching the plaza.⁶ Such confusion and inattention contributes to side-swipe collisions, rear-end collisions, vehicle strikes upon plaza infrastructure, and close-calls or collisions with toll workers. One of the biggest concerns related to driver confusion involves unfamiliar, non-ETC equipped drivers entering high-speed ETC lanes. When realizing their error, many drivers stop, exit their vehicles, and cross toll lanes in an attempt to pay the toll. While agencies report that this situation has improved somewhat over time, it remains a large concern at each of the sites visited in the study.

There are a number of ways in which the design or construction of the facility can reduce the likelihood of collisions with the plaza related to the plaza configuration, channelization of traffic, and the use of signs and markings to identify the ETC lanes well in advance of the plaza.

4.1.1.1 Plaza Configuration

Toll authorities have tackled the challenge of improper lane choices / last-minute lane changes in a variety of ways. Many agencies make it a standard practice to position their dedicated high-speed ETC lanes to the left side of their plazas (i.e., toward the center of the roadway), with the idea that the customer expects faster-moving traffic to be primarily to the left side of the

⁶ Teamsters Safety & Health Facts: Distracted Driving, Cell Phone Use, and Motor Vehicle Crashes
<http://www.teamster.org/content/distracted-driving-cell-phone-use-and-motor-vehicle-crashes>

roadway. This practice appears to be effective except in situations where there are on-ramps or off-ramps in close proximity to the plaza, in which case positioning the ETC lanes to the left side of the plaza can cause unnecessary weaving maneuvers. To reduce weaving in these situations, some agencies position dedicated-ETC lanes to both the left and right side of their plazas as



Figure 4-1. Dedicated ETC Lanes Positioned at Both Sides of a Plaza

shown in Figure 4-1.

Another strategy that some agencies feel works well is to position the dedicated ETC lanes in the same location at all plazas including those that are reconfigured throughout the day as traffic density changes. This assists ETC patrons with identifying the proper lane when approaching the plaza. Another agency reported that when reconfiguring their plaza to include dedicated ETC lanes whereas previously cash and ETC were accepted in all lanes, they reviewed ETC usage in all lanes to determine which lane(s) would be best for dedicated-ETC based on prior usage.

Safety can be further compromised when truck traffic which normally travels in right lanes seek out ETC lanes. A common issue is that trucks are prohibited from traveling in the left lane on many roadways, which can pose a weaving problem if the dedicated-ETC lanes and/or the truck-only lanes are located to the left side of the plaza. To address this concern, the Illinois Toll Authority solicited feedback from truck drivers on the best configuration for their truck lanes. They recruited a number of commercial truck drivers and asked them to drive their facility and indicate where they would ideally like to access the plaza. Truck-only lanes were then situated based in part on these responses.

4.1.1.2 Channelization of Traffic

One way to reduce last-minute lane changes at plazas is to channelize traffic well in advance of the plaza (as shown in Figure 4-2).

Channelization can also be used to delay the merging of traffic downstream of the plaza. Some agencies take this a step further, making it a policy to separate ETC and cash-paying customers until the cash-paying customers have accelerated to two-thirds of the normal operating speed. Barriers can also be used to prevent vehicles in the left-most lanes (typically ETC lanes) from making unsafe



Figure 4-2. Concrete Barriers and Attenuators Physically Separate Traffic Upstream of an Illinois Tollway Plaza

maneuvers to reach off-ramps located just downstream of the plaza. The drawback to physical barriers is that they can be costly to install and costly to maintain. A less expensive alternative is to use a buffer lane in lieu of physical barriers; or to extend the longitudinal markings further upstream or downstream of the toll plaza to assist with lane delineation (as shown in Figure 4-3).

High-visibility flexible delineators can also be used to separate traffic at plazas, but they pose their own challenge with regard to maintenance. The Florida Turnpike has found it effective to



Figure 4-3. Pavement Markings and Cones Delay Merging Downstream at the NYS Thruway's Holland Tunnel Plaza

use wide yellow sergeant-striped delineators in place of the solid white delineators that they previously used to separate traffic. They also found that motorists are more responsive to delineators positioned in a “bowling pin” configuration instead of in a straight line.

For those agencies that face the additional challenge of lane assignments changing throughout the day at a particular plaza, pop-up delineators can be a solution. However, some agencies in colder climates have found that pop-up delineators do not perform well during snowy and icy conditions. To address this, the NYS Thruway designed a new pop-up delineator in-house that operates off of air compression and survives the winters.

4.1.1.3 Signs and Markings to Identify Electronic Toll Collection Lanes

Agencies have implemented a number of strategies to direct non-ETC drivers away from ETC lanes. These include adding signs – for example supplementing “brand” signs such as SunPASS with generic signs such as “Pre-Paid Only” (to make it more clear to out of town travelers who may not be familiar with the brand name), and using specialized lane markings, such as differentiating high-speed ETC lanes with purple paint on the outside edges of the lane (as shown in Figure 4-4).

In addition to this, several agencies use pavement markings to assist drivers with lane selection at the toll plaza. Some agencies paint messages on the pavement in the lanes such as CASH ONLY, or the name of the ETC system (e.g., EZ PASS). Other agencies have painted lane numbers on the pavement to match the lane



Figure 4-4. The Use of Pavement Markings to Identify Dedicated-ETC Lanes

numbers on the canopy signs, which aids motorists in choosing the proper lane well in advance of the plaza.

4.1.1.4 Designing for Open Road Tolling

There is clearly a trend toward ORT in the industry. By a strict definition, ORT refers to fully-automated electronic tolling in an “open road” environment, allowing vehicles to travel at highway speeds when passing through toll collection points. Under this definition, customers must either possess an electronic transponder, or be assessed toll charges via license plate recognition technology. By this strict definition, safety is improved as there is inherently lower exposure: there are fewer worker-vehicle interactions since there is no plaza, and there are fewer vehicle-vehicle conflicts since less traffic is traveling through a plaza. Also, noise and emissions are lessened due to the reduction in vehicles starting and stopping.

Beyond this strict definition of ORT, a number of agencies have implemented what might best be termed hybrid ORT operations: that is, they include a combination of mainline, full-speed ETC along with fully separated cash lanes. Typically, cash-paying customers must exit the roadway or shift to a separated toll plaza in order to make cash payment at a traditional, staffed plaza. An example of this is shown in Figure 4-5.



Figure 4-5. Open Road Tolling in Illinois

A new safety challenge that hybrid-ORT has introduced is the issue of managing queue spillback onto the mainline from the cash payment plaza. Queue spillback can result in rear-end collisions.

Preventing this involves both design and operational solutions. For the Illinois

Tollway, which recently converted all of their mainline plazas to hybrid-ORT facilities (a cash payment plaza separated from the mainline traffic by physical barriers), this has been a challenge that they have had to actively monitor and manage. At the planning stage, they modeled each of their plazas to estimate queue lengths at various times of the day, and designed longer deceleration lanes at plazas where they expected longer queues. As an ongoing effort, they have been monitoring the number of cash transactions occurring at each plaza and performing targeted marketing to residents in areas near plazas with a high percent of cash transactions in an effort to increase adoption of ETC, thereby reducing queues. The issue of queue spillback is expected to be less of a concern over time as more and more customers switch to electronic payment, but is likely to be an initial challenge for any agency switching to ORT.

4.1.2 The Safety of Crosswalks Used by Toll Collectors in Transit to and from Toll Booths

When asked about their biggest concern relative to toll plaza safety, nearly every individual that the study team visited with or talked with gave the same response – a worker being struck by a

vehicle. While such incidents are relatively rare,⁷ they have occurred, and the potential certainly exists for them to occur again. Among the factors that have contributed to such incidents in the past (or to more recent close calls) are the introduction of ETC lanes, the uncertainty of driver actions in mixed-use lanes, the inability of operators of large trucks to see someone crossing directly in front of them, the dangers associated with closing a lane, and worker complacency.

To improve the safety of these crossings and/or to reduce exposure of workers to traffic, agencies are using a number of strategies as discussed in the following sections.

4.1.2.1 Direct Access to Toll Booths for Workers

The most aggressive mitigation strategy to protect workers from vehicular traffic is to provide workers access to booths without requiring them to cross active traffic by-pass toll lanes. This can be accomplished with the use of tunnels or bridges (example shown in Figure 4-6).

Approximately half of the agencies visited by the study team have built such structures for their larger plazas. However, these structures rarely prevent workers from being in the roadway altogether. Most of the structures do not have entrances for each and every lane; consequently workers are typically required to cross two to three lanes. Even if collectors can avoid crossing a lane by using the structure, they still sometimes find themselves in live traffic – whether to pick up dropped money, to assist customers having problems with their ETC transponders, or to close a lane. Further, the use of such structures by collectors is typically not mandated (even when present), and many of the agencies that have them report that the use of the tunnels/bridges remains quite low. The reasons for this are varied – workers avoid bridges without elevators because of the need to climb stairs, tunnels are often dank and the entrances slippery, and using a tunnel or bridge can take more time than simply crossing a lane.



Figure 4-6. Tunnels Provide Access to Booths without Exposure to Traffic

Another strategy for minimizing the number of lanes that a worker must cross is to provide break areas on either side of the plaza. Some agencies with plazas or with staffed lanes at either end of the plaza (with ETC lanes in the middle rather than on the far lanes) have placed break rooms on either side of the plaza to minimize the number of lanes that workers must cross. These are found to be effective where they have been implemented, but they can be costly and they are often simply impractical given space limitations and lack of right-of-way.

Two final design strategies for minimizing worker exposure include:

- Locating all high-speed ETC lanes to the left of the facility (i.e., toward the middle of the roadway) and prohibiting employees from crossing these high-speed lanes.

⁷ The accident and injury data obtained through this study did not include any fatalities and the project team learned of only one fatality from the agency interviews.

- Eliminating all mixed-mode lanes, relying instead on dedicated ETC and cash lanes.

4.1.2.2 Policies and Procedures for Crossing

For those cases where workers must still cross travel lanes (either because a tunnel or bridge does not have an entrance to every lane, or because such a structure is not present), agencies have implemented a variety of different crossing procedures, both formal and informal. As an example, nearly all agencies require workers to make eye contact with vehicles before crossing. However, this is the only procedure that was common to all agencies visited and interviewed. Other crossing procedures include the following:

- Most agencies require safety vests to be worn by workers at all times (or at least at all times when outside the booth).
- A number of agencies strictly prohibit workers from crossing high-speed ETC lanes. Some agencies only allow supervisors to cross these lanes. Two agencies reported that employees are never allowed to cross active lanes of traffic – if an employee needs to cross a lane, it must first be shut down.
- Owing to an earlier incident that resulted in a fatality, one agency has a policy that workers are not allowed to cross in front of vehicles larger than a sport utility vehicle, fearing that commercial vehicle operators simply cannot see a person immediately in front of their vehicle.
- Nearly all agencies require their workers to signal their intent to cross to drivers and to wait for confirmation from the driver.
- A number of agencies do not allow their workers to cross behind vehicles as vehicles frequently back up at plazas.
- Employees of one agency are issued a small personal “stop paddle” (as shown in Figure 4-7) that is utilized by both the employee crossing an active lane of traffic and by the collector working in the adjacent toll booth.
- Some workers reported that they have taken to providing verbal cues to motorists (e.g., yelling “I’m crossing!”).



Figure 4-7. Handheld Stop Sign Aids Collector in Crossing Travel Lanes



Figure 4-8. Clear Plastic Shoulder Bag for Collectors to Use when Crossing

- One agency reported that they require workers to look over their shoulder every few steps after closing a lane.
- Several agencies stress the importance of hands-free crossing. Having both hands free while crossing makes it easier for collectors to signal to oncoming traffic and to catch themselves if they fall. To facilitate hands-free crossing, a strategy that many agencies use is to issue collectors shoulder bags or backpacks – such as that shown in Figure 4-8 – in which they can carry their personal belongings to the booth (e.g., a sweater or a bottle of water). In some cases the bag provided was a high-visibility color, such as orange, to make the collector more visible to motorists. One agency has even replaced their collectors' cash drawers with cash bags that they can slip into a shoulder bag for completely hands-free crossing. Most collectors that the team talked with spoke favorably about using carry bags.
- Workers at a number of agencies have adopted informal procedures of mutual support for lane crossing (i.e., the collector in the booth directs the motorist to stop for the crossing collector).
- One agency suggested that it might be a good practice to employ a person to escort workers while crossing lanes, much like a school crossing guard. One agency already does this with the support of their dedicated police force. Although this practice may not be feasible for many agencies, the agency did note that in 42 years an employee has never been hit while crossing a lane using this practice.



Figure 4-9. Booths can create a Visual Obstacle when Crossing

4.1.2.3 Location and Demarcation of Crosswalks

One interesting finding from the study was related to the level of diversity in the location and demarcation of collector crosswalks. For the most part, crosswalks are located just downstream of the booth – minimizing the exposure time of the employee in walking from the crosswalk to the booth. However, a few agencies have alternative approaches. One places their crosswalks upstream of the booth. This reduces the issue of vehicles not being able to see collectors crossing behind booths (and collectors not being able to see vehicles around booths as shown in Figure 4-9). However, it also forces collectors to cross traffic lanes in an area where vehicles do not typically stop.



Figure 4-10. Painted Crosswalk for Workers with Fencing to Channelize Workers to Cross at the Crosswalk

Another agency has their crosswalks positioned at a significant distance downstream of the booths. This provides collectors with somewhat better sight lines (e.g., so that they can see around the booth) and a greater distance between when the vehicle begins accelerating (at the booth) and the crossing point. However, it also means that collectors can have a more difficult time making eye contact with stopped vehicles and with fellow collectors in booths who might be able to offer mutual support.

There was also significant diversity in the methods used to demark the locations where collectors should cross. Most agencies use crosswalks painted on the pavement (as shown in Figure 4-10) and jersey barriers or railings (with openings at the crosswalks) to encourage workers to use the crosswalk. However, a small number of agencies are not as restrictive as to where collectors could cross – while they may still use painted crosswalks, they do not physically channel collectors to openings with gates, etc., for fear that these barriers could present dangerous obstructions if a collector was outside of the crosswalk area and needed to quickly get out of the travel lanes.



Figure 4-11. ManSaver™ Safety Bar

4.1.2.4 Signs for Employees

Related to crosswalks, many agencies have implemented some type of mitigation strategy to remind workers that they are crossing live lanes of traffic. At the most extreme end, some agencies make use of a device called a ManSaver Safety Bar™. As shown in Figure 4-11, these are physical gates adopted from use on fire trucks. These gates must be carefully opened to enter a travel lane (i.e., the worker must stop and pull the gate either



Figure 4-12. Various Signs and Markings Remind Collectors of the Dangers of Crossing Lanes

upward or toward themselves), but can be easily pushed through to get out of the travel lane once on the other side of the crossing. To ensure that collectors cross at the ManSaver bar, one agency that the study team visited has begun using chains at the sides of the crossing area to in effect channelize workers to a specific crossing area.

At the other end of the spectrum, a number of agencies have simply stenciled or painted messages on the curbs abutting the travel lanes. These messages include LOOK → and WATCH FOR TRAFFIC (examples shown in Figure 4-12 and Figure 4-13). Through conversations with collectors, the general consensus is that such messages tend to be effective for new employees or when first added, but that over time they become part of the background and are ignored.



Figure 4-13. Signs and Stickers in Plaza Building and Toll Booth Remind Workers about Safety

Two agencies visited use signs at toll lane crossings to mark ETC lanes so that employees can easily

identify lanes where traffic does not stop. One agency uses signs that read E-Z LOOK, with eyes drawn into LOOK and an arrow pointing in the direction of oncoming traffic. The signs are metal and mounted on the side of the bullnose facing in toward the lane at crossing locations. The same agency also uses red on white signs that read BE ALERT HIGH SPEED TRAFFIC. Another agency uses signs that are installed on the backs of booths and read WARNING – EZ PASS TRAFFIC DOES NOT STOP.

4.1.2.5 Garments for Improved Worker Visibility

Vests are typical safety garments provided to toll plaza employees (Figure 4-14). Beginning in November of 2008, all workers within the right-of-way of a Federal-aid highway who are exposed to traffic or to construction equipment within the work area shall wear high-visibility safety apparel, defined as personal protective safety clothing that is intended to provide conspicuity during both daytime and nighttime usage, and that meets the Performance Class 2 or 3 requirements of the ANSI/ISEA 107–2004 publication entitled “American National Standard for High-Visibility Safety Apparel and Headwear.”^{8,9} In terms of variations on the standard vest, one agency has recently adopted a safety smock which is light-weight, has short arms, and is waist length. It is fluorescent yellow green with



Figure 4-14. Safety Vest

⁸ Federal Register / Vol. 71, No. 226 / Friday, November 24, 2006 / Rules and Regulations, Page 67792. <http://www.tpsps.org/Standards%20Revisions/Hi-Visibility%20Requirements.doc>

⁹ Revised American National Standard for High-Visibility Safety Apparel and Headwear, ANSI ISEA 107-2004. <http://www.safetysupply.com/hivisstd.htm>



Figure 4-15. Retroreflective Jacket

orange sections and retro-reflective strips.

Depending on the climate, some agencies issue collectors a retroreflective jacket (as shown in Figure 4-15).

Another agency issues toll collectors a 3-in-1 coat. The coat is lined and fluorescent yellow-green. The sleeves can be unzipped and removed for spring and fall and the lining unzips so that it is more vest-like in the summer.

Another agency has gone to using battery-powered flashing vests for employees who work in the toll lanes, and still another reported moving toward a high visibility safety vest with five-point breakaway. The vests were

ordered in response to news reports that vests would get caught on passing vehicles and workers were being dragged several hundred feet. The vests are fluorescent yellow green, and are supplied to each employee and replaced as needed. The agency reported that the collectors provided input to management when the vests were being selected and the breakaway vest has received a positive response by employees.

Three agencies reported that they are considering development of new uniforms that will have safety features built in, thereby eliminating the need for safety vests.

4.1.2.6 Reducing Slips, Trips, and Falls while Crossing

In terms of strategies to mitigate slips, an obvious solution that most agencies reported is simply making it a priority to keep the crossing areas clear of debris and oil. Beyond this, many agencies use grooved or textured pavement in the crossing area to provide better traction (for example, the Golden Gate Bridge has recently begun using a material called FlexCrete™, a fiber-reinforced aerated concrete, in place of standard concrete at their crossing areas).

For colder climates, ice and snow can present a challenge. One agency has made a point to position drain gates below the curb at all crossing areas to avoid ponding water, which can lead to icy conditions. Another agency ensures that all of their walkways are covered to help reduce snow and ice on the walkways. Denver E-470



Figure 4-16. Crampons Can Help Collectors Avoid Slips in Snowy and Icy Conditions



Figure 4-17. Cash Bags Can Facilitate Hands-Free Crossing

has recently begun issuing collectors crampons (shown in Figure 4-16) which can be worn on the outside of their shoes to provide better traction on snow and ice.

Finally, as previously mentioned, several agencies focus on hands-free crossing with the use of shoulder bags to carry belongings (with the idea that having both hands free will make it easier for collectors to catch themselves if they fall). One agency now issues cash bags instead of cash drawers to facilitate hands-free crossing for their collectors (as shown in Figure 4-17).

In an attempt to mitigate trips, some agencies use brightly colored striping on the edges of stairs and curbs to improve visibility and depth perception. For those agencies with tunnels or overhead access to booths, many stressed the importance of having handrails on both sides of stairways (as shown in Figure 4-18).



Figure 4-18. Handrails on Both Sides of Tunnel Stairways Can Improve Safety

4.1.3 The Use of Warning Devices, such as Vibration and Rumble Strips, to Alert Drivers Approaching the Facilities

Toll plazas present unique challenges to drivers. Many plazas operate much like a complex intersection in that there are on-ramps or off-ramps in close proximity to the plaza creating excessive weaving maneuvers. Additionally, many agencies face challenges in dealing with truck traffic and over-sized loads, particularly in regard to trucks “mixing” with automobiles. Finally, speed variance between ETC and cash-paying customers is a safety challenge faced by all agencies with plazas accepting both electronic and cash payment.

4.1.3.1 Rumble Strips

Although agencies reported mixed feelings regarding the effectiveness of rumble strips, nearly half of the agencies that the study team spoke with use rumble strips or grooved pavement to alert drivers that they are approaching a toll plaza. The rumble strips are typically positioned in advance of the flare for the plaza although some agencies position them closer to the plaza (as shown in Figure 4-19) to provide toll collectors with an auditory warning that a vehicle is approaching.



Figure 4-19. Rumble Strips

As for the agencies who do not use rumble strips, some commented that the noise they generate is disruptive to nearby residential areas while others reported that rumble strips cause problems with snow plow operations.

4.1.3.2 Informing Motorists of Changing Conditions

Frequently changing conditions at toll plazas can contribute to driver confusion and distraction. These variable conditions include lane closures, changes in lane direction (at some facilities), changes in lane configuration (ETC versus mixed use), and the presence of maintenance activities (scheduled and otherwise). Strategies to combat these particular sources of driver confusion typically center on providing better information to motorists. For example, an increasing number of agencies are employing the use of Variable Message Signs (VMS) upstream of the toll plazas to warn drivers of unexpected conditions such as incidents and maintenance activities. The NYS Thruway is experimenting with the use of digital signs upstream of the plaza indicating which lane numbers are currently accepting ETC and which are cash or mixed use (see Figure 4-20).

To reduce the occurrence of rear-end collisions resulting from queues, one agency positions visibility maintenance trucks and/or flaggers at the end of the queue any time it extends beyond the sight of the plaza. This can be a very effective strategy, but is also resource intensive.

4.1.3.3 Providing Advance Warning to Motorists of Approaching Plaza

All agencies use advance signing to warn drivers that they are approaching a toll plaza. Specific messages include TOLL PLAZA AHEAD, PAY TOLL AHEAD, etc. In addition to these warning signs, some agencies use lane designation signs in advance of the plaza. For example, one agency has a plaza where drivers can exit to an Interstate or onto a local road immediately after passing through the plaza. After experiencing a number of vehicular accidents in the area immediately downstream of the plaza, the agency has implemented advance signing that directs drivers to the side of the toll plaza where they will need to be depending on their direction of travel downstream of the plaza. Since installing the lane designation signs, the agency has not experienced any accidents downstream of the plaza.



Figure 4-20. Dynamic Signs Display Current ETC Lane Numbers at a NYS Thruway Plaza

4.1.3.4 Increasing Conspicuity of Facilities and Workers

Some agencies are installing messages on signs and on the pavement at the toll plaza to caution drivers about employee presence in the toll lanes. One agency has installed pedestrian crossing warning signs with flashing amber lights at the beginning of the toll island to caution drivers. Signs are also posted in holders on the front of the bullnose. One of the messages used is SLOW DOWN - PROTECT OUR WORKERS.

Another innovative strategy reported by West Virginia Parkways is the installation of white strobe lighting on the canopies at all toll plazas to highlight their facilities during inclement weather. They feel that the strobe lighting has been helpful in ensuring that drivers will see the upcoming plaza in foggy driving conditions.

4.1.4 The Use of Traffic Control Arms in the Vicinity of the Facilities

Nearly all agencies use some form of traffic control arms in the vicinity of their facilities, even if only in advance of a booth to close a lane. The gates used to designate a closed lane are typically manually operated by a worker who must physically walk into the lane to open and close the gate.

4.1.4.1 Reducing Speeds and Reducing Toll Violations

Gates downstream of the plaza are typically used for speed reduction, toll violation reduction, and/or traffic control. In terms of where these traffic control arms are used and how they operate, there is a great deal of variation. Some agencies use gates in all of their lanes, including their ETC lanes, but a majority of agencies use them in their manual lanes only. In many cases the gates are automated (i.e., they automatically lift as a vehicle equipped with an ETC transponder approaches), but in many cases the gates will not lift until the collector finishes the transaction. Agencies that do not use gates report several reasons for their decisions: the industry trend toward open road tolling, volume is too high through the plaza, expense, and maintenance.

The appearance of traffic control arms vary in terms of color schemes, messaging, and materials. Many agencies construct their gates out of materials that will minimize damage to vehicles in the event that a vehicle drives through the gate. Some agencies affix signs to their gates with messages such as STOP or DO NOT BACK UP. In addition to this, many agencies use some sort of reflective materials on the gates to increase visibility.

Many agencies felt that gates played a role in successfully controlling speeds – whether or not they were installed for this reason. Where gates are in use, all customers, including those with electronic payment, must wait for a gate to lift before proceeding through the plaza. Typically the gates lift automatically as an ETC vehicle approaches, so that ETC customers can proceed safely through the plaza without stopping as long as they maintain a reasonable speed – typically below 15 miles per hour. While effective in reducing speeds through toll plazas, doing so may be in contradiction with agency objectives to maximize throughput and mobility.

4.1.4.2 Informing Motorists of Lane Closures

Agencies use a variety of methods for conveying a closed lane to motorists. Some agencies simply close a lane with a traffic cone or gate (some examples are shown in Figure 4-21 and Figure 4-22). While this creates a physical barrier to help discourage drivers from entering closed lanes, it can be dangerous for collectors to physically close the gate. In addition to this, some agencies have faced problems with motorists not seeing closed gates. In an effort to make the gates more visible, one agency has installed unique three-foot high orange reflectors on their



Figure 4-21. Gates in use to Indicate that a Lane is Closed

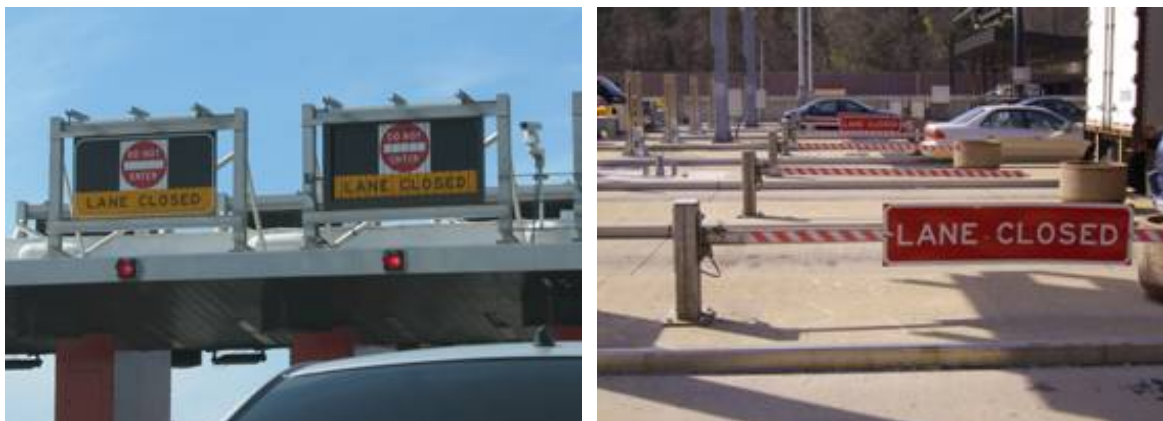


Figure 4-22. Options for Conveying a Closed Lane to Motorists

gates (similar to driveway markers). Since the addition of the reflectors, the agency reported that there has been a significant reduction in the gates being hit. Beyond this, many agencies have signs on their gates to further communicate to motorists that the lane is closed, and to draw attention to the gates. In terms of messages, some use a LANE CLOSED sign or a DO NOT ENTER sign. One agency used to use a STOP Sign on a gate, but moved away from this after noticing cars approaching the gate and waiting for it to open. Other agencies have moved away from written signs entirely, feeling that they add to visual clutter and confusion; they now simply employ Red X's or Green arrows to indicate lane closure status that can be changed remotely, thereby reducing worker exposure to vehicles.

4.2 Enforcement Practices

This section presents information regarding ways in which toll agencies have responded to safety issues at toll plazas through enforcement practices. This section includes a discussion of:

- The extent of the enforcement of speed limits in the vicinity of the facilities.
- The use of cameras to record traffic violations in the vicinity of the facilities.
- Law enforcement practices and jurisdictional issues that affect safety in the vicinity of the facilities.

As discussed in the previous section, the introduction of ETC, and particularly of high-speed ETC lanes, has introduced a new concern at plazas: speeding. Prior to the advent of ETC, every customer was required to come to a complete stop in order to collect a ticket or pay a toll. Now a good portion of customers are not required to stop at all, and in some cases, they are able to maintain near highway speeds while passing through a plaza.

Many toll agencies have a dedicated police force which can make it easier to enforce speeding and other traffic violations. For others, State and local police patrol their facilities, but there is no regular schedule for their patrols. Others contract with State Police to ensure that regular enforcement services are provided.

Some agencies are unable to enforce speed limits at their plazas due to State or local laws. For example, one agency is unable to enforce speeds at their plazas because of laws requiring “Reduced Speed Ahead” signs and the need to step down the speed limit over a distance that is too long for to be practical at their plazas. For those agencies who are able to enforce speed limits, a variety of different tactics are used. In some cases speed enforcement activities are

accomplished using radar from a vehicle positioned either in the plaza parking lot or on the shoulder downstream of the plaza. Other times an officer is positioned on the toll island with radar, and when a speeder is identified, the officer calls the vehicle description out to a chase cruiser downstream of the plaza. Another method is to use decoys for speed enforcement by placing radar inside an inconspicuous vehicle, such as a dump truck, on the shoulder at the plaza. A final method is to park unmanned police cruisers at the plaza to give the impression of enforcement presence which can assist with speed reduction.

A fair number of agencies across the country use cameras as a means to record toll violators; however, very few agencies use cameras to record traffic violations. Many are unable to use cameras for this purpose due to State or local laws that disallow the use of cameras due to privacy concerns or other concerns; others find it cost-prohibitive. For those who are able to make use of automated enforcement, speeding is the traffic violation typically monitored.

No agencies reported being affected by jurisdictional issues that they feel negatively impact safety in the vicinity of toll facilities. While a handful of agencies reported that law enforcement practices minimally affect safety in the vicinity of their toll plazas, an overwhelming majority of agencies reported that they feel that there is no negative affect on plaza safety due to law enforcement activity.

Of the facilities visited by the team, those that reported having the lowest incidence of speeding were two agencies that had an aggressive automated enforcement program: the NYS Thruway and the PANY/NJ. Although there is no hard data to substantiate this observation, it seems plausible that their extensive automated speed enforcement program may be the main success factor in keeping speeds under control at their plazas. Like most other agencies that have an automated enforcement program, cameras record violators and then the agency notifies violators by mail of their offense. What makes their program unique is that they suspend ETC tags for a period of time for repeat or excessive violators, a practice that is particularly effective with trucking firms due to the toll discount associated with having a transponder.

Of those agencies that do have some form of automated enforcement, most choose to inform



Figure 4-23. Enforcement Presence at an MTA Plaza

motorists that the toll plaza is photo enforced, and in most cases this is done with white on black regulatory signs.

Increasing enforcement presence at plazas is another way that some agencies combat speeding (Figure 4-23 and Figure 4-24 show examples of how different agencies demonstrate enforcement to motorists). In fact, some agencies feel that it is critical to all safety programs – so much so that one workshop participant even noted that no strategy would be effective without a strong enforcement program. Increasing enforcement presence is obviously an easier feat for those agencies that have a dedicated police force or well established relationships with the local police force.

Different tactics are used when enforcing traffic violations. In some cases police conduct speed enforcement using radar from their vehicle – either from the plaza parking lot or from the shoulder downstream of the plaza. Another speed enforcement tactic used by the police is to place an officer on the toll island with radar. When a speeder is identified, the officer calls the vehicle description out to a chase cruiser that is downstream of the plaza. The police also sometimes use decoys for speed enforcement by placing radar inside an inconspicuous vehicle, such as a dump truck, on the shoulder at the plaza. Some agencies reported that the police will also park unmanned police cruisers at the plaza to assist with speed reduction.



Figure 4-24. Sign Notifying Motorists that Plaza Is Photo Enforced

One agency reported that they have succeeded in reducing speeding by getting legislation passed that allows for doubled fines for speeding in toll areas. In this particular case, the legislation applies only to toll plazas where the speed at the plaza is reduced to 30 mph for ETC lanes. This agency has open road tolling where the speed limit is not reduced and increased fines for speeding do not apply at these areas. Other strategies include:

- Ensuring that speed limits at plazas are consistent with nearby toll authorities.
- Implementing a public outreach campaign targeting speeders. To do this cost-effectively, many agencies do this as part of their regular mailings to ETC customers. One agency has a program called “Give Them 10” that encourages motorists to maintain speeds below 10 mph in the vicinity of toll plazas.
- Painting the speed limit on the pavement in advance of the plaza as shown in Figure 4-25 to remind drivers of the speed limit.



Figure 4-25. Pavement Markings Reinforce the Speed Limit in Dedicated ETC Lanes



Figure 4-26. Speed Limits Are Posted at Each Lane to Reinforce Speed Limits

- Posting speed limits at each lane as reminder to motorists as shown in Figure 4-26. This is especially helpful in situations where the speed limit varies by lane.
- Using regulatory speed limit signs instead of advisory speed limit signs where possible.
- Using temporary or permanent digital signs displaying real-time speeds of motorists. Some use these signs in the area upstream of the plaza while others use them at the plaza area itself.
- Using pavement markings to lower speeds. The NYS Thruway makes use of transverse yellow pavement markings that are spaced progressively closer to give motorists the illusion that they are increasing speed even when they are maintaining a constant speed (as shown in Figure 4-27).



Figure 4-27. The Use of Transverse Pavement Markings to Reduce Speeding

4.3 Maintenance Practices

There are a variety of strategies in use across the country specifically to reduce the occurrence of incidents and injuries related to maintenance activities in and around toll plazas. Some of these strategies include:

- Requiring the use of attenuator trucks for all maintenance activities that require a lane closure.
- Placing “Your Speed Is” dynamic signs on the rear of attenuator trucks to slow down vehicles in the vicinity of maintenance activities.
- Positioning cameras on the roadside rather than overhead (with the use of side-fire cameras), allowing maintenance activities to take place away from the travel lanes.
- Requiring maintenance workers to use a “buddy” system (i.e., a worker never goes out alone so that there is always another worker to watch for unsafe traffic conditions).
- Positioning qualified flagging personnel and maintenance trucks with flashing lights at the rear of traffic back-ups whenever the queue stretches beyond sight of the plaza. This technique is used to reduce the occurrence of rear-end collisions.

Equipping maintenance vehicles with partial red lights (i.e., amber on front, red on back) to give motorists the impression of enforcement presence. The PANY/NJ believes that this has helped them successfully lower speeds around incidents and maintenance work. Beyond this strict definition of ORT, a number of agencies have implemented what might best be termed hybrid ORT operations: that is, they include a combination of mainline, full-speed ETC along with fully separated cash lanes. Typically, cash-paying customers must exit the roadway or shift to a separated toll plaza in order to make cash payment at a traditional, staffed plaza. An example of

this is shown in Figure 4-5 above. This type of arrangement can also present some new challenges that are worthy of discussion.

4.3.1 Maintenance Activities with Open Road Tolling

One potential safety-related drawback to ORT (both fully “open road” and hybrid-ORT) is equipment maintenance since, in most cases, repairs that take place over the roadway would require that all lanes be closed. However, the Florida Turnpike has addressed this concern with a unique overhead gantry design that allows maintenance workers access to equipment without closing lanes or disturbing traffic (see Figure 4-28). The gantry provides an area large enough for maintenance employees to work above the roadway, and all ETC equipment is positioned on a lever that allows workers to pull the equipment up into the work area. Additionally, there is a screen shielding workers from passing motorists to avoid distraction, and there is a fine mesh material at the base of the gantry below the work area to prevent the danger of debris dropping onto the traffic below during maintenance activities.



Figure 4-28. Florida Turnpike’s Overhead Gantry for ORT Allows for Maintenance Activities without Road Closure

4.4 Human Factors Issues

There are a variety of strategies in use across the country that specifically address human factors issues. Some of these strategies include reducing the incidence of vehicles stopping or backing up in high-speed lanes, mitigating sensory overload, and mitigating driver inattention as discussed in the following sections.

4.4.1 Reducing the Incidence of Vehicles Stopping or Backing Up in High-Speed Lanes

Some agencies have deployed mitigation strategies that are aimed at preventing vehicles from stopping in high-speed lanes. For example:

- Implementing public education campaigns to familiarize drivers with the concept of ETC.
- Installing a tall barrier wall to prevent motorists in high-speed lanes from stopping and crossing to staffed booths.
- Removing driver violation warning



Figure 4-29. “DO NOT BACK UP” Sign to Reduce Unsafe Motorist Behavior

signs – many agencies feel that it is better to lose the toll (or pursue the toll through automated enforcement) than to have a vehicle stop in high speed lanes.

- Adding signs to educate drivers about safe behavior with messages such as DO NOT STOP or DO NOT BACK UP – STAY IN VEHICLE (as shown in Figure 4-29).
- Using public address systems to communicate with drivers at unmanned booths so that staff can instruct motorists to stay in their vehicle and to keep moving. It should be noted that there is some debate as to the usefulness of this approach owing to noise and the impracticality of constantly monitoring the travel lanes for such situations.

4.4.2 Mitigating Sensory Overload

The final significant source of driver confusion identified in the site visits was simply sensory overload, or the challenge of reading, recognizing, and appropriately acting upon the multitude of messages and signs presented to a driver approaching a plaza. Among the solutions sites have explored to combat this issue are:

- Minimizing the number of signs.
- Moving toward the use of symbols (such as “\$”) in lieu of, or in addition to, words (such as “cash only”) as shown in Figure 4-30.
- Moving toward simplification of messages on signs.
- Placing signs at eye level (as opposed to overhead or in-pavement).
- Using focus groups to test different sign configurations and messages.
- Banning advertising in the vicinity of plazas.



Figure 4-30. One Option for Conveying that Cash is Accepted in All Lanes

4.4.3 Mitigating Driver Inattention

In addition to the various sources of confusion inherent in the design, layout, and operations of plaza facilities, drivers also introduce their own activities that contribute to inattention and distraction. While not unique to toll plazas, many customers engage in cell phone conversations, read maps, and undertake a variety of activities that have been demonstrated to cause driver distraction and crashes on all roadway facilities, not just toll plazas. In addition, a subset of drivers, colloquially referred to as “wavers,” undertake a form of distraction that is unique to plaza facilities. These individuals fail to properly mount their ETC tags and instead hold them up to the windshield, out the window, etc., with little regard to traffic conditions around them. While there is not much that can be done to mitigate against the actions of these individuals, agencies have pursued strategies such as public education campaigns, providing warnings against the practice in billing mail-outs, and instructing toll collectors to look for and discourage the practice if possible.

4.4.4 Educating Drivers about Electronic Toll Collection

A drawback noted by the Illinois Tollway in their switch to hybrid-ORT is that their cash lanes now have a higher percentage of inexperienced users. They feel that this has increased the amount of erratic driving behavior at some of their plazas as the motorists who are less familiar with the facility can no longer “follow” the experienced motorists through the plaza.

A final challenge associated with hybrid-ORT is that vehicles that are not ETC-equipped may stop in travel lanes due to confusion over how to make payment. One agency that faced this challenge was the PANY/NJ, which recently changed the lower deck of the George Washington Bridge over to ETC-only during nighttime hours (the plaza is unstaffed at night and equipped with an automated enforcement system that charges customers by mail), and they initially encountered a wide range of unsafe maneuvers (e.g., vehicles turning around, backing up, cutting across the plaza). To address these issues, they added signs at each booth that say “YOU WILL BE BILLED,” and they added an intercom system to provide customers access to supervisory staff on the staffed upper deck toll plaza. They also changed their signs to direct non-ETC customers to the right side of the plaza where they will pose less of a danger to other motorists in the event that they do come to a stop or attempt other erratic behavior. The sign that they have evolved to at the right side of the plaza is “ALL OTHERS.”

5 Summary

This report described a study to investigate issues surrounding worker and motorist safety in the vicinity of toll collection facilities. The study was undertaken in direct response to Section 1403 of SAFETEA-LU legislation, and is focused on accomplishing two main objectives:

- (1) To study the incidence of accidents and injuries in the vicinity of highway toll collection facilities.
- (2) To study the safety of toll collection facilities for workers and motorists – and to document strategies for improving toll plaza safety.

The study involved a review of existing literature, a survey of toll operators, site visits to 7 agencies, interviews with 21 agencies, a workshop with representatives from 20 agencies, and an analysis of available worker injury and motorist crash data.

To address the first goal of the study, the team analyzed available data on accidents and injuries occurring in the vicinity of toll booths. While the team examined several trends in the data, the data obtained was not broad enough or consistent enough to allow national conclusions to be drawn or to fully examine trends.

The data did show that approximately one-quarter of workplace injuries occurring at toll plazas are the result of general falls, slips, and trips (28 percent). Other common injuries are those resulting from being struck by an object (11 percent), and from pulling, lifting, or pushing an object (9 percent). In terms of the types of injuries that occur most frequently, the most common injury types reflected in the data obtained were cuts, scrapes, and abrasions (22 percent), strains (18 percent), pains (11 percent), and sprains (11 percent).

The accident data showed that of 406 crashes where the location was reported, approximately half (52 percent) occurred at the plaza. Of the remaining crashes, approximately 37 percent occurred upstream of the plaza, and approximately 11 percent occurred downstream of the plaza.

It is important to note that the study did not find evidence to suggest that toll collector fatalities are a frequent occurrence at toll plazas. The extensive accident and injury records obtained through this study did not include any fatalities, and the project team learned of only one fatality through agency interviews. In order to compare data across toll facilities to make industry-wide observations and conclusions, the study team recommends that standardized reporting procedures be implemented for accident and injury data, and that a centralized database be created and maintained to store this data and organize it in a searchable format. In addition, the team recommends that a field be added to the FARS to denote whether a crash occurred within the vicinity of a toll plaza.

To address the second goal of the study, the team gathered information through a survey, telephone interviews, and site visits. These activities revealed information about a number of safety challenges that toll authorities face across the United States. These activities also revealed that authorities across the country are implementing a wide range of safety strategies with success, and that many of these strategies could be effective for other agencies.

These strategies, which span a wide range of issues, and tackle a wide range of safety challenges, were vetted with representatives from 20 of the Nation's toll agencies in a facilitated workshop setting in order to obtain feedback from individuals in the field on the perceived effectiveness of each strategy and of any concerns and/or constraints that they may see or have with any

particular strategy. As the operating conditions, culture, etc., are different at each agency and even at each toll plaza in some cases, the strategies are presented not as recommendations, but as ideas for agencies to consider when seeking ways to improve safety for workers and motorists at their toll collection facilities.

The findings were presented in four categories with the first two focusing directly on the issues called for in the legislation:

- *Design of toll facilities* - this includes the effect of design or construction of the facilities on the likelihood of vehicle collisions with the facilities; the safety of crosswalks used by toll collectors in transit to and from toll booths; the use of warning devices, such as vibration and rumble strips, to alert drivers approaching the facilities; and the use of traffic control arms in the vicinity of the facilities.
- *Enforcement practices* – this includes the extent of the enforcement of speed limits in the vicinity of the facilities; the use of cameras to record traffic violations in the vicinity of the facilities; and law enforcement practices and jurisdictional issues that affect safety in the vicinity of the facilities.

The final two categories present additional information that was uncovered during this study that is still very relevant to the topic of highway safety at toll plazas, but that does not directly address the requirements of the legislation:

- *Maintenance practices* – this includes strategies focused on reducing the occurrence of incidents and injuries related to maintenance activities in and around toll plazas.
- *Human factors issues* – this includes strategies focused on reducing the incidence of vehicles stopping or backing up in high-speed lanes, mitigating sensory overload, and mitigating driver inattention.

Beyond these four categories, the study also uncovered information about other safety challenges at toll plazas that are not highway-related – such as *ergonomics*, *worker exposure to the environment*, and *worker risk of assault*.

Appendix A – Panel Members and Participating Agencies

This project was guided by a panel of stakeholders from a variety of industries relevant to this project including the tolling and transportation industries. The panel worked together to set the scope for this project and has actively provided guidance and participated in the project. The panel members included:

- Don Bell, New York State Thruway Authority
- Linda Brown, Federal Highway Administration, Office of Operations
- Clayton Chen, Federal Highway Administration, Office of Safety
- Neil Gray, International Bridge, Tunnel and Turnpike Association
- Mark Hagemann, Occupational Health and Safety Administration
- Ken Jacoby, Federal Highway Administration, Office of Asset Management (Panel Chair)
- Ken Kobetsky, American Association of State Highway and Transportation Officials
- Kathy Landkrohn, Occupational Health and Safety Administration
- Azita Mashayekhi, International Brotherhood of Teamsters
- Gary Pennick, Pennsylvania Turnpike Commission
- Bob Rupert, Federal Highway Administration, Office of Operations

The study team interviewed the following representatives from toll authorities across the country:

- Stephan Andriuk - Director of Toll Operations, Miami-Dade Expressway Authority
- Kirk Avila - Treasurer, Orange County Transportation Authority
- Neal Belitsky - Vice President & General Manager, Detroit & Canada Tunnel Corporation
- David Caldwell - Richmond Metropolitan Authority
- Terry Cooke - Facility Director, Virginia DOT – Coleman Bridge
- Tom Dwyer - Safety & Security Manager, Thousand Islands Bridge Authority
- Jim Eden - Chief Operating Officer, North Carolina Turnpike Authority
- Wayne Ferguson - Manager of Bridge Operations, New York State Bridge Authority
- Richard Frassetto - Superintendent-Toll Operations, Delaware River & Bay Authority
- Terry Herbert - Expressway Administrator, Chesapeake Expressway
- Fred Hilliard - North Texas Tollway Authority
- David Machamer - Director, Toll Operations, Oklahoma Turnpike Authority
- Steve Maynard - Toll Director, West Virginia Parkway
- Cliff Miller – Director, Toll Collection, Garden State Parkway (NJ Turnpike Auth.)
- Donald Milstead - Delaware River Port Authority
- Clement Pruitt - Director of Operations/Chief of Police, Chesapeake Bay Bridge Tunnel District
- Curt Richardson - Safety Coordinator, Maine Turnpike Authority
- Joe Staub - Deputy Director, Massachusetts Port Authority

- Michael Whelan - Regional Operations Manager, Pocahontas Parkway

The workshop participants were as follows:

- Stephan Andriuk - Deputy Executive Director, Miami-Dade Expressway Authority
- Walter Arnason - Operations Manager, E-470 Public Highway Authority
- Steve Bobrick - Director of Operations, Northwest Parkway Public Highway Authority
- Deborah Crane - Toll Facilities Manager, Lee County DOT / Toll Facilities
- Mark Davern - Toll Collector, Teamsters Local 127 (Massachusetts Turnpike Authority)
- Ernie Davis - Assistant Toll Division Manager, NYS Thruway Authority NY Division
- Wayne Ferguson - Manager of Bridge Operations, NYS Bridge Authority
- Gerry Flint - Trustee, Teamsters Local 72 (NYS Thruway Authority)
- Richard Lash - Director Safety Services, Ohio Turnpike Commission
- Michael Locati - Bridge Captain, Golden Gate Bridge Highway & Transportation District
- Steve Maynard - Toll Director, West Virginia Parkways Authority
- Johnny Melton - Assistant Toll Operations Director, Oklahoma Turnpike Authority
- Jill Mergen - Operations Manager, Chesapeake Expressway
- Cliff Miller - Director, Toll Collection, Garden State Parkway
- Clement Pruitt - Director of Operations, Chesapeake Bay Bridge-Tunnel District
- Robert Quirk - Director, Toll Collection, New Jersey Turnpike
- Enrique Ramirez - Manager, Operations Programs, PANY/NJ
- Alisha Urbina - Business Agent/Toll Collector, Teamsters Local 436 (Ohio Turnpike)
- Joe Volk - Senior Engineer, Delaware River and Bay Authority, Delaware Memorial Bridge
- Ed Wallace - General Manager, Throgs Neck Bridge, MTA Bridges and Tunnels

Appendix B – Literature Review

Background

There are many papers and reports that take an in-depth look at toll facilities and their operational characteristics, but few studies exist that focus on *safety* at toll facilities. Those studies that do exist and presented here according to the following four areas:

- Safety Conscious Planning in Toll Facility Design.
- Driver and Occupant Safety in the area of Toll Facilities.
- Traffic Volume at Toll Plazas and the Impact on Safety.
- Toll Collector Health and Safety.

Safety Conscious Planning in Toll Facility Design

Adequate toll facility design can have an impact on the safety of toll facilities once constructed and operational. Several papers and reports reviewed by the project team describe case studies and state-of-the-practice for toll facility design. In recent years, many of the studies deal with effective design for facilities with a combination of conventional and ETC lanes.

In National Cooperative Highway Research Program (NCHRP) Synthesis 240 *Toll Plaza Design* (Schaufler 1997), various practices are described related to the design, current practice, and use of ETC. One of the major considerations of safety design is the use of safety devices on the approach to toll islands. Devices include: concrete-filled steel bollards or I-beams, concrete ramparts, barrier shapes, concrete crash blocks, impact attenuators, and frangible devices (such as sand barrels). Toll agencies recognize that the purpose of the device is to protect the toll attendants and redirect vehicles back into the toll lane and away from the toll plaza structure. The synthesis report also describes the importance of appropriately designed traffic control devices since a lack of consistency can be confusing to new patrons and older drivers. Inadequate traffic control devices can also lead to slower processing of the tolls as well as abrupt maneuvers in a plaza. The author states that toll plazas should have consistent signing, marking, and signal practices to encourage consistent behavior.

A paper by McDonald and Stammer (2001) provides a contribution toward guidelines for toll facility design. The authors state that safe toll facility design is more critical than ever when ETC lanes are implemented. Safety considerations mentioned include the safety of drivers who stop to pay a toll using conventional lanes, drivers who proceed without stopping when using ETC lanes, and toll plaza workers. Various qualities of toll facilities change depending on the agency as well as the individual facility including lane configurations, reversible lanes, taper rates, transition lengths, lane width, and vertical geometrics.

With respect to lane configurations, toll facilities can contain a combination of toll payment options including full service booths, automatic coin machines, and ETC. These ETC lanes can be either express or dedicated depending on the facility. Care should be taken in the selection of speed limits for ETC lanes where speeds can range from 5 to 45 mph for dedicated ETC lanes and up to 60 mph or more for express ETC lanes. The use of reversible lanes is fairly common especially in areas where there is a directional effect such as morning versus evening rush hour.

McDonald and Stammer recommend that reversible lanes not be used with ETC express lanes unless the speed of the nonstop traffic is drastically reduced. A better option may be to place the high-speed lanes on the outside (or right side) of the toll facility, but the authors suggest that this would be inconsistent with the usual design of multi-lane roadways, in which faster traffic normally uses the left lanes.

McDonald and Stammer also found taper rates to be very different when comparing the transition between the roadway and the toll facility. There are two tapers, one on the approach and a second for the departure or merge. The authors suggest a modification to existing taper rate equations for the area where vehicles are anticipated to stop for toll payment. The authors suggest that at 40 mph or less, the approach taper equation should be:

$$L = \frac{WS^2}{105}$$

where L is the minimum length of taper in feet, S is the posted speed in mph, and W is the offset distance in feet. For 45 mph or more, the approach taper equation should be:

$$L = \frac{3}{8}WS$$

Once vehicles have paid their toll, the authors suggest that the merge taper equation should be:

$$L = (1.5) \frac{WS^2}{105} + 5W$$

for exit speeds of 40 mph or less. When speeds leaving the plaza are more than 40 mph, as in the case for ETC lanes where traffic does not stop for the toll plaza, conventional taper equations are recommended.

Transition lengths include both the queue area length prior to entering the toll plaza and the recovery zone after leaving the toll plaza. Appropriate distances need to be chosen to allow vehicles to decelerate and get back up to speed when leaving the toll plaza.

Transition lengths that are too short can cause conflicts and should be avoided. In general, the queue area was found to range from 75 feet to over 1000 feet and the recovery zone was found to range from 30 to 650 feet, depending on the facility. The authors state that the queue area will depend on demand, but the recovery zone should be a minimum of 75 feet in length to allow for slow deceleration of trucks.

McDonald and Stammer acknowledge that lane width at the toll plaza will depend on the lane type, but they recommend that wide load lanes meet State regulations, ETC express lanes be 12 feet wide with shoulders, ETC dedicated lanes be 12 feet wide, lanes with high truck traffic (≥ 30 percent) be 12 feet wide, lanes with substantial truck traffic (> 10 percent but < 30 percent) be 11 feet wide, and all other lanes be 10 feet wide, as a minimum.

McDonald and Stammer also discuss vertical geometrics in the areas of cross slopes and sight distance. The authors recommend that the cross slope for express ETC lanes be the same as that of the adjacent roadway to remove excess water and avoid icy conditions, and that a cross slope of 1.5 percent to 1.6 percent should be used on the approach, at the plaza, and on the departure. The authors also explain the importance of stopping and decision sight distance at toll plazas and

thus urge the reader to consult the AASHTO Green Book for sight distance considerations and equations.

A recent report by FHWA, conducted by Wilbur Smith Associates (2006), *State of the Practice and Recommendations on Traffic Control Strategies at Toll Plazas*, also provides general information on toll plaza design and traffic control devices. The report describes several recommendations dealing with safety design at toll facilities. The first section addresses design in the approach zone and recommends the use of the transition zone taper values proposed by McDonald and Stammer (see above). Additionally, the authors suggest that if an upstream interchange is located in a way that drivers cannot change lanes quickly enough to reach the ETC lanes, then the maneuver should be physically prevented through barriers. A third recommendation dealing with the approach zone is that sensors should be placed at toll lanes to prevent oversized trucks from entering the lane.

The second section on safety design deals with the departure zone. The authors recommend that the transition zone taper values proposed by McDonald and Stammer be used and that recovery zones should be long enough to allow sufficient driver reorientation, acceleration, and initial merge. The authors again recommend that in departure zones, if a downstream interchange is located so close to the toll plaza that ETC users cannot safely change lanes to make the exit, then the movement should be restricted through physical barriers. The authors also suggest that when dedicated ETC lanes are used, a physical barrier should separate the dedicated lanes from other toll traffic until the other traffic has accelerated to two-thirds of the operating speed.

The report addresses various other safety design issues as well, suggesting, for example, that when express lanes are used, they should be located to the far left of the plaza for consistency and that they should be designed with shoulder and lane width characteristics that are similar to the mainline approach. The report also advises the use of lighting for safety in which the intensity levels and uniformity ratios should be based on the American National Standards Institute (ANSI) and Illuminating Engineering Society (IES) values.

A case study by Mohamed et al (2001) describes safety considerations related to the design of electronic toll plazas. The authors define five main lane types that are used at toll facilities (a classification similar to the one McDonald and Stammer describe) which are: manual, automatic, mixed, dedicated automatic vehicle identification (AVI), and express AVI. During a period of 3½ years from 1994 to 1997, data was analyzed for the Orlando-Orange County Expressway Authority in Florida. The data show that 32 percent of the crashes occurred at their 10 mainline toll plazas. The monthly crash rate also significantly increased when comparing the rate before ETC was added and after ETC was added (from 3.4 to 7.5 crashes per month). The authors identify several conflict points and dangerous behaviors including merging, queuing, and speeding vehicles. Some suggested reasons that ETC caused an increase in crashes could be driver unfamiliarity with the system, toll plaza configuration, and the possible speed variance between drivers that use ETC and drivers that do not. Solutions mentioned include increasing the width of the ETC lanes, arranging similar lane types within the plaza, providing more advance signing, adding variable message signs to show payment methods available and status of lanes, and an extensive use of pavement markings. Pavement markings could be used to reduce speeds, discourage weaving and lane changes, reduce driver confusion, and reduce conflict points.

In 1990, Zilocchi described a success story on the Garden State Parkway dealing with the addition of branch toll lanes to improve safety and operations at toll plazas. This practice is used by several toll agencies when expanding toll plazas to create more toll lanes. Traditionally, toll plazas were expanded by adding lanes horizontally, which caused issues with increased right-of-way, construction time needed, disruption of traffic, opposition from the community, and cost. Branch lanes are used to add toll lanes either ahead of or after the existing lanes as a branch of the mainline plaza. Zilocchi stated that safety was a prime concern and thus the safety aspects were carefully monitored. One issue deals with motorists traveling too fast on the approach to the branch lanes, and thus signing was used to successfully cut down on approach speeds. Of additional concern was toll worker safety, and thus the New Jersey State Police were asked to carefully monitor the branch toll lanes due to an increased danger of robbery or other inappropriate action with tollbooth personnel in the branch lanes. Other concerns included protecting collectors from being injured by vehicles, and thus impact attenuators and sidewalks with steel guidrails were added to make the branch lanes as safe as the traditional lanes. Zilocchi reported that as of publication of the article, there were not any serious accidents in the branch lanes and that there did not seem to be any reason to think that the lanes were inherently unsafe as designed.

Driver and Occupant Safety in the Area of Toll Facilities

In 2003, Mohamed Abdel-Aty (2003) published a paper analyzing driver injury severity levels and what factors had the most influence. In the paper, models were developed at roadway sections, intersections, and toll plazas in Central Florida. The toll plazas analyzed were on the Central Florida expressway system on state roads 408, 417, and 528 for a total of 79 miles. Ten mainline toll plazas and 42 ramp tolls are located in the system. The ETC was added starting in 1994 and the installations were completed by 1998. Police reports were obtained in 1999 and 2000 to analyze the results.

Variables collected fell into the categories of crash, driver, vehicle, plaza, and roadway. Crash-related factors included age, gender, driver license type, alcohol involvement, driver violation, presence in an ETC lane, and ETC user. Vehicle factors included vehicle type, point of impact, number of impacts, and speed ratio (as compared with the posted limit). Plaza factors included mainline versus ramp, and roadway factors included weather condition, lighting condition, and time and day information. Of 1,932 total crashes on the system in 1999 and 2000, 447 crashes (23.1 percent) occurred near a toll plaza with 803 drivers involved. The type of crashes were: rear-end (40.1 percent), sideswipe (26.5 percent), fixed object (21.3 percent), backed-into (6.4 percent), and other (5.7 percent). As for data that indicated crash location relative to the toll plaza (725 vehicles), 43.6 percent of the accidents were when the vehicle was approaching, 43.7 percent were when the vehicle was at the plaza, and 12.7 percent were when the vehicle was leaving the plaza. When looking at injury severity, 61.0 percent had no injury, 21.0 percent had possible injury, 15.3 percent had evident injury, and 2.8 percent had a severe or fatal injury.

The results showed that older drivers, male drivers, and occupants not wearing a seat belt had a higher probability of severe injury. Additionally, drivers of passenger cars, vehicles struck on the driver's side, and vehicles that were speeding experienced higher severity injury. Additionally, it was found that vehicles with an ETC transponder had a higher injury rate to those without the transponders. This may occur when a vehicle without a transponder stops in the lane with fast-moving ETC transponder users.

Another study conducted in Florida by Abdelwahab and Abdel-Aty (2002) looked at the same data as the Abdel-Aty paper described previously and compared the use of logit models and artificial neural networks to analyze the safety at toll plazas. The authors state that an ETC transponder user is 11 percent more likely to be involved in a crash than nonusers. The results showed that a neural network approach was a better model to predict crash severities, but more important to this topic are the recommendations made after running the models. The first suggestion is that improvement is needed in lane markings at the approach to toll plazas. The second suggestion states that traffic signs should be used to deter motorists from stopping in ETC lanes. The authors also suggest that warning signs be placed downstream of plazas located at off-ramps to show that a toll plaza is located on the ramp. Additionally, the authors recommend that ETC lanes be made wide enough to accommodate heavy trucks that use the ETC system. Finally, it is suggested that the approach zone and toll plaza structure should be illuminated to enhance visibility.

Traffic Volume at Toll Plazas and the Influence on Safety

There is a scarcity of published research dealing with the effect of traffic volume on safety at toll plazas; however, a paper by Chang et al. (2000) investigated how volume-to-capacity (v/c) ratios affected safety on a freeway section with two mainline toll booths. The study section included a four-lane freeway with four interchanges, two toll gates, and two tunnels. It was found that the accident rate of the toll facility section was higher than the other sections. The overall relationship of crashes represented a U-shaped curve with v/c ratios from 0.1 to 0.8 and an accident rate from 90 to 2,714 crashes per million kilometers traveled. When analyzing the curve, the fewest crashes occurred at the toll facility section when the v/c ratio was 0.57. The authors do state, however, that the model did not fully explain the relationship and that additional explanatory variables should be considered.

Toll Collector Health and Safety

A comprehensive review of toll collector health and safety was performed by Szeinuk et al. (2006) for the International Brotherhood of Teamsters. As identified in other reports, the authors state that ETC systems may contribute to the health and safety risks of toll collectors. Overall, the report identified several concerns to toll collectors. Outside the tollbooth, these concerns include:

- Crossing the toll plaza due to poor design, lack of signs, lack of tunnels, and danger of trips and falls.
- Poor maintenance of plaza facilities.
- Motorist issues including disregard for signs, speeding, failure to stop, and dangers of tractor-trailers.
- Lack of enforcement resulting in a vulnerability to security.

Inside the tollbooth, risks to toll collectors include:

- Lack of protection
- Uncomfortable uniforms
- Ergonomic concerns (i.e., uneven floors, uncomfortable seats, fixed window height, door jamming, poor lighting, and repetitive motion)

- Inadequate air conditioning and heat
- Respiratory issues
- Noise-induced issues
- Motorist behavior from rudeness to road rage
- Poor sanitation
- Sense of insecurity
- Understaffing
- Respiratory and cardiovascular diseases
- Musculoskeletal injury
- Cancer
- Noise-induced hearing loss
- Chemical exposure
- Vehicle-pedestrian accidents
- Homicide, assault, and violence
- Slips and falls
- Mental health, job strain, and stress

Several remedies are suggested by the author, including minimizing exposure of tollbooth collectors to vehicular exhaust and noise; improving ergonomics of toll collection facilities; protecting collectors from injury, violence, and slips; and providing an adequate work frame to minimize the risks for strain and shift-work-related disease.

A paper by Feist et al. (2001) detailed the results of a survey of tollbooth agencies regarding traffic noise and the performance of a headset to increase noise control. The surveys were conducted at the Portage Barrier Toll Collection Plaza located west of Portage, Indiana. Sources of noise included emissions from trucks and motorcycles, idling engines, and accelerating vehicles, which are all low frequency sounds. The employees identified that the presence of noise caused discomfort, made communication with patrons difficult, and caused fatigue. The survey showed that a properly configured and comfortable active noise control headset would be acceptable to employees. One caution noted by the authors, though, is that the device may be confused by motorists as a source of entertainment rather than a noise reduction device. The authors add that this may be overcome with a professional-looking design.

The Wilbur Smith Associates report on *State of the Practice and Recommendations on Traffic Control Strategies at Toll Plazas* emphasizes that safe access be given to toll collectors at toll facilities. Specifically, the report recommends that toll collectors should never have to cross an ETC lane to reach their plazas and that, preferably, tunnel or overhead access should be given for all lanes. The authors recognize that tunnel or overhead access can not be provided for every toll booth, but it should be designed that toll collectors would not have to cross more than one toll lane to get to their assigned booth.

The NYS Thruway Authority contracted with Vollmer Associates in 2000 to perform a *Toll Lane Safety Study Report*. This study was undertaken following a fatal pedestrian accident in 1999, and the purpose of the study was to analyze the issue of toll collector safety operations in light of the accident and to determine whether any additional measures could be effective and practical in improving the safety of toll collectors crossing active toll lanes. This study included an industry review, a summary of practices at other facilities, and a review of measures noted in the citation issued by the New York State Department of Labor. It also included information about how 8 different toll authorities deal with 16 different safety practices. Six of the eight had safety programs in place or under development. Seven of the eight had formal lane crossing procedures with requirements ranging from wearing safety vests, to holding up a hand or stop sign paddle, to making eye contact with the driver, to verbally asking a vehicle to stop while paying a toll and notifying them to wait until the toll collector crosses in front of them. Various traffic control devices are also used to show crosswalks and close toll lanes. These devices include traffic lights, stop signs, striping, gates, and traffic cones. Agencies primarily use gates for safety as well as violation deterrence. Five agencies had data available on crashes. Four of the five did not have any injuries dealing with toll collector/vehicle crashes. One agency had one instance of a toll collector/vehicle injury crash in which a vehicle with a transponder was at an ETC lane and then changed lanes to a staffed lane and failed to stop in the staffed lane even though a stop sign was present.

The NCHRP Synthesis 240 also describes security issues that occur at toll facilities. Access cards are increasingly being used at toll administration buildings to monitor the individuals who are entering and leaving the facility as well as to deny access to unapproved individuals. Various devices have also been used at toll booths, including surveillance cameras, silent alarms, bulletproof toll booth glass, and bill alarms.

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Appendix C – Agency Survey

The findings from the survey are presented here according to the four parts of the survey:

- General Information
- Accident and Injury Data
- Strategies and Programs to Improve Safety
- Recommended Toll Facilities for Data Collection

General Information

Most agencies reported that the types of worker injuries listed on the survey occur infrequently. From the types of worker injuries listed on the survey, slips, trips, and falls were reported to have occurred with the most frequency. While two agencies reported moderate to frequent occurrences of worker injuries caused by vehicles passing through toll plazas, an overwhelming majority reported this injury type as occurring *very infrequently*. Agencies were invited to write in other types of worker injuries that were not included in the survey. Other reported worker injuries included *over-exertion / repetitive motion, lifting, cash drawers, toll equipment, pulled arm, and insects*.

Respondents also indicated that vehicular accidents caused by the factors listed in the survey occur infrequently in the vicinity of a toll plaza. The most frequent type of vehicular accident indicated that caused by vehicles selecting an improper lane at the plaza. The responses indicated that, of the types listed, the least frequent type of vehicular accident occurring in the vicinity of a toll plaza was accidents caused by vehicles backing at the plaza. As in the worker injury section, agencies were invited to write in other causes of vehicular crashes that were not included in the survey. Other causes reported by agencies included *inattentive driving, striking the toll booth/toll equipment, truck/car interactions, and rear-end collisions*.

Accident and Injury Data

Of the 27 agencies responding, 15 reported that they maintained crash data and most reported that they had between 5 and 10 years of data available electronically. Of the toll agencies that reported that they do not maintain crash data, most reported that the State Police maintain the data. An overwhelming majority of agencies reported maintaining worker injury data. Agencies reported maintaining anywhere from 2 to 25 years of electronic worker injury data, with an average of 8 years of data available. Virtually every agency did provide a point of contact for worker injury data, which the study team used in the subsequent data collection phase of the study.

Strategies and Programs to Improve Safety

In this section of the survey agencies were asked to provide information about safety strategies that have been implemented at their toll collection facilities. These findings can be found in the section of this report dealing with strategies (*Section 4*).

Agencies were also asked, “Are there any specific issues associated with toll facility safety that you are interested to see what other agencies are doing?” Issues of interest included:

- Methods for reducing the occurrence of vehicles stopping in ETC lanes.
- Methods for controlling speed through the lanes, especially ETC lanes.
- Methods employees use for crossing lanes.
- Methods used for closing a lane.
- Use of different pavement marking patterns to encourage drivers to reduce their speed as they approach the plaza (specifically, patterns that give a perception that drivers are going faster than they really are).
- Methods used to separate ETC lanes from other lanes.
- Methods used to warn drivers of employees crossing the lane.

Recommended Toll Facilities for Data Collection

At the conclusion of the survey, respondents were asked to recommend some of their facilities for a site visit.

Appendix D – Agency Site Visits

This section presents findings according to the following contributing factors that the study team took note of during the site visits. Along with each contributing factor are strategies that the various sites have implemented to address these challenges.

- Merging / Lane Changing Behavior
- Speeding
- Driver Confusion and Distraction
- Worker Exposure to Vehicles
- Environmental Issues
- Ergonomics
- Assault

Note that much of the information presented here was also presented, together with a synthesis of the interviews and the workshop, in Section 4, *Findings – Factors Affecting Safety at Toll Plazas*.

Merging / Lane Changing Behavior

Toll plazas present unique challenges in terms of lane-changing behavior and merging. Many plazas operate much like a complex intersection (i.e., there are on-ramps or off-ramps in close proximity to the plaza, which creates excessive weaving maneuvers).

Speed variance between ETC and cash-paying customers is a challenge faced by all plazas accepting both electronic and cash payment. Toll authorities across the country have tackled this problem in a variety of ways. To start, many agencies make a standard practice of positioning their ETC lanes to the left side of their plazas, with the idea that the faster-moving traffic will be to the left side of the roadway. This practice appears to be effective except in situations where there are on-ramps or off-ramps in close proximity to the plaza, in which case this practice causes unnecessary weaving maneuvers. To combat this, many agencies have taken to positioning dedicated-ETC lanes to both the left and right side of certain plazas.

Beyond this, some agencies have gone toward channelizing ETC traffic well in advance of the plaza to reduce last-minute lane changes, and to channelize ETC traffic downstream of the plaza to delay merging of traffic. Other agencies have begun adding a buffer lane between the ETC lanes and cash or mixed-use lanes or to use physical separation (such as with a concrete barrier) for the higher-speed traffic.

More common than physical separation, many agencies make use of delineators. However, visibility can be an issue. To combat this problem, one agency replaced their solid white delineators with wide yellow sergeant-striped delineators. Others have found that visibility was improved after positioning the delineators in a “bowling pin” configuration instead of a straight line. For those agencies that face an additional challenge in that their lane assignments change throughout the day, pop-up delineators can be a good approach. However, some agencies in colder climates have found that pop-up delineators do not perform so well during snow and icy

conditions. To address this, the NYS Thruway designed a new pop-up delineator in-house that operates off of air compression and survives the winters.

Safety can be further compromised when truck traffic is introduced to the plaza – so much so that one agency solicited feedback from truck drivers on the best configuration for one of their plazas (particularly on what would make the most sense for the location of the truck-only lanes in relation to the rest of the plaza). A common issue is that trucks are prohibited from traveling in the left lane on many roadways, which poses a weaving problem since the dedicated-ETC lanes – and in many cases the truck-only lanes – are located to the left side of the plaza.

Speeding

The introduction of electronic toll collection – and particularly of high-speed ETC lanes – has introduced a new concern at plazas: speeding. Prior to the advent of ETC, every customer was required to come to a complete stop in order to collect a ticket or pay a toll. Now a good portion of customers are not required to stop at all, and in many cases, are able to maintain near highway speeds while passing through a plaza. Vehicles speeding through plazas present an obvious safety concern for workers, and as a result many agencies have implemented strategies specifically targeted at combating speeding.

Of the facilities visited by the team, those that reported having the lowest incidence of speeding were the NYS Thruway and the PANY/NJ. Although there is no hard data to substantiate this observation, it seems plausible that their extensive automated speed enforcement program may be the main success factor in keeping speeds under control. Through their automated enforcement program, cameras record violators and letters are mailed out to provide notification of the violation. The ETC tags are suspended for a period of time for those who are repeat or excessive violators. The agencies involved have found this practice to be particularly effective with trucking firms.

Another measure that many agencies felt played a role in successfully controlling speeds was gates. Where they are used, all customers - including those with electronic payment - must wait for a gate to lift before proceeding through the plaza. Typically the gates lift automatically as an ETC vehicle approaches, so ETC customers can proceed safely through the plaza without stopping as long as they maintain a reasonable speed (typically below 15 miles per hour). Excessive speeds also affect first responders and maintenance workers, and many agencies expressed concern about this. The PANY/NJ has combated this by equipping their maintenance vehicles with red lights (i.e., amber on front, red on back) to give motorists the impression of enforcement presence, and they feel that this has successfully lowered speeds.

Other speed mitigation strategies observed by the team on the site visits included:

- Using rumble strips in the area just upstream of the plaza to draw motorist's attention to their speed.
- Using pavement markings to lower speeds (e.g., transverse yellow pavement markings with spacing gives the illusion that you are speeding)
- Painting the speed limit on the pavement to reinforce the speed limit.
- Using regulatory speed limit signs rather than advisory to encourage motorist to obey the speed limit.

- Posting temporary or permanent signs displaying real-time speeds of motorists.
- Boosting enforcement presence at plazas with speeding issues.

Driver Confusion and Distraction

Toll plazas are inherently confusing environments. There are multiple distractions from merging vehicles, unfamiliar messages on signs, inconsistent lane configurations, and a wide variety of competing visual inputs. These issues are exacerbated by the fact that conditions may change from agency to agency, from plaza to plaza, and even by time of day. Not surprisingly driver confusion was frequently cited as one of the primary observed reasons for vehicle crashes at the various sites visited. Such confusion contributes to side-swipe collisions, rear-ends, vehicle strikes upon plaza infrastructure, and close-calls or collisions with toll workers. One of the biggest concerns related to driver confusion involves unfamiliar, non-ETC equipped drivers entering into and then stopping in high-speed ETC lanes. While this situation has improved somewhat over time, it remains a large concern at each of the sites visited in the study. A number of mitigation strategies have been implemented to address this situation. First there are a series of strategies that aim to direct non-ETC drivers away from ETC lanes in the first place. These include, public education campaigns to familiarize drivers with the concept of ETC, careful consideration of signs – for example supplementing ambiguous lane indication “brand signs,” such as SunPASS, with generic signs such as “Pre-paid only,” and specialized lane markings, such as differentiating high-speed ETC lanes with purple paint at the edges of the lanes and adding pavement markings.

Further mitigation strategies are aimed at preventing non-ETC equipped drivers who enter ETC lanes from stopping there. For example, some agencies have removed or reduced the conspicuity of driver violation warning signs – feeling that it is better to lose the toll (or pursue the toll through automated enforcement) than to have a vehicle stop in the high speed lanes. A great number of agencies have added signs that say DO NOT STOP or to DO NOT BACK UP. Others have gone so far as to add public address systems to communicate with drivers and instruct them to stay in their vehicle and to keep moving. However, there is some debate as the usefulness of this approach owing to noise and the impracticality of constantly monitoring the travel lanes for such situations.

As mentioned earlier, frequently changing conditions at toll plazas also contribute to driver confusion and distraction. These variable conditions include lane closures, changes in lane direction (at some facilities), changes in lane configuration (ETC versus Mixed Use), and the presence of maintenance activities (scheduled and otherwise). Strategies to combat these particular sources of driver confusion typically center on providing improved traveler information. For example, an increasing number of agencies are employing the use of VMS upstream of the toll plazas that could be used to warn drivers of unexpected conditions, such as incidents and maintenance activities. The NYS Thruway is experimenting with the use of digital signs upstream of the plaza indicating which lanes are accepting ETC and which are cash or mixed use. These electronic signs are supplemented by lane numbers painted on the pavement as drivers approach the plaza as well as by lane numbers on top of the canopy.

In terms of lane closure, a number of agencies simply use signs and traffic cones. Others use physical barriers or gates. Such gates are felt to aid in keeping drivers from entering closed lanes, but can be dangerous for collectors to put in place. Finally, there seems to be some diversity in the best way to communicate the status of lanes as closed or open – with messages

ranging from LANE CLOSED to DO NOT ENTER. One agency used to use a stop sign on a gate, but moved away from this after noticing cars approaching the gate and waiting for it to open. Other agencies have moved away from written signs entirely – feeling that they add to visual clutter and confusion – and now simply employ a red X or a green arrow to indicate lane closure status.

The final significant source of driver distraction identified in the site visits was simple sensory overload, or the challenge of reading, recognizing, and appropriately acting upon the multitude of messages and signs presented to a driver approaching a plaza. Among the solutions sites have explored to combat this issue are efforts to minimize the number of signs, movements toward symbols (such as “\$”) in lieu of or in addition to words (such as “cash only”), simplification of messages, the placement of signs at eye level (as opposed to overhead or in-pavement), the use of focus groups to test different sign configurations and messages, and banning advertisements in the vicinity of plazas.

In addition to the various sources of confusion inherent in the design, layout, and operations of plaza facilities, drivers also introduce their own activities that contribute to inattention and distraction. While not unique to toll plazas, many customers engage in cell phone conversations, read maps, and undertake a variety of activities that have been demonstrated to cause driver distraction and crashes on all roadway facilities, not just toll plazas. In addition, a subset of drivers, colloquially referred to as “wavers,” undertake a form of distraction that is unique to plaza facilities. These individuals fail to properly mount their ETC tags and instead hold them up to the windshield, out the window, etc. with little regard to traffic conditions around them. While there is not much that can be done to mitigate against the actions of these individuals, agencies have pursued strategies such as public education campaigns, provider warnings against the practice in billing mail-outs, and instructing toll collectors to look for and discourage the practice if possible.

Worker Exposure to Vehicles

When asked the one fear that kept them up at night, nearly every individual that the research team visited with gave the same response – a worker being struck by a vehicle. While such incidents are relatively rare,¹⁰ they have occurred, and the potential certainly exists for them to occur again. Among the factors that have contributed to such incidents in the past (or to more recent close calls) are the introduction of ETC lanes, the uncertainty of driver actions in mixed use lanes, the inability of operators of large trucks to see someone crossing directly in front of them, the dangers in closing a lane, and worker complacency.

Given the level of concern surrounding this particular safety issue, it is perhaps not surprising that a large and varied number of mitigation strategies have been tried and implemented to address the problem.

The most aggressive mitigation strategy to protect workers from vehicular traffic is the use of tunnels and bridges. Approximately half of the agencies visited by the research team had built such structures for their larger plaza facilities. However, these structures rarely prevented all incidents of workers being in the roadway. Most of the structures did not have entrances for

¹⁰ The accident and injury data obtained through this study did not include any fatalities and the project team learned of only one fatality from the agency interviews.

each and every lane – consequently workers would still need to cross two to three lanes. Even if collectors could avoid crossing a lane by using the structure, they could still find themselves in live traffic – to pick up dropped monies, to assist customers having problems with their ETC transponders, or to close a lane. Further, the usage of such structures is typically not mandated (even when present) and their actual usage remains quite low. The reasons for this are varied – workers avoid bridges without elevators because of the need to climb stairs; tunnels are often dank and the entrances slippery, and the use of both structures can take more time than simply walking across a lane.

For those cases where workers must still cross traffic lanes (either because a tunnel or bridge does not have an entrance to every lane or such a structure is not present) agencies have generated a variety of different crossing procedures (both formal and informal). Nearly all agencies require workers to make eye contact with vehicles before crossing and to keep one hand free. However, these were the only two procedures that appeared to be common to all agencies visited. Crossing procedures that were employed by one or more agencies, but not common to all, included:

- *Safety vests* – most agencies required safety vests to be worn by workers at all times; others required them to be worn only when outside of the booth, one did not require vests at all.
- *Prohibition on crossing any high-speed ETC lanes* – A number of agencies had a strict prohibition against workers crossing high-speed ETC lanes, some only allowed supervisors to cross these lanes, others allowed all staff to cross such lanes.
- *Limitation on crossing vehicles larger than an SUV* – owing to an earlier incident, one agency did not allow their workers to cross in front of any vehicle larger than an SUV, fearing that operators of large trucks simply cannot see a person immediately in front of their vehicle.
- *Signal intention* – A number of agencies require their workers to signal their intent to cross to drivers and wait for confirmation from the driver.
- *Prohibiting crossings behind vehicles* – a number of agencies did not allow their workers to cross behind vehicles, for fear that the vehicle would back up. Other agencies did not have his prohibition.
- *Require verbal cues* – some workers have taken to providing verbal cues to motorists (e.g., yelling “I’m crossing!”).
- *Mutual support* – workers at a number of agencies have adopted informal procedures of mutual support for lane crossing (i.e., collector in the booth directs the motorist to stop for the crossing collector).
- *An escort* – one agency suggested that it might be a good practice to employ a person to accompany workers while crossing lanes, much like a school crossing guard.

Other strategies are focused on warning the traveling public to watch out for workers in the plaza facility. These efforts include public education campaigns, the implementation of pedestrian crossing signs, and the use of hand-held stop signs by crossing employees.

One interesting finding from the study was the diversity in the location, demarcation, and set-up of collector crosswalks. Most of these crosswalks were located just downstream of the booth – minimizing the exposure time of the employee in walking from the cross-walk to the booth. However, a few agencies had tried alternative approaches. One had placed their crosswalks up-

stream of the booth. This reduces the issue of vehicles not being able to see collectors crossing behind booths (and collectors not being able to see vehicles around booths). However, it also forces collectors to cross traffic lanes in an area where vehicles do not typically stop. Another agency had placed their crosswalks at a significant distance downstream of the booths. This provided the collectors with somewhat better sight lines and more time between vehicle acceleration (from the booth) and the crossing point. However, it also meant that collectors had a more difficult time making eye contact with stopped vehicles and with fellow collectors in booths that might offer mutual support. There was also significant diversity in the methods used to demark the locations where collectors should cross. Most agencies used crosswalks painted into the pavement and jersey barriers, or railings (with openings at the crosswalks) to encourage workers to use the cross-walk. However, a small number of agencies were not as restrictive as to where collectors could cross – while they may still use painted crosswalks, they do not physically channel collectors to openings with gates, etc. for fear that these barriers could present dangerous obstructions if a collector was outside of the cross-walk area and needed to quickly get out of the travel lanes.

Related to crosswalks, most agencies visited had implemented some type of mitigation strategy to remind workers that they were crossing live lanes of traffic. At the most extreme end, two of the agencies visited made use of “bars.” These are physical gates adopted from use on fire trucks that must be carefully opened to enter into the travel lanes, but can be easily pushed through to get out of the travel lane. At the other end of the spectrum a number of agencies had simply stenciled or painted messages on the curbs abutting the travel lanes. These messages included “Look →” and “Watch for Traffic.” Through conversations with collectors, the general consensus was that such messages tended to be effective for new employees or when first added, but became just part of the background and were ignored over time.

Several agencies visited stressed the importance of hands-free crossing. Having both hands free while crossing makes it easier for collectors to signal to oncoming traffic and to catch themselves if they fall. To facilitate hands-free crossing, a strategy mentioned by many agencies visited was to issue collectors shoulder bags or backpacks in which to carry their personal belongings to the booth (e.g., a sweater or bottle of water). In some cases the bag provided was a high-visibility color, such as orange, to make the collector more visible to motorists. One agency visited has even replaced their collector’s cash drawers with cash bags that they can slip into a shoulder bag for completely hands-free crossing. Most collectors that the team talked with spoke favorably about using carry bags.

Other mitigation strategies related to worker safety in travel lanes included requiring workers to look over their shoulder (toward traffic) every few steps after closing barriers, providing break areas on either side of plaza facilities to minimize the number of lanes that need to be crossed, using attenuator trucks for all maintenance activities that require a lane closure, using side-fire cameras to allow for maintenance work without closing a lane (i.e., cameras are mounted by the roadside instead of overhead), and requiring maintenance workers to use a “buddy” system, with one worker watching for unsafe traffic conditions.

Environmental Issues

Toll collectors are exposed to a range of environmental hazards on the job, such as excessive noise and emissions. Through the site visits, the team found that agencies typically perform some combination of the following mitigation strategies to lessen the impact of these hazards:

- *CO testing* – Some agencies have CO monitors in their booths, while others perform periodic CO testing.
- *Noise and emissions testing* – Many agencies perform noise and emissions testing on a periodic basis and take measures to reduce these hazards if they are at unacceptable levels. As an example, one agency found excessive noise levels at a booth with high truck traffic and responded to this concern by putting time restrictions on working in that particular booth.
- *Positive air pressure* – Many agencies have positive air pressure in their booths, and all agencies retrofitting booths were adding positive air.
- *Air conditioning* – Agencies in warmer climates consistently had air conditioning in their booths; some provide collectors with individual controls in the booths.

In terms of protective equipment, the most common equipment that the agencies issue to collectors for environmental reasons are gloves, although most collectors interviewed by the study team reported that they do not wear gloves very often on the job either due to the negative public perception or due to the fact that they make it difficult to quickly perform work tasks. In addition to this, some agencies provide safety shoes to protect workers' feet from injury.

Beyond this, the work environment can pose physical hazards that can result in injuries such as slips, trips, and falls, which were commonly mentioned as the most prevalent workplace injury occurring at the plaza. Slips can be caused by icy or snowy conditions, from the presence of debris or other substances on the pavement, from uneven pavement, or simply from carelessness by workers when climbing stairs or curbs.

In terms of strategies to mitigate slips, an obvious solution is that most agencies make it a priority to keep the crossing areas clear of debris and oil. Beyond this, many agencies use grooved or textured pavement in the crossing area to provide better traction (for example, the Golden Gate Bridge has recently begun using a material called FlexCrete™, a fiber-reinforced aerated concrete, in place of standard concrete at their crossing areas). For colder climates, ice and snow can present a challenge. One agency has made a point of positioning drain gates below the curb at all crossing areas to avoid ponding water, which can lead to icy conditions. Denver E-470 has recently begun offering collectors the option of wearing crampons which can be worn on the bottom of their shoes to provide better traction on snow and ice. Finally, as previously mentioned, several agencies focus on hands-free crossing with the use of shoulder bags to carry belongings to the booth (with the idea that having both hands free will make it easier for the collector to catch themselves if they fall).

In an attempt to mitigate trips, some of the agencies visited paint the edges of stairs and curbs to help with visibility and depth perception. For those agencies with tunnels, many stressed the importance of having handrails on both sides of tunnel stairways.

Ergonomics

Another workplace injury commonly mentioned was strains, which are difficult to avoid given that the nature of the work requires a good deal of reaching and twisting. During the site visits it was noted that some agencies reduce these injuries with adjustable-height terminals, chairs, or cash drawers.

Many of the agencies visited have experienced injuries resulting from collectors' arms being pulled by customers as they pass through the plaza. To reduce these kinds of injuries, one agency has made it a point to instruct collectors never to place their hands outside of the booth until after the vehicle has come to a complete stop. Another agency changed their procedures such that the collector now validates payment as the last step in processing a transaction so that the gate will stay down and the vehicle will not move until the transaction is complete. In many cases strains can be caused by leaning out of the booth to see oncoming traffic. Depending on the booth design, collectors sometimes noted that leaning was necessitated by advertisements or sunshades on the window making it difficult to see out, or simply by booth/plaza design (e.g., a pillar blocks the view of oncoming traffic). Some agencies have less of a problem with this as their booths have a bumped-out door design which allows collector to see oncoming traffic and to reach vehicles more easily without having to lean quite as far. Others have added a convex mirror adjacent to the window to allow collectors to see vehicles exiting the plaza while looking toward the oncoming traffic. Collectors reported that the mirror reduces twisting motions as they often need to watch vehicles exiting to ensure that the gate lifted properly.

Assault

Another concern related to toll worker safety is the possibility of physical assault, either by irate customers or in connection with a robbery. At each site we visited we heard examples of workers being spit upon, having objects thrown at them, and in some cases being shot at. Fear of armed robbery was particularly pronounced in locations where a lone worker might be present – such as at an exit ramp plaza.

While little can be done to entirely eliminate these occurrences, a number of mitigation strategies have been adopted. These include keeping doors locked while in the booth (although some agencies feel that this is a safety hazard preventing emergency egress), periodic cash drops between shifts (to minimize the amount of cash on hand), close relationships with law enforcement, CCTV cameras, and, at one agency, providing collectors with Kevlar vests.

Appendix E – Agency Interviews

The interview findings are presented in three sections according to the three goal areas:

- Issues addressing the requirements of the Report to Congress.
- Safety strategies aimed at reducing vehicular accidents.
- Safety strategies aimed at reducing worker injuries.

Note that much of the information presented here is also presented, together with a synthesis of the site visits and the workshop, in *Section 4, Findings – Factors Affecting Safety at Toll Plazas*.

Findings Directly Related to the Requirements of the Report to Congress

The Extent of the Enforcement of Speed Limits

Of the 21 toll operators interviewed, 4 reported that they have a dedicated police force. Other operators reported that State and local police patrol their facilities, but that there is no regular schedule for their patrols. Some operators contract with State Police to ensure that regular enforcement services are provided.

When police are at the plaza, different tactics are used when enforcing traffic violations. Sometimes the police stay in their vehicles and conduct speed enforcement using radar from either the plaza parking lot or from downstream of the plaza on the shoulder.

Another speed enforcement tactic used by the police is to place an officer on the toll island with radar. When a speeder is identified, the officer calls the vehicle description out to a chase cruiser that is downstream of the plaza to pull the vehicle over. The police will also sometimes use decoys for speed enforcement by placing radar inside an inconspicuous vehicle, such as a dump truck, on the shoulder at the plaza. Some operators reported that the police will also park unmanned police cruisers at the plaza to assist with speed reduction.

In addition to speed enforcement, the police will also use toll plazas to conduct checkpoints for seat belt use, expired stickers, drugs, and drunk driving. For this activity, police officers typically stand either in the toll booth with the collector, or behind the toll booth.

While one agency reported that law enforcement practices minimally affect safety in the vicinity of their toll plazas, an overwhelming majority of those interviewed reported that there is no negative affect on plaza safety due to law enforcement activity.

The Use of Warning Devices

Of those interviewed, 13 reported that they do not use rumble strips to alert drivers that they are approaching a toll plaza. Most commented that they do not use rumble strips because the noise they generate is disruptive to nearby residential areas. Some reported that the rumble strips also cause problems during snow plow operations.

The operators that do use rumble strips typically install them in advance of the flare for the toll plaza. The primary goal of the rumble strips is to generate sound to alert the collectors of a vehicle approaching. One operator reported that they have rumble strips at select plazas in locations where collectors cross traffic. Another reported that rumble strips are part of their plaza design for new plazas under construction.

The Use of Traffic Cameras for Traffic Violations

Four operators reported using traffic cameras to record traffic violations. One agency reported using white on black regulatory signs to advise motorists that the toll plaza is photo enforced. One agency reported that they do not use automated enforcement because they cannot legally use cameras for traffic violations such as speeding in their State.

The Use of Traffic Control Arms

Eleven operators reported using traffic control arms at their plazas, with most reporting that they use their gates at the exit of the plaza. Two operators reported using the gates in all of their lanes, including ETC lanes, but a majority of operators reported using them in their manual lanes only. With the exception of one agency, the gates are automated (i.e., they automatically lift as a vehicle with ETC approaches). Operators reported various reasons for using traffic control arms including speed reduction, toll violation reduction, and traffic control. Operators that do not use gates report several reasons for their decisions: the industry trend toward open road tolling, volume is too high through the plaza, expense, and maintenance.

One operator reported using gates at the front of the toll island (their gates are used to close lanes and are manually operated by toll collectors).

The traffic control arms when used are typically red and white. Some operators affix signs to the gates with messages like STOP or DO NOT BACK UP. One operator reported that advertising signs are placed on their gates. One agency has installed unique 3-foot high orange reflectors that look like driveway markers on their gates. The operator was having trouble with truckers hitting the gates because they could not see that the gate was still closed. Since the addition of the reflectors, the operator reported that there has been a significant reduction in the gates being hit. The reflectors are bolted onto the gates with stainless steel bolts and they do not interfere with the island when the gate is in the vertical position.

Law Enforcement Practices and Jurisdictional Issues

There were no reports during the interviews of law enforcement practices or jurisdictional issues that affect safety in the vicinity of toll plazas.

Safety Strategies for Reducing Vehicular Accidents

State Legislation

A majority of toll operators reported that speed through the toll plazas is a major safety concern. One agency reported that State legislation allows increased fines for speeding in toll areas. The legislation applies only to toll plazas where the speed at the plaza is reduced to 30 mph for ETC lanes. This operator has ORT where the speed limit is not reduced and increased fines for speeding do not apply at these areas. The operator reported that signs are present to warn drivers of increased fines at the plaza. There is not yet any feedback to substantiate if the increased fines have had an affect on speed through the plazas.

Preventing Vehicle Stops in ETC / ORT Lanes

Stopping in ETC / ORT lanes is a major hazard and can cause rear end collisions. One operator was concerned about drivers stopping in its ORT lanes and trying to get the attention of toll collectors to pay cash. The operator even reported that some drivers would stop, get out of their vehicle, and cross toll lanes to get to a booth to pay the toll.

In an attempt to mitigate this risk, the operator constructed a raised barrier wall at the toll plaza that is 72 inches high. A second agency also reported using a raised barrier wall to separate ORT lanes from manual lanes, but its purpose was solely to visually separate the faster ORT vehicles from the stopped vehicles in the manual lanes. Another tactic for preventing vehicles from stopping in electronic lanes is the use of signs. One agency reported using red on white signs advising motorists not to stop in the ETC lanes. Signs are placed on the gantry approaching the plaza and additional signs are placed at an angle on the barrier wall that separates the direction of traffic. There are approximately 18 total signs warning drivers not to stop. The operator reported that signs seem to make some difference in reducing vehicle stops in the ETC lanes.

In addition to the signs, the same operator has speakers installed on the barrier wall at the toll island so that if a vehicle stops in an ETC lane at the plaza an employee can verbally direct the driver to keep moving.

One operator with a new turnpike under construction reported that it plans to use video tolling as a method of preventing vehicle stops in ORT lanes. Video tolling will be used for drivers that get in the ORT lane by mistake as well as for people that simply do not want to get a transponder. Since video tolling will be in use, signs are being considered for the ORT lanes that read DO NOT STOP - WE WILL BILL YOU.

Three agencies reported specialized lane attendant personnel for handling stopped vehicles in ETC lanes. These employees are stationed in areas at the toll plaza so that they can quickly assist drivers who encounter problems in the ETC lanes, such as those whose transponders are not working or cash drivers who are in the wrong lane.

Lane Delineation

Pavement Markings

Eight operators reported installing special pavement markings to assist drivers with lane selection at the toll plaza. Some operators installed messages in the lanes such as CASH ONLY or the name of the ETC system (i.e., EZ PASS). Some operators also installed lane numbers on the pavement to match the lane numbers on the canopy signs. The numbers were often installed so that the drivers could see the number on the canopy and the number in the lane at the same time. A few operators also reported extending their longitudinal markings further upstream of the toll plaza to assist with lane delineation. In most cases, the markings are white with the exception of a few operators that are using purple markings to further assist drivers with identifying ETC lanes.

A majority of operators report that the markings hold up fairly well and do not need to be replaced very often. Most reported that their markings had been in place for 2 years or more. Operators also commented that thermoplastic markings seem to last longer than paint.

While some operators reported a significant reduction in last minute lane changes at the plaza others reported no reduction in this driver behavior at all. One operator indicated that last minute lane changes may not be attributed to driver confusion. Some drivers will ride the faster lane and then cut into the lane they need at the last minute. Other times, drivers will commit to a toll lane but then see a shorter line at the plaza and switch lanes.

Flexible Delineators

One operator uses flexible delineators upstream of the toll plaza to prevent severe lane changes. The delineators are red and white and are moveable. They do get hit, but they are designed to bounce back and only occasionally is there a problem with delineators littering the roadway.

Cones

One operator reported using cones to separate directions of travel at the plaza. Orange cones are used because the toll facility has reversible lanes. The operator reported that the cones do not get hit often because traffic is typically slow through the plaza, but there are problems with the color fading due to ultraviolet exposure.

Advance Signs

All operators use advance signs to warn drivers that they are approaching a toll plaza. Sign messages frequently include TOLL PLAZA AHEAD, PAY TOLL AHEAD, etc. In addition to these warning signs, some operators are also using lane designation signs in advance of the plaza.

One operator uses two advance signs to get drivers into the proper lane and then drivers receive a third lane designation sign overhead at the plaza. Personnel report that the addition of these signs seems to have decreased the weaving of traffic at the toll plaza.

Another operator uses advance lane designation signs, but its signs are more unique. After departing the plaza, drivers can either take an Interstate or exit onto a local road. The advance signs direct drivers to the side of the toll plaza where they will need to be depending on their direction of travel downstream of the plaza. The operator reported that since installing the lane designation signs, there has not been one accident downstream of the plaza.

A few operators reported that the issue of too many signs has been a problem for them as drivers become overwhelmed and do not see anything. One operator reported excessive signs as a problem, but commented that none of the signs could be removed because the facility is at a border crossing where extra signs are necessary.

Toll Plaza Approach Warning Devices

An innovative strategy reported by one agency was the installation of white strobe lighting on the canopies at all toll plazas to highlight facilities in inclement weather. The operator reported that the strobe lighting has definitely helped drivers in foggy driving conditions.

The same agency reported using maintenance trucks with flashing lights and qualified flagging personnel at the rear of traffic back-ups when the traffic volume stretches beyond sight of the plaza. This technique is used to prevent rear end collisions at the end of the queue.

Safety Programs

One operator initiated a Toll Plaza Safety Awareness Program. This is a month-long program that runs twice a year. The operator has its own dedicated police force, and together with the State Police, they run the awareness program. Police perform various operations at the toll plaza including seatbelt checks and ETC speed enforcement. Additional signs, such as portable changeable message signs, are used as needed. The operator reported that toll operations are not negatively impacted and the program seems to have a short-term affect on negative driver behavior.

Safety Strategies for Reducing Worker Injuries

Worker Garments

Vests are typical safety garments provided to toll plaza employees. In an innovative strategy, one operator uses battery powered flashing vests for employees who work in the toll lanes.

Another operator has adopted a new safety smock. The smock is light-weight, has short arms and is waist length. It is fluorescent yellow green with orange sections and retroreflective strips.

Another operator issues toll collectors a 3-in-1 coat. The coat is lined and fluorescent yellow green. The sleeves can be unzipped and removed for spring and fall and the lining unzips so that it is more vest-like in the summer.

One operator reported using a high visibility vest with five-point breakaway. The vests were ordered in response to news reports that vests would get caught on passing vehicles and workers were being dragged several hundred feet. The vests are fluorescent yellow green, are supplied to each employee and replaced as needed. The operator reported that the collectors provided input to management when the vests were being selected and the breakaway vest has received a positive response by employees.

Three operators reported that they are considering development of new uniforms that will have safety features built in, thereby eliminating the need for safety vests.

Lane Crossing Techniques

Employees of one operator use small, personal stop sign paddles that are utilized by both the employee crossing an active lane of traffic and the employee in the toll booth. The vehicle that is stopped at the toll booth is allowed to depart the plaza, but the stop paddle is directed at the vehicle behind so that it must remain stopped. This procedure was developed out of concern for potential rear end collisions.

Four operators reported using a ManSaver bar. The bars are placed at locations where employees must cross a toll lane. When entering the lane (going into danger), the employee must lift or pull back on the bar, when exiting a lane (going into safety) the bar is pushed. The bars force employees to stop before entering a toll lane and also serve as a reminder to look before crossing. One operator reported that employees would go around the bars so chains were installed to prevent them from avoiding the bars to cross the lanes.

Toll collectors for one operator use small bags to carry personal items with them out to the booths. This allows them to keep one hand free to operate the ManSaver bars. The bags also prevent collectors from dropping an item in the lane leaving them vulnerable to traffic while bending over to pick it up.

Two operators reported that employees are never allowed to cross active lanes of traffic. In fact, this is agency policy for one operator. The second operator reported that if an employee needs to cross a lane, it must first be shut down. Another operator, who has a dedicated police force, reported that the police escort toll collectors across toll lanes. This operator commented that in 42 years, an employee has never been hit while crossing a lane.

Signs

Signs Directed at Employees

Two operators reported using signs at toll lane crossings to remind employees to look before crossing. Both use specialized signs to mark ETC lanes so that employees can easily identify lanes where traffic does not stop. One operator uses signs to identify ETC lanes that read E- Z LOOK, with eyes drawn into LOOK and an arrow pointing in the direction of traffic. The signs are metal and mounted on the side of the bullnose facing in toward the lane at crossing locations. The same operator also uses red on white signs that read BE ALERT HIGH SPEED TRAFFIC.

Another operator uses signs that are installed on the backs of booths and read WARNING – EZ PASS TRAFFIC DOES NOT STOP.

Signs Directed at Motorists

Some operators are installing messages on signs and the pavement at the toll plaza to caution drivers about employees in the toll lanes. One operator has installed pedestrian crossing warning signs with flashing amber lights at the beginning of the toll island to caution drivers. Signs are also posted in holders on the front of the bullnose. One of the sign messages used is SLOW DOWN, PROTECT OUR WORKERS.

Another operator has a GIVE THEM 10 program that was started when ETC was introduced. The message is for drivers to slow down to 10 mph for the safety of toll plaza employees. White markings are installed in every lane each spring with the message 10 mph.

Booth Design

Toll booths at one toll facility were renovated 3 years ago in response to numerous occupational injuries. The booths are now more ergonomic and have light weight sit/stand stools, shelving to help keep things off the floor and fatigue mats. Ergonomic training has also been provided at this toll agency which has drastically reduced repetitive injury claims.

A second operator is in the process of collecting information to make changes to its toll booths to make them more ergonomic. Management is talking directly to toll collectors to obtain their input.

Another operator reported pumping pre-conditioned air into the toll booths to reduce fumes. The air is pumped up through the tunnel and into the booths.

Two operators reported that panic alarms are installed in toll booths so that collectors can call for help in an emergency situation. Two operators also reported that collectors are issued cell phones as an additional means of being able to communicate during emergencies. Operators reported no problems stemming from unauthorized use of agency-issued phones.

One operator reported that toll booths at their facility are bullet-resistant. This is to ensure employee safety, especially for collectors working at night.

Employee Safety Meetings

Three operators reported that regular employee safety meetings are conducted. One operator conducts daily meetings before and after each toll collector shift. Other operators conduct monthly or quarterly meetings. Most often the meetings are considered mandatory. In this instance, the meetings are held at different times of the day to allow each shift of toll collectors

an opportunity to attend. Collectors either arrive for work 1 hour early or stay 1 hour late and are compensated with overtime pay.

One operator has select employees participate in quarterly meetings. There is one representative from each toll plaza that attends the quarterly meeting. S/he cannot be someone who has had an accident and s/he must also be assertive and able to identify and correct safety violations.

Operators reported that the topics of safety meetings include reminders about safety procedures for lane crossing and lane closing; procedures for handling robberies; procedures for emergency situations; information on preventing slips, trips and falls; information on stretches to prevent repetitive stress injuries; etc. Many times, safety concerns will be addressed. Several operators take the opportunity at scheduled meetings to review a recent incident and go over the proper steps employees should take to prevent a similar incident from occurring again.

Employee Safety Training

One operator reported that there is a State law that requires quarterly safety training. The training can take several forms such as a newsletter or spot training. While the law exists, the operator reported that there is no penalty for violating this law.

One operator provides refresher training once a quarter to all employees and three operators provide annual safety training. Operators reported that safety training includes information on safety procedures at toll plazas including lane crossing, lane closing, hazardous materials, emergency situations, robbery, proper attire, review of drug and alcohol policies, etc. One operator reported that safety training topics are based on injury statistics from the previous year.

Employee Safety Programs

Toll operators are using award programs as part of their strategy to reduce worker injuries at toll plazas. Most awards are presented annually. One operator presents a Plaza Award to a plaza where no one has been injured and a Turnpike Award to a turnpike that has had no employee injuries.

Another operator gives employees awards for preventing possible injuries. This same operator will also reprimand employees for not calling out safety concerns. For example, if one employee sees another employee crossing a lane without a vest and does not try to correct it, not only does the employee not wearing the vest receive a reprimand, but so does the employee that witnessed the violation and did not try to correct it. All employees are ordained as safety officers, even though that might not be their official title. The operator reported that employees are empowered to correct safety violations and report safety concerns.

Appendix F – Additional Strategies Identified

Through the survey, telephone interviews, site visits, and workshop, the team identified a number of strategies in use across the country that have the potential to improve safety at toll collection facilities. As the operating conditions, culture, etc., are different at each agency and even at each toll plaza in some cases, the strategies may not be applicable in all situations. The strategies are therefore presented here not as recommendations, but as ideas for agencies to consider when seeking ways to improve safety for workers and motorists at their toll collection facilities. It is also important to note that although each strategy was not necessarily implemented with the exclusive goal of safety in mind, and although every strategy will not work at every plaza, each of the strategies presented here does have the potential to improve safety under certain circumstances.

Many of these strategies were presented in the main body of the document (*Section 4*). Other strategies that were identified that are not high-way related are presented here as supplemental information.

The remaining strategies are organized according to the challenge that agencies face. The challenges are as follows:

- Reducing Worker Exposure to the Environment
- Improving Ergonomics for Workers
- Reducing Worker Risk of Assault
- Keeping Safety at the Forefront of an Agency's Focus

Within each of these categories, a brief discussion of the challenge is first presented, followed by a discussion of various strategies being used across the country that have the potential to address that particular challenge.

Information on workshop participants' thoughts on all of the strategies (both those presented here and those presented in Chapter 4) can be found in Appendix H.

Reducing Worker Exposure to the Environment

The Challenge

Toll collectors are exposed to a range of environmental hazards on the job, such as excessive noise and automotive emissions. Beyond this, the work environment can pose physical hazards that can result in injuries such as slips, trips, and falls, which were commonly mentioned by agencies as the most prevalent workplace injury occurring at the plaza. Slips, trips, and falls can be caused by icy or snowy conditions, from the presence of debris or other substances on the pavement, from uneven pavement, or simply from carelessness by workers when climbing stairs or curbs.

Potential Mitigation Strategies

Mitigating Air Quality Issues

Through the site visits the team found that many agencies typically perform some combination of the following mitigation strategies to lessen the impact of air quality hazards for collectors:

- CO and emissions testing – Some agencies have CO monitors in their booths while others perform periodic CO and/or emissions testing.
- Positive air pressure – Many agencies have positive air pressure in their booths, and all agencies retrofitting booths were adding positive air.
- Air conditioning – Agencies in warmer climates typically have air conditioning in their booths; some also provide collectors with individual controls in the booths.

Mitigating Excessive Noise Levels

Many agencies perform noise testing on a periodic basis and take measures to reduce noise if they find that it is at an unacceptable level. Some agencies limit the length of time that workers are permitted to work at booths with high volumes of truck traffic due to the excessive noise levels that can be associated with trucks.

In addition to this, some agencies provide ear plugs to collectors, although nearly all of the collectors that the team spoke with indicated that they do not wear ear plugs on the job since they can make it difficult to converse with customers.

Personal Protective Equipment

In terms of protective equipment to deal with environmental impacts, the most common equipment that the agencies issue to collectors for environmental reasons are gloves, although most collectors interviewed by the study team reported that they do not wear them very often on the job either due to the negative public perception or due to the fact that they make it difficult to quickly perform work tasks. In addition to this, some agencies provide slip-resistant safety shoes to protect workers' feet from injury.

Improving Ergonomics for Workers

The Challenge

Another workplace injury commonly mentioned was strains to various body parts such as the wrist, back, or shoulder. The data analysis showed that strains make up approximately 18 percent of workplace injuries among toll collectors. Strains are difficult to avoid given that the nature of the work requires the worker to stand for much of the time and that it requires a good deal of reaching and twisting, but there are some mitigation strategies that agencies have implemented to reduce these issues.

Potential Mitigation Strategies

Agencies have worked to improve ergonomics for collectors in a number of different ways, including through implementing new policies and procedures, through modifying their booth design, and through providing special equipment.

Equipment

The team saw a variety of equipment in use to reduce workplace injuries including:

- Nearly all of the agencies that the team visited provide some sort of stool for collectors to use while in the booth. However, few collectors that the team spoke with indicated that they use the stool very often since they find it easier to perform their work while standing (this was particularly the case with those who work the busier shifts). As a result, many agencies have looked into different options for stools, but most indicated that they have had difficulty getting collectors to agree on the best design. One agency represented at the workshop warned of the danger of selecting chairs with a flexible back as this design encouraged their collectors to lean back resulting in some serious injuries. One agency that the team spoke with has gone toward a sit/stand stool that allows collectors the support of a chair without requiring them to sit. Another agency indicated that after having numerous discussions with their collectors about their needs, they have found that foot rests are very important to collectors and, as a result, they have found that a chair with a foot rest surrounding the entire chair is preferable (similar to that shown in Figure F-1).



Figure F-1. Chair with Circular Foot Rest

- A number of agencies spoke of the importance of keeping items off the floor in the booth to avoid tripping hazards and also to maximize collector sight lines to outside their booths. To combat this, many agencies make it a policy of not allowing collectors to bring any personal items into the booth when working. Others have moved toward providing shelves and hooks in the booth to make certain that collectors have sufficient places to store their items without introducing a tripping hazard or blocking views.
- Nearly all agencies visited had anti-fatigue mats in their booths (similar that shown in Figure F-2). Anti-fatigue mats are designed to reduce fatigue that is caused by standing for long periods on a hard surface. Fatigue-reducing mats can be made of various materials including rubber, carpeting materials, vinyl, and wood, and are used to



Figure F-2. Anti-Fatigue Mat



Figure F-3. Convex Mirrors Can Reduce Twisting and Turning for Collectors

decrease foot weariness for workers who stand in one position for long periods of time.¹¹

- Denver E-470 has found it helpful to add a convex mirror to the side of the booth as shown in Figure F-3. The position of the convex mirror allows collectors to see vehicles exiting the plaza while they are facing oncoming traffic. Collectors reported that the mirror reduces twisting motions as they often need to watch vehicles exiting to ensure that the gate has lifted properly.
- Some agencies provide collectors with ergonomic training to reduce repetitive injuries.

Booth Design

Some agencies have implemented adjustable-height terminals, chairs, and/or cash drawers in an effort to reduce workplace injuries associated with reaching (an example of an adjustable-height terminal is shown in Figure F-4). In many cases strains can be caused by leaning out of the booth to see oncoming or exiting traffic. Depending on the booth design, collectors sometimes noted that leaning was



Figure F-4. Denver E-470's Adjustable Height Terminal

necessitated by advertisements or sunshades on the window making it difficult to see out, or simply by booth/plaza design (e.g., a pillar can sometimes block their view of oncoming traffic).

Some agencies have less of a problem with this as their booths have a bumped-out door design which allows the collector to see oncoming traffic and to reach vehicles more easily without having to lean quite as far (see Figure F-5).



Figure F-5. Bumped Out Dutch Doors Can Reduce Twisting and Turning for Collectors

Policies and Procedures

Nearly all agencies that the team spoke with indicated that they have experienced injuries resulting from collectors' arms being pulled by customers as they pass through the plaza. To reduce these kinds of injuries, one agency has made it a point to instruct collectors never to place their hands outside of the booth until after the vehicle has come to a complete stop. Another agency now instructs their collectors to validate payment as the last step in processing a transaction (which in most cases keeps the gate down) to reduce the chance that the vehicle will attempt to pull away before the transaction is complete.

¹¹ Canadian Centre for Occupational Health and Safety.

Reducing Worker Risk of Assault

The Challenge

Another concern related to toll worker safety is the possibility of physical assault, either by irate customers or in connection with a robbery. At each site the study team visited, the agencies cited examples of workers being spit upon, having objects thrown at them, and – in extreme cases – being shot at. Fear of armed robbery was particularly pronounced in locations where a lone worker might be present – such as at an exit ramp plaza.

Potential Mitigation Strategies

While little can be done to entirely eliminate these occurrences, a number of mitigation strategies have been adopted. These include:

- Keeping doors locked while in the booth.
- Having periodic cash drops during shifts to minimize the amount of cash that a collector has on hand at any given time.
- Maintaining close relationships with local law enforcement.
- Having closed-circuit television (CCTV) cameras in and around the booths.
- Having bullet-resistant glass on the booths.
- Providing collectors with Kevlar vests.

Nearly all agencies that the team spoke with have a handset in the booth for collectors to communicate directly with other collectors at the plaza, with a supervisor at the plaza building or at a nearby plaza, or - in many cases – with a communications center that is open 24 hours a day, 7 days a week. In addition to this, most agencies that the team spoke with have covert panic alarms in their booths so that collectors can call for help in an emergency situation; some also issue cell phones to collectors as an additional means of being able to communicate during an emergency.

One agency has a “Toll Security Committee” that meets every few months to discuss any incidents that have occurred recently and to brainstorm ways to prevent these types of incidents in the future.

Keeping Safety at the Forefront of an Agency’s Focus

This section provides examples of ways in which training and a strong safety culture have helped agencies improve safety at their facilities.

Training

The use of training as a safety mitigation strategy varied widely from agency to agency. At one end of the scale were those agencies that offered short, on-the-job safety sessions taught as part of a general course focused primarily on revenue collection, with minimal to no re-training. At the other end of the scale were agencies that offered intensive safety training sessions upon hiring, used professional trainers and props such as safety videos, and undertook periodic refresher courses and annual “safety” or “toll training” days. One agency had undertaken a unique approach by offering Web-based training that workers could access from break rooms. Another agency required all maintenance staff to go through work zone safety classes and

flagging classes. Yet another agency requires crossing training for *all* workers (even vendors who put out ads at plazas).

In terms of safety training topics, most covered safety procedures at toll plazas including lane crossing, lane closing, hazardous materials, emergency situations, and robbery. Some agencies determine their safety training topics based on injury statistics from the previous year.

Safety Culture

The final set of mitigation strategies refer to something that was ever-present during the various site visits, but almost intangible to quantify: a culture of safety. Establishing a safety culture involves both setting an overall tone of safety (e.g., by featuring safety as the first topic in annual reports), and undertaking a series of small, often changing actions (e.g., posting rotating safety reminders in break rooms, displaying safety reminders around the workplace such as the floor mat shown in Figure F-6).

Focus on Safety for Maintenance Staff

One way that many agencies ensure that safety is a priority is that they place a higher priority on safety-related maintenance items than on other requests. For example, one agency records such safety-related requests on red paper versus the regular white paper used for other requests.

Safety Committees

Most agencies that the team visited have some type of

safety committee in place. Those that placed the greatest emphasis on these committees ensured representation from all spectrums of the workforce – from collectors to senior managers – and often established subcommittees at each plaza or for a small group of plazas.

Safety Audits

Two agencies that the team visited made use of random safety audits, with one using internal staff to conduct the audits and one using an outside firm (since plaza personnel were able to identify the internal auditors). Both of these agencies also supplemented the formal audits with more frequent “self-inspections” by plaza managers and supervisors.

Employee Safety Meetings

Several agencies have regular employee safety meetings, typically held on a monthly or quarterly basis. Topics of safety meetings include reminders about safety procedures for lane crossing and lane closing; procedures for handling robberies; procedures for emergency situations; information on preventing slips, trips, and falls; and information on stretches to prevent repetitive stress injuries. Several agencies take the opportunity at scheduled meetings to review a recent incident and to review the proper steps employees should take to prevent a similar incident from occurring again.

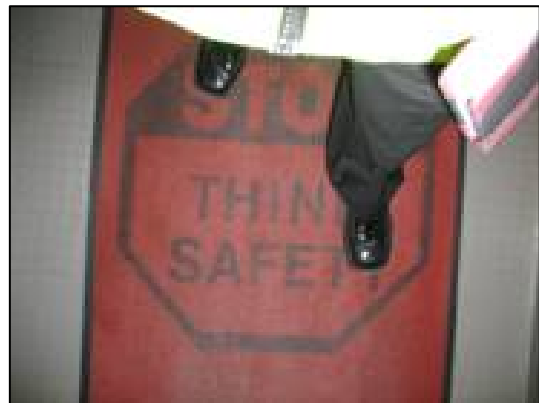


Figure F-6. Floor Mat in Plaza Building Reminds Employees to “Think Safety”

Safety Award Programs

Many toll agencies use award programs as part of their overall strategy to reduce worker injuries at toll plazas. Most awards are presented annually. One agency presents an annual “Plaza Award” to any plaza where no one has been injured over the past year, and an annual “Turnpike Award” to any turnpike that had no employee injuries.

Another agency gives employees awards for preventing possible injuries. This same agency will also reprimand employees for not calling out safety concerns. For example, if one employee sees another employee crossing a lane without a vest, and does not try to correct it, not only does the employee not wearing the vest receive a reprimand, but so does the employee that witnessed the violation and did nothing to correct it.



Figure F-7. Tracking Employee Performance Publicly Can Be an Incentive for Employees to Follow Safety Procedures

Safety Incentive Programs

Safety incentive programs are also a fairly common technique for promoting a culture of safety. These types of programs reward employees for passing safety audits and maximizing days without injury either with cash bonuses or with points that employees can use to purchase items out of catalogues (examples of this are shown in Figure F-7 and Figure F-8). In some cases, the program works such that an entire plaza is rewarded as a group, thus introducing the factor of peer pressure to maintain good safety records. While successful, these programs are not without controversy. One concern is that they must be constantly re-invented to remain fresh and capture the imagination and interest of the staff. Another concern is that they may actually lead to under-reporting or treatment of legitimate injuries and/or safety violations and can present challenges to management-worker relations.¹²

Safety Awareness Programs

One agency has a Toll Plaza Safety Awareness Program. This is a month-long program run twice a year by the agency together with their dedicated police force and the State Police. Police perform various operations at the toll plaza, including seatbelt checks and ETC speed enforcement. Additional signs, such as portable changeable message signs, are used as needed. The agency reported that toll operations are not negatively impacted and that the program seems



Figure F-8. Sign in Plaza Office Reminds Employees about Safety Record

¹² Teamsters Safety & Health Facts: The Hazards of Behavior-Based Safety
<http://www.teamster.org/content/hazards-behavior-based-safety>

to reduce unsafe driving behaviors in the vicinity of plazas, but that the benefit is only short-term.

Appendix G – Agency Workshop / Workshop Ratings

Participants of the June 25/26 Toll Facility Safety Study Workshop were asked to review each of the safety strategies that the study team had uncovered throughout the course of this study. The team presented the strategies in 7 categories and the 20 participants were asked to select and rank 3 strategies within each category that they believed would have the greatest potential to improve safety for both workers and customers at toll plazas. The tables that follow present the workshop findings. Each table represents one category; the categories of challenges include: Worker Exposure to Vehicles; Environmental Issues; Ergonomics; Assault¹³; Merging and Lane Changing; Speeding; and Driver Confusion and Distraction. Note that the categories presented in the workshop differ slightly from the categories presented in this report. The table titles indicate the category names as presented at the workshop while a footnote below each table indicates the title of the category as presented in Section 4 of this report.

The results are ranked by the number of participants who selected the strategy as among the top three most effective strategies to improve safety in that category. The strategies are listed in the first column, followed by the number and percent of participants who thought it would be the most effective, second most effective, and third most effective. The last two columns show the number and percentage of respondents who selected the strategy as one of the top three most effective in that particular category of strategies.

For example, for the first strategy listed as a potential option for addressing safety issues resulting from merging and lane changing behavior, 15 participants (75 percent) indicated that this was the strategy with the greatest potential to improve safety for workers and customers at toll plazas. Three respondents thought this would be the second most effective strategy, resulting in 90 percent of respondents selecting this as one of the top three strategies to consider when addressing safety issues resulting from merging and lane changing behaviors.

Much of the information gathered through the agency workshop is presented, together with a synthesis of the site visits and interviews, in Section 4, *Findings – Factors Affecting Safety at Toll Plazas*.

¹³ Note that data for the category entitled “Assault” was not able to be retained from the system due to a power outage that occurred during the workshop.

| Improving Safety Issues Associated with Worker Exposure to Vehicles ¹⁴ | | | | | | | | |
|--|--|-----|---|-----|--|-----|--|-----|
| Strategies | Number of participants who identified this strategy as the most effective in this group. | % | Number of participants who identified this strategy as the second most effective in this group. | % | Number of participants who identified this strategy as the third most effective in this group. | % | Number of participants who identified this strategy as one of the top three most effective strategies in this group. | % |
| Require workers to make eye contact with motorists when crossing. | 8 | 40% | 4 | 20% | 0 | 0% | 12 | 60% |
| Require workers to wear vests at all times. | 2 | 10% | 3 | 15% | 1 | 5% | 6 | 30% |
| Locate all dedicated-ETC lanes to the far left of the plaza so that collectors can avoid crossing these lanes. | 4 | 20% | 0 | 0% | 1 | 5% | 5 | 25% |
| Require workers to signal their intention to the approaching driver and to wait for confirmation from that driver. | 2 | 10% | 1 | 5% | 2 | 10% | 5 | 25% |
| Require the use of attenuator trucks for all maintenance work requiring a lane closure. | 1 | 5% | 0 | 0% | 4 | 20% | 5 | 25% |
| Use signs to warn motorists about the potential for workers crossing (e.g., a pedestrian crossing sign at the plaza or a "SLOW DOWN, PROTECT OUR WORKERS" sign). | 1 | 5% | 0 | 0% | 4 | 20% | 5 | 25% |
| Use "ManSaver bars" to slow collectors down while crossing the plaza. | 1 | 5% | 2 | 10% | 1 | 5% | 4 | 20% |
| Do not allow workers to cross ETC lanes. | 2 | 10% | 2 | 10% | 0 | 0% | 4 | 20% |

¹⁴ Note that strategies discussed here are presented in Section 4 of this report in the category of "Improving Worker Safety when Accessing Toll Booths."

| Improving Safety Issues Associated with Worker Exposure to Vehicles ¹⁴ | | | | | | | | |
|--|--|-----|---|-----|--|-----|--|-----|
| Strategies | Number of participants who identified this strategy as the most effective in this group. | % | Number of participants who identified this strategy as the second most effective in this group. | % | Number of participants who identified this strategy as the third most effective in this group. | % | Number of participants who identified this strategy as one of the top three most effective strategies in this group. | % |
| Encourage workers to use mutual support when crossing lanes (i.e., the collector in the booth directs the motorist to stop for the crossing collector). | 2 | 10% | 0 | 0% | 1 | 5% | 3 | 15% |
| Paint pedestrian crosswalks at the plaza. | 1 | 5% | 2 | 10% | 0 | 0% | 3 | 15% |
| Require maintenance workers to use a "buddy" system (i.e., no maintenance work is done alone). | 0 | 0% | 1 | 5% | 2 | 10% | 3 | 15% |
| Issue shoulder bags to collectors for hands-free crossing, and consider a high-visibility color such as orange. | 1 | 5% | 2 | 10% | 0 | 0% | 3 | 15% |
| Eliminate all mixed-mode lanes to reduce uncertainty of motorist behavior. | 0 | 0% | 1 | 5% | 1 | 5% | 2 | 10% |
| Use pavement markings to remind collectors about the dangers of crossing lanes (e.g., stencil "LOOK" on the pavement, paint "WATCH FOR CARS" on the pavement). | 0 | 0% | 2 | 10% | 0 | 0% | 2 | 10% |
| Use warning stickers to remind collectors about the dangers of crossing lanes (e.g., on the ground outside the booth doors warning of the potential for injuries when crossing lanes, "WEAR YOUR VEST" sticker on the door collectors pass through | 1 | 5% | 1 | 5% | 0 | 0% | 2 | 10% |

| Improving Safety Issues Associated with Worker Exposure to Vehicles ¹⁴ | | | | | | | | |
|--|--|----|---|----|--|----|--|-----|
| Strategies | Number of participants who identified this strategy as the most effective in this group. | % | Number of participants who identified this strategy as the second most effective in this group. | % | Number of participants who identified this strategy as the third most effective in this group. | % | Number of participants who identified this strategy as one of the top three most effective strategies in this group. | % |
| as they prepare to cross the plaza). | | | | | | | | |
| Carefully consider the location of crosswalks (i.e., Upstream of the booth to provide improved sight lines? Downstream of the booth so that vehicles stop prior to crossing? Well downstream of the booth to provide for longer stopping distance?). | 0 | 0% | 1 | 5% | 1 | 5% | 2 | 10% |
| Require workers to have one hand free while crossing. | 1 | 5% | 0 | 0% | 1 | 5% | 2 | 10% |
| Encourage workers to give a verbal cue to motorists when crossing (e.g., yell "I'm crossing!") | 1 | 5% | 0 | 0% | 1 | 5% | 2 | 10% |
| Issue handheld STOP sign paddles to workers to hold while crossing lanes. | 0 | 0% | 0 | 0% | 1 | 5% | 1 | 5% |
| Consider 5 pt. breakaway vests which are designed to come off with minor or no injury if the vest becomes hooked on an object. | 0 | 0% | 1 | 5% | 0 | 0% | 1 | 5% |
| Label ETC and mixed use lanes differently from the cash-only lanes to remind collectors that vehicles may not stop in these lanes (e.g., with purple lights). | 0 | 0% | 0 | 0% | 1 | 5% | 1 | 5% |
| Use signs to remind collectors about the dangers of crossing lanes (e.g., "BE ALERT HIGH SPEED TRAFFIC", | 1 | 5% | 0 | 0% | 0 | 0% | 1 | 5% |

| Improving Safety Issues Associated with Worker Exposure to Vehicles ¹⁴ | | | | | | | | |
|---|--|----|---|----|--|----|--|----|
| Strategies | Number of participants who identified this strategy as the most effective in this group. | % | Number of participants who identified this strategy as the second most effective in this group. | % | Number of participants who identified this strategy as the third most effective in this group. | % | Number of participants who identified this strategy as one of the top three most effective strategies in this group. | % |
| red and white warning signs at the crossing points). | | | | | | | | |
| Use "YOUR SPEED IS" signs on rear of attenuator trucks. | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Use tunnels or bridges to reduce the need for workers to cross lanes. | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Provide break areas on either side of larger plazas to reduce lane crossings. | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Require a police escort for employees crossing lanes. | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Implement a crossing guard who acts like a school crossing guard to escort workers to the booth with a stop sign in hand. | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Use vests with battery-powered flashing lights. | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Do not allow workers to cross in front of anything larger than an SUV. | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Do not allow workers to cross behind a vehicle, or require workers to look both ways in case a vehicle advancing through the plaza suddenly backs up. | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Require collectors to look over shoulder at traffic after manually closing a gate to close a lane. | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |

| Improving Safety Issues Associated with Environmental Issues ¹⁵ | | | | | | | | |
|--|---|-----|---|-----|--|-----|--|-----|
| Strategies | Number of participants who identified this strategy as the most effective strategy in this group. | % | Number of participants who identified this strategy as the second most effective in this group. | % | Number of participants who identified this strategy as the third most effective in this group. | % | Number of participants who identified this strategy as one of the top three most effective strategies in this group. | % |
| Install positive air in all booths. | 7 | 35% | 5 | 25% | 3 | 15% | 15 | 75% |
| Periodically conduct noise and emissions testing at the booths. | 2 | 10% | 5 | 25% | 2 | 10% | 9 | 45% |
| Install air conditioning in booths in warmer climates and consider individual controls. | 1 | 5% | 4 | 20% | 1 | 5% | 6 | 30% |
| Switch from cash drawers to cash bags to facilitate hands-free crossing. | 0 | 0% | 2 | 10% | 3 | 15% | 5 | 25% |
| Issue safety shoes (i.e., slip resistant, steel-toe) to collectors. | 3 | 15% | 0 | 0% | 2 | 10% | 5 | 25% |
| Add brightly-colored striping to the edges to stairs and curbs to improve visibility and depth perception. | 2 | 10% | 0 | 0% | 2 | 10% | 4 | 20% |
| Install CO monitors in booths or test for CO periodically. | 2 | 10% | 1 | 5% | 1 | 5% | 4 | 20% |
| Use "FlexCrete" or other skid resistant surface at the crossing area to reduce slips. | 2 | 10% | 1 | 5% | 1 | 5% | 4 | 20% |
| Provide gloves to collectors. | 0 | 0% | 2 | 10% | 1 | 5% | 3 | 15% |
| Install handrails on both sides of tunnel stairways to reduce falls. | 1 | 5% | 0 | 0% | 2 | 10% | 3 | 15% |

¹⁵ Note that strategies discussed here are presented in Section 4 of this report in the category of "Reducing Worker Exposure to the Environment."

| Improving Safety Issues Associated with Environmental Issues ¹⁵ | | | | | | | | |
|--|---|----|---|----|--|----|--|----|
| Strategies | Number of participants who identified this strategy as the most effective strategy in this group. | % | Number of participants who identified this strategy as the second most effective in this group. | % | Number of participants who identified this strategy as the third most effective in this group. | % | Number of participants who identified this strategy as one of the top three most effective strategies in this group. | % |
| Provide "snow shoes" to reduce slips on ice. | 0 | 0% | 0 | 0% | 1 | 5% | 1 | 5% |
| Provide ear plugs to collectors. | 0 | 0% | 0 | 0% | 1 | 5% | 1 | 5% |
| Limit exposure time of workers at booths with high truck traffic. | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Install drain gates at the curb at crossing areas to avoid ponding water and icy conditions. | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Ensure that all walkways are covered. | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |

| Improving Safety Issues Associated with Ergonomics ¹⁶ | | | | | | | | |
|---|---|-----|---|-----|--|-----|--|-----|
| Strategies | Number of participants who identified this strategy as the most effective strategy in this group. | % | Number of participants who identified this strategy as the second most effective in this group. | % | Number of participants who identified this strategy as the third most effective in this group. | % | Number of participants who identified this strategy as one of the top three most effective strategies in this group. | % |
| Provide floor pads in the booths. | 5 | 25% | 5 | 25% | 4 | 20% | 14 | 70% |
| Use bumped-out Dutch doors and mirrors on the booths to allow collector to see oncoming traffic and exiting traffic without having to lean. | 6 | 30% | 2 | 10% | 2 | 10% | 10 | 50% |
| Provide an adjustable height terminal. | 2 | 10% | 4 | 20% | 3 | 15% | 9 | 45% |
| Provide a chair with adjustable height and swivel, and consider "sit/stand" stools. | 1 | 5% | 4 | 20% | 3 | 15% | 8 | 40% |
| Provide ergonomic training to reduce repetitive injuries. | 4 | 20% | 2 | 10% | 2 | 10% | 8 | 40% |
| Instruct collectors never to place hands outside of the booth until after the vehicle has stopped. | 2 | 10% | 2 | 10% | 3 | 15% | 7 | 35% |
| Make it a policy for collectors to perform validation as their last step so that the gate stays down until the transaction is complete (makes sure that the vehicle does not proceed until the collector is completely done). | 0 | 0% | 1 | 5% | 2 | 10% | 3 | 15% |
| Provide an adjustable height cash drawer. | 0 | 0% | 0 | 0% | 1 | 5% | 1 | 5% |
| Install shelving in booths to keep items off the floor that can pose a hazard. | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |

¹⁶ Note that strategies discussed here are presented in Section 4 of this report in the category of "Improving Ergonomics for Workers."

| Improving Safety Issues Associated with Merging and Lane Changing Behavior ¹⁷ | | | | | | | | |
|---|--|-----|---|-----|--|-----|--|-----|
| Strategies | Number of participants who identified this strategy as the most effective in this group. | % | Number of participants who identified this strategy as the second most effective in this group. | % | Number of participants who identified this strategy as the third most effective in this group. | % | Number of participants who identified this strategy as one of the top three most effective strategies in this group. | % |
| Use physical separation (e.g., concrete barriers) to separate high-speed traffic lanes from cash or mixed use lanes. | 15 | 75% | 3 | 15% | 0 | 0% | 18 | 90% |
| Make delineators more visible. | 3 | 15% | 2 | 10% | 4 | 20% | 9 | 45% |
| Channelize traffic downstream of the plaza with delineators so that people won't merge too quickly. | 0 | 0% | 3 | 15% | 5 | 25% | 8 | 40% |
| Position dedicated-ETC lanes both on the right and left side of select "problem" plazas (e.g., those with nearby on- or off-ramps) to reduce weaving. | 0 | 0% | 6 | 30% | 1 | 5% | 7 | |
| Provide a buffer lane (i.e., an unused lane) between ETC and cash customers. | 1 | 5% | 2 | 10% | 3 | 15% | 6 | 30% |
| Use physical barriers to prevent vehicles in left-most lanes from making unsafe maneuvers to reach off-ramps located immediately downstream of plaza. | 0 | 0% | 1 | 5% | 4 | 20% | 5 | |
| Use pop-up delineators to delineate to reduce worker exposure at plazas requiring lane changes throughout the day. | 0 | 0% | 3 | 15% | 1 | 5% | 4 | 20% |
| Select location of truck-only lanes at the plaza based on feedback from truck drivers on the best configuration. | 1 | 5% | 0 | 0% | 2 | 10% | 3 | |

¹⁷ Note that strategies discussed here are presented in Section 4 of this report in the category of "Reducing Unsafe Merging and Lane Changing Behavior."

| Improving Safety Issues Associated with Speeding ¹⁸ | | | | | | | | |
|---|--|-----|---|-----|--|-----|--|-----|
| Strategies | Number of participants who identified this strategy as the most effective in this group. | % | Number of participants who identified this strategy as the second most effective in this group. | % | Number of participants who identified this strategy as the third most effective in this group. | % | Number of participants who identified this strategy as one of the top three most effective strategies in this group. | % |
| Use automated speed enforcement at plazas (and possibly suspend tags for excessive or repeat violators) | 5 | 25% | 5 | 25% | 6 | 30% | 16 | 80% |
| Increase enforcement presence at plazas. | 2 | 10% | 3 | 15% | 6 | 30% | 11 | 55% |
| Use rumble strips in advance of plazas. | 6 | 30% | 3 | 15% | 0 | 0% | 9 | 45% |
| Double fines for speeding in the vicinity of plazas. | 2 | 10% | 2 | 10% | 3 | 15% | 7 | 35% |
| Use real-time "YOUR SPEED" signs in each lane at the plaza. | 3 | 15% | 1 | 5% | 2 | 10% | 6 | 30% |
| Use gates downstream of plazas so that vehicles are required to stop - or at a minimum slow down - while waiting for the gate to lift. | 1 | 5% | 2 | 10% | 0 | 0% | 3 | 15% |
| Equip maintenance vehicles with red lights (amber on front / red on back) to reduce vehicle speeds near maintenance activities and incident response activities. | 0 | 0% | 1 | 5% | 1 | 5% | 2 | 10% |
| Post speed limit signs at each lane as a reminder to motorists. | 1 | 5% | 0 | 0% | 1 | 5% | 2 | 10% |
| Paint the speed limit on the pavement upstream of plazas. | 0 | 0% | 1 | 5% | 0 | 0% | 1 | 5% |
| Use transverse pavement markings to "trick" motorists into slowing down (markings are spaced progressively closer to provide the illusion that a vehicle is speeding up). | 0 | 0% | 1 | 5% | 0 | 0% | 1 | 5% |
| Use regulatory speed limit signs instead of advisory signs at | 0 | 0% | 0 | 0% | 1 | 5% | 1 | 5% |

¹⁸ Note that strategies discussed here are presented in Section 4 of this report in the category of "Reducing Speeding."

| Improving Safety Issues Associated with Speeding ¹⁸ | | | | | | | | |
|--|--|----|---|----|--|----|--|----|
| Strategies | Number of participants who identified this strategy as the most effective in this group. | % | Number of participants who identified this strategy as the second most effective in this group. | % | Number of participants who identified this strategy as the third most effective in this group. | % | Number of participants who identified this strategy as one of the top three most effective strategies in this group. | % |
| plazas. | | | | | | | | |
| Ensure that speed limits at plazas are consistent with nearby toll authorities. | 0 | 0% | 1 | 5% | 0 | 0% | 1 | 5% |
| Implement a public outreach campaign targeting speeders (e.g., "GIVE THEM 10" Program which conveys the message that motorists should slow down to 10 mph for the safety of toll plaza employees). | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |

| Improving Safety Issues Associated with Driver Confusion and Distraction ¹⁹ | | | | | | | | |
|--|--|-----|---|-----|--|-----|--|-----|
| Strategies | Number of participants who identified this strategy as the most effective in this group. | % | Number of participants who identified this strategy as the second most effective in this group. | % | Number of participants who identified this strategy as the third most effective in this group. | % | Number of participants who identified this strategy as one of the top three most effective strategies in this group. | % |
| Use variable message signs to convey messages to motorists upstream of the plaza. | 3 | 15% | 4 | 20% | 1 | 5% | 8 | 40% |
| For plazas where lane assignments change throughout the day, use digital signs in advance of the plaza to let customers know which lanes are currently dedicated to ETC. | 0 | 0% | 3 | 15% | 4 | 20% | 7 | 35% |
| Use a tall barrier wall to physically prevent motorists in high-speed lanes from stopping and attempting to cross to staffed lanes to pay a toll. | 5 | 25% | 1 | 5% | 1 | 5% | 7 | 35% |
| Differentiate dedicated high-speed ETC lanes from cash or mixed use lanes with pavement markings (e.g., purple paint at the edges of the high-speed lanes). | 1 | 5% | 2 | 10% | 3 | 15% | 6 | 30% |
| Use "PREPAID ONLY" signs to label ETC lanes in lieu of only using a brand name (e.g., "SunPass Only"). | 3 | 15% | 2 | 10% | 0 | 0% | 5 | 25% |
| Include signs on the gate upstream of the plaza to convey to motorists when a lane is closed (e.g., with a LANE CLOSED sign, a STOP sign, a DO NOT ENTER sign, or a red "X"; 3-foot high orange reflectors to aid in visibility for trucks). | 2 | 10% | 2 | 10% | 1 | 5% | 5 | 25% |
| Post "STAY IN VEHICLE" signs at booths to reduce the occurrence of customers exiting their vehicles. | 0 | 0% | 2 | 10% | 2 | 10% | 4 | 20% |
| Paint lane numbers on the pavement in advance of the plaza corresponding with lane numbers | 2 | 10% | 1 | 5% | 1 | 5% | 4 | 20% |

¹⁹ Note that strategies discussed here are presented in Section 4 of this report in the category of "Reducing Driver Confusion and driver Inattention."

| Improving Safety Issues Associated with Driver Confusion and Distraction ¹⁹ | | | | | | | | |
|---|--|----|---|----|--|-----|--|-----|
| Strategies | Number of participants who identified this strategy as the most effective in this group. | % | Number of participants who identified this strategy as the second most effective in this group. | % | Number of participants who identified this strategy as the third most effective in this group. | % | Number of participants who identified this strategy as one of the top three most effective strategies in this group. | % |
| above the plaza. | | | | | | | | |
| Use white strobe lighting at plazas to highlight facilities during inclement weather (particularly during foggy conditions). | 0 | 0% | 1 | 5% | 2 | 10% | 3 | 15% |
| Ban the use of advertisements on plazas to reduce "sign overload." | 0 | 0% | 1 | 5% | 2 | 10% | 3 | 15% |
| Install a PA system at unmanned booths to enable staff to communicate with motorists remotely (whether from a control center or from another booth or plaza). | 1 | 5% | 0 | 0% | 2 | 10% | 3 | 15% |
| Create a buffer lane (i.e., an unused lane) between bi-directional traffic at plazas that do not have physical separation between opposite directions of travel. | 0 | 0% | 1 | 5% | 0 | 0% | 1 | 5% |
| Eliminate violation warning signs or reduce the conspicuity of the violation warning signs to reduce the occurrence of customers exiting their vehicles to pay. | 1 | 5% | 0 | 0% | 0 | 0% | 1 | 5% |
| Conduct a public education campaign to reduce "wavers" (i.e., educating the public about the risks associated with not properly mounting transponders). | 1 | 5% | 0 | 0% | 0 | 0% | 1 | 5% |
| Position maintenance trucks with flashing lights and certified flaggers at the rear of a traffic back-up whenever the queue stretches beyond sight of the plaza to prevent rear-end collisions at the end of the queue. | 1 | 5% | 0 | 0% | 0 | 0% | 1 | 5% |
| Determine sign messaging based on feedback from motorists (e.g., surveys, focus groups). | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |

Appendix H – Feedback on Strategies from Workshop

Potential Strategies to Improve Worker Safety When Accessing Toll Booths

| Strategy | Description | Rankings from Workshop Participants and Comments on Effectiveness ²⁰ | Concerns / Constraints |
|--|--|---|---|
| <i>Providing Direct Access to Booths</i> | | | |
| Provide physical by-passes of toll lanes for collectors. | Use tunnels or bridges to reduce the need for workers to cross lanes. | <ul style="list-style-type: none"> • Effective if used properly. • However, ranked last (tied) of all solutions considered by workshop participants to reduce worker exposure. | <ul style="list-style-type: none"> • Very expensive. • Tunnels present problems with flooding. • Even when available many workers do not use them. |
| Provide break areas on either side of large plazas. | Some agencies with large numbers of plaza lanes or with staffed lanes on both outside lanes (with ETC in the middle) have placed break rooms on either side of the plaza to minimize the number of lanes that must be crossed. | <ul style="list-style-type: none"> • Considered highly effective (though costly) where appropriate. • Due to the fact that this strategy would only be required in limited situation, it was not selected by any workshop participants in their “top three list” of the most effective strategies for reducing worker exposure. | <ul style="list-style-type: none"> • Can be expensive to implement. |
| Locate all dedicated ETC lanes to the far left side of the plaza, eliminating the need for workers to cross ETC lanes. | Locate all dedicated ETC lanes to the far left of the plaza so that collectors can avoid crossing these lanes. | <ul style="list-style-type: none"> • Highly effective where feasible. • Ranked 3rd (tied) of 30 strategies considered by workshop participants for reducing worker exposure, with 4 of 20 participants selecting it as the most effective solution. | <ul style="list-style-type: none"> • Will not work where ETC lanes are required on the right to facilitate exiting on down-stream ramps close to plaza. |

²⁰ Within each strategy grouping, workshop participants were asked to select and rank the three strategies that they believed to have the greatest potential to improve safety for workers and customers at toll plazas. Some of this ranking information is provided here; the full details of the rankings are provided in Appendix G. Note that at the workshop, the strategies discussed here were presented in a category entitled “Improving Safety Issues Associated with Worker Exposure to Vehicles.”

| Strategy | Description | Rankings from Workshop Participants and Comments on Effectiveness ²⁰ | Concerns / Constraints |
|---|--|--|--|
| Eliminate all mixed mode lanes to reduce uncertainty of driver behavior. | Many toll collectors consider mixed-mode lanes (with both ETC and cash customers) to be more dangerous to cross than cash or ETC lanes because it is more difficult to predict driver behavior. Consequently, some agencies have given consideration to eliminating these lanes. | <ul style="list-style-type: none"> • Does increase worker safety, but may reduce throughput. • Ranked 15th (tied) of 30 strategies considered by workshop participants for reducing worker exposure. | <ul style="list-style-type: none"> • May not be feasible at certain plazas due to space constraints, traffic volumes, mix of ETC and cash traffic. • May cause increased weaving and lane changing behavior. |
| <i>Crossing Procedures</i> | | | |
| Require workers to make eye contact with motorists in approaching vehicles. | Require workers to make eye contact with drivers before crossing. | <ul style="list-style-type: none"> • Considered very effective by agencies that have this rule. • Was ranked as the number 1 strategy out of 30 strategies considered by workshop participants for reducing worker exposure. | <ul style="list-style-type: none"> • None. |
| Require workers to wear safety vests at all times. | A number of agencies require workers to wear safety vests at all times while on shift. This is thought to reduce incidences of workers failing to put their vest on when they exit a booth or break area. | <ul style="list-style-type: none"> • Highly effective where enforced. • Ranked 2nd (tied) of 30 strategies considered by workshop participants for reducing worker exposure. | <ul style="list-style-type: none"> • None. |
| Prohibit workers from crossing any high-speed ETC lanes. | Many agencies prohibit workers from crossing high-speed ETC lanes under any circumstances. | <ul style="list-style-type: none"> • Effective, but may not always be practical. • Ranked 7th (tied) of 30 strategies considered by workshop participants for reducing worker exposure. | <ul style="list-style-type: none"> • There may be no other way for collectors to reach staffed lanes. |
| Prohibit workers from crossing in front of any vehicle larger than an SUV. | After experiencing a fatality when a collector crossed in front of a large truck that was not able to see the worker, the agency now prohibits workers from crossing in front of any vehicle larger than an SUV. | <ul style="list-style-type: none"> • Highly effective, where practical. • However, was not selected as a top three strategy to mitigate worker exposure by any of the workshop participants. Ranked last (tied). | <ul style="list-style-type: none"> • May not be practical depending on placement of truck lanes. |
| Require workers to signal intention to cross. | Require workers to signal their intention to cross to the approaching driver and to wait for acknowledgement from that driver. | <ul style="list-style-type: none"> • Considered very effective. • Ranked 3rd (tied) of 30 strategies considered by workshop participants for reducing worker exposure. | <ul style="list-style-type: none"> • None. |

| Strategy | Description | Rankings from Workshop Participants and Comments on Effectiveness ²⁰ | Concerns / Constraints |
|---|---|---|--|
| Prohibit workers from crossing BEHIND vehicles. | A number of agencies instruct their employees not to cross behind vehicles in case the vehicle backs up. | <ul style="list-style-type: none"> • Common practice with a number of agencies, but not all. • Was not selected as a top three strategy to mitigate worker exposure by any of the workshop participants. Ranked last (tied). | <ul style="list-style-type: none"> • None. |
| Require toll collectors to use stop paddles when crossing. | Issue handheld STOP sign paddles to workers to hold while crossing lanes. | <ul style="list-style-type: none"> • A number of agencies that have tried this have not found it to be effective. • Gave a false sense of security. • Ranked near the bottom of all strategies considered by workshop participants for reducing driver exposure. | <ul style="list-style-type: none"> • Requires workers to be properly trained. • Difficult to hold paddle while also holding cash drawer. |
| Instruct workers to provide verbal cues to motorists when crossing. | Instruct workers to give verbal cues to motorists when crossing (e.g., yell “I’m Crossing!”). | <ul style="list-style-type: none"> • Considered moderately effective, mitigated by noisy environment. • Ranked 13th (tied) of 30 strategies considered by workshop participants for reducing worker exposure. | <ul style="list-style-type: none"> • May be too noisy to practically implement. |
| Promote hands-free crossing for workers. | Require workers to have at least one hand free during crossing so that they can signal to drivers if need be. | <ul style="list-style-type: none"> • Considered moderately effective. • Ranked 13th (tied) of 30 strategies considered by workshop participants for reducing worker exposure. | <ul style="list-style-type: none"> • None. |
| Issue shoulder bags to workers to use when crossing. | Issue shoulder bags to collectors for hands-free crossing, and consider high-visibility color such as orange. | <ul style="list-style-type: none"> • Helps to keep hands free. • Ranked 9th (tied) of 30 strategies considered by workshop participants for reducing worker exposure. | <ul style="list-style-type: none"> • None. |
| Instruct workers to use mutual support when crossing. | Instruct workers to use mutual support when crossing lanes (i.e., the collector in the booth directs motorists to stop for the crossing collector). | <ul style="list-style-type: none"> • Considered moderately effective. • Is simply done as a matter of course (without formal instruction) at a number of facilities. • Ranked 9th (tied) of 30 strategies considered by workshop participants for reducing worker exposure. | <ul style="list-style-type: none"> • None. |

| Strategy | Description | Rankings from Workshop Participants and Comments on Effectiveness ²⁰ | Concerns / Constraints |
|--|--|---|--|
| Escort employees across lanes. | A small number of agencies have, or have considered, a police escort or crossing guard for crossing lanes. | <ul style="list-style-type: none"> • Effective at reducing worker risk, but very cost prohibitive. • One agency that has implemented this strategy reports that in 42 years, no employee has been hit while crossing a lane. • Was not selected as a top three strategy to mitigate worker exposure by any of the workshop participants. Ranked last (tied). | <ul style="list-style-type: none"> • Very cost prohibitive. • May simply expose another employee. |
| <i>Crosswalks</i> | | | |
| Strategically locate crosswalks. | Carefully consider the location of crosswalks (i.e., upstream of the booth to provide improved sight lines, downstream of the booth so that vehicles stop prior to crossing, or well downstream of the booth to provide for longer stopping distance) to encourage workers to cross where most appropriate for the environment at that particular plaza. | <ul style="list-style-type: none"> • Two workshop participants selected this in their ranking of the top 3 most effective strategies for reducing worker exposure, placing the overall ranking of this strategy toward the middle of the 30 strategies considered. • Effectiveness is somewhat dependent on plaza configuration. | <ul style="list-style-type: none"> • May be constrained by physical layout of plaza. |
| Paint pedestrian crosswalks at the plaza. | Designed to warn the public and to ensure that workers cross at the same dedicated location. | <ul style="list-style-type: none"> • Encourages collectors to cross at a consistent location. • Ranked 9th (tied) of 30 strategies considered by workshop participants for reducing driver exposure. | <ul style="list-style-type: none"> • Need to be re-painted periodically. • May give the collector a false sense of security. |
| <i>Warnings to Employees</i> | | | |
| Use ManSaver™ Bars to slow collectors down while crossing the plaza, possibly with chains at the sides of the crossing area to channelize workers. | These bars, patterned after those used on fire trucks, require a worker to stop and lift the bar to enter a lane but to easily push to exit. | <ul style="list-style-type: none"> • Ranked 7th (tied) of 30 strategies considered by workshop participants for reducing worker exposure. | <ul style="list-style-type: none"> • Some concerns that they may be difficult to open when workers' hands are full. • Chains may hinder a quick escape in the event of an emergency. • Adding bar or chains may pose a hazard in that collectors' bags and/or clothing may get caught as they are crossing. |

| Strategy | Description | Rankings from Workshop Participants and Comments on Effectiveness ²⁰ | Concerns / Constraints |
|---|--|--|---|
| Use visual cues to remind workers of the danger of crossing lanes. | Agencies use a variety of visual cues to remind workers of the danger of crossing lanes including: <ul style="list-style-type: none"> • Signs (e.g., BE ALERT HIGH SPEED TRAFFIC, red and white warning signs at crossing points). • Pavement markings (e.g., LOOK and WATCH FOR CARS) to remind collectors about the dangers of crossing lanes. • Warning stickers (e.g., on the ground outside the booth doors, or notes such as WEAR YOUR VEST on the booth door). | <ul style="list-style-type: none"> • May be most effective for newer employees. • Ranked near the bottom of all strategies considered by workshop participants for reducing driver exposure. | <ul style="list-style-type: none"> • No real constraints, although workers may become complacent and ignore signs and markings over time. |
| Visually remind workers when they are entering ETC and mixed use lanes. | Label ETC and mixed use lanes differently from cash only lanes to remind collectors that vehicles may not stop in these lanes (e.g., with purple lights). | <ul style="list-style-type: none"> • Ranked near the bottom of all strategies considered by workshop participants for reducing driver exposure. | <ul style="list-style-type: none"> • Concerns that this strategy may give workers a false sense of security when crossing the non-ETC lanes. |
| Garments for Improved Worker Visibility | | | |
| Consider higher visibility vests. | Use vests with battery-powered flashing lights. | <ul style="list-style-type: none"> • Was not selected as a top three strategy to mitigate worker exposure by any of the workshop participants. Ranked last (tied). | <ul style="list-style-type: none"> • Most plazas are well-lit, approach may not be cost effective. |
| Consider 5-pt breakaway safety vests. | Safety vests have a 5-point breakaway system designed to come off with minor or no injury if the vest becomes hooked on an object. | <ul style="list-style-type: none"> • Ranked low by workshop participants considering strategies to reduce worker exposure, with only one participant placing this strategy in their top three. | <ul style="list-style-type: none"> • Cumbersome to put on. |
| Maintenance and Lane Closures | | | |
| Instruct workers to look back over their shoulder at traffic after manually closing a lane. | Require workers to look back over their shoulder every few steps after manually closing a gate. | <ul style="list-style-type: none"> • Mixed assessment of effectiveness, some concern about workers tripping. • Was not selected as a top three strategy to mitigate worker exposure by any of the workshop participants. Ranked last (tied). | <ul style="list-style-type: none"> • Concerns about tripping. |

| Strategy | Description | Rankings from Workshop Participants and Comments on Effectiveness ²⁰ | Concerns / Constraints |
|--|--|--|---|
| Require attenuator trucks for all maintenance work requiring a lane closure. | Some agencies require the use of attenuated trucks for all maintenance work requiring a lane closure. | <ul style="list-style-type: none"> Highly effective when implemented, but often not feasible. Ranked 3rd (tied) of 30 strategies considered by workshop participants for reducing worker exposure. | <ul style="list-style-type: none"> Very expensive. Time consuming to wait for attenuator truck. |
| “Your Speed” signs on attenuator trucks. | Use digital “Your Speed is...” on the rear of attenuator trucks to protect maintenance workers. | <ul style="list-style-type: none"> Was not selected as a top three strategy to mitigate worker exposure by any of the workshop participants. Ranked last. | <ul style="list-style-type: none"> Very expensive. |
| Require maintenance workers to use a “buddy” system. | Require maintenance workers to use a “buddy” system (i.e., no maintenance work is performed alone) so that one worker can watch for traffic. | <ul style="list-style-type: none"> Considered very effective, but may be cost prohibitive in certain situations. Ranked 9th (tied) of 30 strategies considered by workshop participants for reducing worker exposure. | <ul style="list-style-type: none"> Cost. |

Potential Strategies to Reduce Worker Exposure to the Environment

| Strategy | Description | Rankings from Workshop Participants and Comments on Effectiveness ²¹ | Concerns / Constraints |
|--|--|--|---|
| <i>Mitigating Air Quality Issues</i> | | | |
| Install CO monitors in booths or test for CO periodically. | A few agencies now have CO monitors in their booths. | <ul style="list-style-type: none"> Ranked 6th (tied) out of 15 strategies considered by workshop participants for reducing environmental impacts for collectors. | <ul style="list-style-type: none"> Must be maintained and tested periodically. |

²¹ Within each strategy grouping, workshop participants were asked to select and rank the three strategies that they believed to have the greatest potential to improve safety for workers and customers at toll plazas. Some of this ranking information is provided here; the full details of the rankings are provided in Appendix G. Note that at the workshop, the strategies discussed here were presented in a category entitled “Environmental Issues.”

| Strategy | Description | Rankings from Workshop Participants and Comments on Effectiveness ²¹ | Concerns / Constraints |
|-------------------------------------|---|---|--|
| Install positive air in all booths. | Positive air systems are designed to extract fresh air from outside of the immediate vicinity of the booth (e.g., above the toll booth structure) where the air is not contaminated with vehicle emissions or particulate matter such as dust and delivering it to the booth at a pressure which allows for positive pressure within the booth, thereby ensuring that air is forced out of the toll booth window. Cold/heat stress can also be controlled by these systems. | <ul style="list-style-type: none"> 15 out of the 20 workshop participants rated this strategy among the top 3 most effective strategies for reducing environmental impacts for collectors, with 7 participants rating it as the most effective strategy. | <ul style="list-style-type: none"> Expensive. |
| Install air conditioning in booths. | Install air conditioning in booths in warmer climates and consider having individual controls inside booths. | <ul style="list-style-type: none"> Ranked 3rd out of 15 strategies considered by workshop participants for reducing environmental impacts for collectors. | <ul style="list-style-type: none"> Adds costs for installation and maintenance. Without individual controls it is difficult to calibrate the systems to individual preferences. |

Potential Strategies to Improve Ergonomics for Workers

| Strategy | Description | Rankings from Workshop Participants and Comments on Effectiveness ²² | Concerns / Constraints |
|---|--|---|---|
| Equipment | | | |
| Provide collectors with ergonomic stools. | Nearly all agencies provide some sort of ergonomic stools to their collectors. Some have gone toward a “sit/stand” stool. Others have found that swivel chairs with surrounding foot rests are preferable to their collectors. | <ul style="list-style-type: none"> 8 of the 20 workshop participants rated this strategy among the top 3 most effective strategies in the “ergonomics” category. | <ul style="list-style-type: none"> Difficult to find stools that suit all collectors. Avoid chairs with flexible backs as this encourages collectors to lean back and can result in serious injury. |

²² Within each strategy grouping, workshop participants were asked to select and rank the three strategies that they believed to have the greatest potential to improve safety for workers and customers at toll plazas. Some of this ranking information is provided here; the full details of the rankings are provided in Appendix G. Note that at the workshop, the strategies discussed here were presented in a category entitled “Ergonomics.”

| Strategy | Description | Rankings from Workshop Participants and Comments on Effectiveness ²² | Concerns / Constraints |
|---|--|---|---|
| Install shelving and hooks in the booths. | Many agencies expressed the importance of keeping the booth floor free of all items that can pose a tripping hazard for workers. Having sufficient shelving and clothing hooks in the booth can facilitate this. | <ul style="list-style-type: none"> Although none rated this strategy among the top 3 most effective strategies in the “ergonomics” category, most workshop participants commented that this was a low-cost, common sense strategy. Important to avoid blocking collectors’ view out of the booth. | <ul style="list-style-type: none"> None. |
| Provide collectors with anti-fatigue mats in the booths. | Anti-fatigue mats in the booths can reduce fatigue caused by standing for long periods on a hard surface. | <ul style="list-style-type: none"> 14 of the 20 workshop participants rated this strategy among the top 3 most effective strategies in the “ergonomics” category, with 5 participants rating it as the most effective strategy. | <ul style="list-style-type: none"> Can present a tripping hazard - important to ensure that the mat is securely fastened to floor and that the chair legs cannot puncture the mat. |
| Install convex mirrors on the side of booths. | A small convex mirror on the booth can allow collectors to monitor vehicles exiting the booth without turning. | <ul style="list-style-type: none"> Most workshop participants commented that this was a low-cost strategy that made sense. | <ul style="list-style-type: none"> Could pose a problem with trucks and large vehicles hitting the mirror at facilities with narrow lanes. |
| Provide ergonomic training to collectors. | Providing ergonomic training to collectors can reduce repetitive motion injuries. | <ul style="list-style-type: none"> 8 of the 20 workshop participants rated this strategy among the top 3 most effective strategies in the “ergonomics” category. | <ul style="list-style-type: none"> Can be expensive. |
| Booth Design | | | |
| Provide collectors with adjustable height terminals, cash drawers, and/or chairs. | Providing collectors with adjustable height equipment can reduce workplace injuries associated with reaching. Especially helpful for tall or short employees. | <ul style="list-style-type: none"> Ranked 3rd out of 9 strategies considered by workshop participants in the “ergonomics” category. | <ul style="list-style-type: none"> Can be expensive. |
| Use bumped-out Dutch doors on booths. | Booths with a bumped-out door design can allow collectors to see oncoming traffic and to reach vehicles without having to lean quite so far out of the booth. | <ul style="list-style-type: none"> Ranked 2nd out of 9 strategies considered by workshop participants in the “ergonomics” category. | <ul style="list-style-type: none"> Lane widths at older plazas may constrain the width of the booth. |
| Policies and Procedures | | | |

| Strategy | Description | Rankings from Workshop Participants and Comments on Effectiveness ²² | Concerns / Constraints |
|--|---|---|---|
| Implement policies to reduce injury due to vehicles pulling into or away from the booth. | To reduce injuries due to pulled arms as vehicles pull away from the plaza, one agency has made it a policy that collectors perform validation as their last step in the transaction process so that the gate stays down until the transaction is complete. Another has implemented a policy that collectors are not allowed to place their hands outside of the booth until after the vehicle has come to a complete stop. | <ul style="list-style-type: none"> 8 of the 20 workshop participants rated this strategy among the top 3 most effective strategies in the “ergonomics” category. | <ul style="list-style-type: none"> Practicality of the validation policy depends on treadle placement. |

Potential for Reducing Worker Risk of Assault

| Strategy | Description | Rankings from Workshop Participants and Comments on Effectiveness ²³ | Concerns / Constraints |
|---|--|---|---|
| Lock booth doors | Instruct collector to keep the booth door locked at all times when inside the booth. | N/A | <ul style="list-style-type: none"> May restrict collectors’ ability to rapidly exit the booth in an emergency. |
| Have periodic cash drops during shifts. | May reduce the temptation for robbery. | N/A | <ul style="list-style-type: none"> None. |
| Install cameras in and around booths. | Provides both a deterrent and investigation tool. | N/A | <ul style="list-style-type: none"> Expensive to install and monitor. |
| Install bullet-resistant glass on booths. | Offers additional protection to collectors against assault and guns. | N/A | <ul style="list-style-type: none"> Very expensive. Limited effectiveness as collectors must keep at least part of the booth open to interact with public. |

²³ Within each strategy grouping, workshop participants were asked to select and rank the three strategies that they believed to have the greatest potential to improve safety for workers and customers at toll plazas. Some of this ranking information is provided here; the full details of the rankings are provided in Appendix G. Note that at the workshop, the strategies discussed here were presented in a category entitled “Assault”, but the comments were not able to be recorded as there was a power outage during this portion of the workshop due to a power outage.

| Strategy | Description | Rankings from Workshop Participants and Comments on Effectiveness ²³ | Concerns / Constraints |
|---|--|---|---|
| Provide bullet-resistant vests to collectors. | One toll agency began offering collectors the option of wearing bullet-resistant vests after one of their collectors was shot. | N/A | <ul style="list-style-type: none"> Expensive. May be uncomfortable to wear. |
| Install covert panic alarms in all booths. | Allows for collectors to summon help either from nearby supervisor or law enforcement. Particularly helpful at remote locations with a single collector. | N/A | <ul style="list-style-type: none"> Potential issue with false alarms. |

Potential Strategies to Reduce Merging and Lane-Changing Behavior

| Strategy | Description | Rankings from Workshop Participants and Comments on Effectiveness ²⁴ | Concerns / Constraints |
|---|--|---|---|
| <i>Plaza Configuration</i> | | | |
| Position ETC lanes on both the right and the left side of plazas with nearby on or off ramps. | In situations where a plaza is quickly followed by an off-ramp, it can be dangerous for high-speed ETC traffic to have to quickly weave across multiple lanes of traffic to utilize the ramp. This is exacerbated in areas with high percentages of truck traffic. | <ul style="list-style-type: none"> There is considerable debate about this practice. While most consider that the practice will increase driver safety there are concerns that it can decrease worker safety – forcing collectors to cross high-speed lanes to reach staffed booths. Ranked among the top 3 most effective merging mitigation strategies by 8 of 20 workshop participants. | <ul style="list-style-type: none"> In many locations the practice is prevented by physical constraints. Can lead to increased worker exposure to high-speed lanes. Concerns that it may be confusing to drivers. Requires additional signs. Additional ETC lane may be blocked by queues from cash lanes. Could create additional, unexpected weaving problems. |

²⁴ Within each strategy grouping, workshop participants were asked to select and rank the three strategies that they believed to have the greatest potential to improve safety for workers and customers at toll plazas. Some of this ranking information is provided here; the full details of the rankings are provided in Appendix G. Note that at the workshop, the strategies discussed here were presented in a category entitled “Merging and Lane Changing.”

| Strategy | Description | Rankings from Workshop Participants and Comments on Effectiveness ²⁴ | Concerns / Constraints |
|---|---|--|--|
| <p>Select location of truck-only lanes at plaza based on feedback from truck drivers.</p> | <p>A number of agencies face difficulties with trucks having to merge from shoulder travel lanes to median lanes to access ETC and then merging back across traffic. To address this concern, the Illinois Toll Authority recruited a number of commercial truck drivers and asked them to drive their facility and indicate where they would ideally like to access the plaza. Truck-only lanes were then situated based in part on these responses.</p> | <ul style="list-style-type: none"> While workshop participants felt that the practice of situating truck-only lanes based on user feedback was effective, there were concerns about the use of truck-only lanes in general. Was rated among the top 3 strategies for mitigating merging incidents by only 3 of the 20 workshop participants. | <ul style="list-style-type: none"> Identified constraints identified referred to the general practice of truck-only lanes and centered on limited space to implement such an operation. |
| <p>Channelization of Traffic</p> | | | |
| <p>Channelize traffic downstream of the plaza with delineators.</p> | <p>While many facilities actively separate traffic upstream of the plazas, a smaller number make use of delineators (and to a lesser extent physical barriers) to similarly maintain separation for some length downstream of the plaza.</p> | <ul style="list-style-type: none"> Would be most effective if the delineated section extended far enough to allow vehicles from the cash and mixed lanes to accelerate to match the speeds of the ETC traffic. Rated among the top 3 most effective strategies to mitigate merging concerns by 8 of the 20 workshop participants, although none rated it as the most effective strategy. | <ul style="list-style-type: none"> Many plazas simply do not have the space. As with all delineators introduces worker safety issues associated with placement and maintenance. |
| <p>Provide a buffer lane between ETC and cash customers.</p> | <p>A small number of agencies use buffer or unused lanes between ETC and cash or mixed lanes. As more and more customers move to ETC and fewer lanes are required at plazas, this is becoming more feasible.</p> | <ul style="list-style-type: none"> Rated as the 2nd or 3rd most effective strategy to address merging by 5 out of the 20 workshop participants and as the most effective strategy by 1 participant. Felt to be more economical than the use of physical barriers. | <ul style="list-style-type: none"> Many plazas simply do not have the space to support unused lanes. Violators may try to use the buffer lane in an attempt to bypass the toll. May confuse patrons. If used intermittently may create an unsafe situation for workers during buffer lane closing and opening. |

| Strategy | Description | Rankings from Workshop Participants and Comments on Effectiveness ²⁴ | Concerns / Constraints |
|---|--|--|---|
| Use physical barriers to separate approaching high-speed traffic from cash or mixed lanes. | A number of agencies use physical separation such as concrete barriers to separate high-speed ETC traffic from lower speed mixed or cash traffic. The length of separation and the type of barrier varies greatly among the facilities employing this technique. | <ul style="list-style-type: none"> 18 of the 20 workshop participants rated this strategy among the top 3 most effective for reducing merging incidents, with 15 of the participants ranking it as the most effective strategy. | <ul style="list-style-type: none"> Barriers themselves could become safety hazards. Installation and maintenance costs are high. Customers may inadvertently become “trapped” in the wrong lane and try to back up. Implementation may be restricted by lane width considerations. May present challenges to snow removal. |
| Use physical barriers to prevent vehicles in left-most lane from making unsafe maneuvers to reach downstream off-ramps. | In situations where off-ramps are immediately downstream of a plaza, some authorities physically prevent vehicles in left-most lanes from merging across traffic to reach the off-ramp. Other authorities use striping and signs to try to enforce such restrictions; however, this was felt to be less effective than physical barriers. | <ul style="list-style-type: none"> Felt to be effective only with physical barriers versus lane striping, barrels, cones, or delineators. Was only rated among the top 3 most effective strategies for mitigating merging incidents by 5 of the 20 workshops participants, with none rating it as the most effective strategy. | <ul style="list-style-type: none"> Concerns that it may confuse patrons and cause them to back up. |
| Use high-visibility flexible delineators to separate traffic lanes. | This method of separating traffic lanes makes use of physical delineators in the roadway that are less expensive to deploy and that do not provide the same physical separation as barriers. Over time agencies have evolved to increasingly higher visibility delineators such as wide sergeant stripe panels and arrangements of multiple delineators in bowling pin configurations. | <ul style="list-style-type: none"> Considered more cost-effective to deploy than physical barriers. Was rated among the top 3 most effective strategies to mitigate merging incidents by 9 out of the 20 workshop participants, with 3 ranking it the most effective strategy. | <ul style="list-style-type: none"> Agencies reported a number of concerns, associated with maintenance of delineators including cost and worker safety. |

| Strategy | Description | Rankings from Workshop Participants and Comments on Effectiveness ²⁴ | Concerns / Constraints |
|---|--|---|--|
| Use pop-up delineators to reduce worker exposure at plazas requiring lane changes throughout the day. | Pop-up delineators are systems where the delineators reside in the pavement and can be automatically activated or raised to demark lanes or support lane closures. | <ul style="list-style-type: none"> Only 4 of 20 workshop participants rated this strategy among the top 3 strategies for mitigating merging incidents. Those facilities that employed the technique, such as the NY State Thruway, were very pleased with their operation and felt that the use of the delineators helped to reduce the worker exposure that is necessitated by manual systems. | <ul style="list-style-type: none"> Some concerns about operation in areas with snow and ice. However, the NY State Thruway’s compressed air system appears to have overcome this operational challenge. Felt to be an expensive solution that introduces its own maintenance concerns. |

Potential Strategies to Reduce Speeding

| Strategy | Description | Rankings from Workshop Participants and Comments on Effectiveness ²⁵ | Concerns / Constraints |
|---|--|---|---|
| <i>Policies and Enforcement</i> | | | |
| Implement an automated enforcement program. | A number of agencies use a combination of an automated video enforcement system to identify violators and a program to issue warning letters and suspend ETC for repeat violators. | <ul style="list-style-type: none"> Anecdotally, sites that employ this technique seem to have the lowest incidence of speeding. 16 out of the 20 workshop participants rated this strategy among the top 3 most effective strategies for reducing speeding. | <ul style="list-style-type: none"> Significant cost. Legislation may make this prohibitive in some States. Somewhat restrictive as most agencies are only able to revoke tags that they have issued. |

²⁵ Within each strategy grouping, workshop participants were asked to select and rank the three strategies that they believed to have the greatest potential to improve safety for workers and customers at toll plazas. Some of this ranking information is provided here; the full details of the rankings are provided in Appendix G. Note that at the workshop, the strategies discussed here were presented in a category entitled “Speeding.”

| Strategy | Description | Rankings from Workshop Participants and Comments on Effectiveness ²⁵ | Concerns / Constraints |
|--|---|--|--|
| Increase enforcement presence at plazas. | Some agencies have increased enforcement presence in the vicinity of their plazas in an attempt to reduce speeds through the plaza. In many cases agencies report that even the presence of an unattended patrol car is quite effective. | <ul style="list-style-type: none"> 11 out of the 20 workshop participants rated this strategy among the top 3 most effective strategies for reducing speeding. Several of the workshop participants spoke very highly of this strategy from their experience. | <ul style="list-style-type: none"> Can be costly depending on what arrangement the agency has with the police. Some plazas may not have sufficient space downstream of the plaza to safely pull over offenders. |
| Double fines for speeding in toll areas. | A number of agencies have worked to enact legislation allowing them to enforce double fines for speeding in toll areas. | <ul style="list-style-type: none"> 7 out of the 20 workshop participants rated this strategy among the top 3 most effective strategies for reducing speeding. | <ul style="list-style-type: none"> Must be accompanied by enforcement. Not feasible in States where legislation does not allow agency to enforce speeds around plazas. |
| Physical Treatments | | | |
| Install gates downstream of the plaza. | Depending on the configuration, gates downstream of the plaza can help control speeds. In most cases, the gates lift automatically as an ETC vehicle approaches, so that ETC customers can proceed safely through the plaza without stopping as long as they maintain a reasonable speed – typically below 15 miles per hour. | <ul style="list-style-type: none"> Most workshop participants agreed that gates are an effective way of controlling speeds. | <ul style="list-style-type: none"> Not feasible at plazas where throughput is an issue. Maintenance can be an issue as gates can be hit by inattentive motorists. Inoperable gates can pose a safety hazard requiring toll collectors to exit their booth to lift the gate. |
| Install rumble strips or saw cuts in pavement upstream of the plaza. | Rumble strips in advance of the plaza can be used to draw motorists' attention to their speed and can also provide toll collectors with an auditory warning that a vehicle is approaching. | <ul style="list-style-type: none"> 9 out of the 20 workshop participants rated this strategy among the top 3 most effective strategies for reducing speeding, with 6 participants rating it as the most effective strategy. One workshop participant reported that thermoplastic rumble strips are somewhat expensive and that there are associated maintenance costs, but that they are still worthwhile since they are so effective. | <ul style="list-style-type: none"> Noise can be an issue for nearby residents. Plastic rumble strips can pose problems with snow plow operations. |
| Other Mitigation Strategies | | | |

| Strategy | Description | Rankings from Workshop Participants and Comments on Effectiveness ²⁵ | Concerns / Constraints |
|---|---|--|--|
| Install transverse pavement markings in advance of the plaza. | Transverse yellow pavement markings with progressively closer spacing gives motorists the illusion that they are increasing speed when in fact they are traveling at a constant speed. | <ul style="list-style-type: none"> • May become less effective over time as motorists become accustomed to the markings. | <ul style="list-style-type: none"> • One workshop participant noted that the pavement markings may lead to further driver confusion in that they may make the lines separating lanes less visible. |
| Ensure that speed limits at plazas are consistent with nearby toll authorities. | Some agencies have found that ensuring consistency in speed limits across agencies can help with speed limit compliance. | <ul style="list-style-type: none"> • Most workshop participants felt that this is an important strategy as it maintains driver expectation. | <ul style="list-style-type: none"> • May not work in areas where plaza configuration and traffic patterns are quite different from one plaza to another. • Interagency coordination can be critical to achieving this. |
| Post speed limits at each lane. | Some agencies post speed limits at each lane to remind motorists of the speed limit. | <ul style="list-style-type: none"> • Especially helpful at plazas where the speed limit varies by lane. | <ul style="list-style-type: none"> • Sign overload was a concern expressed by some workshop participants. |
| Implement a public outreach campaign targeting speeders. | Some agencies employ targeted outreach to their customers to remind them of the dangers of speeding through plazas. This can be done cost-effectively through mailers to ETC customers. | <ul style="list-style-type: none"> • Was not selected by any workshop participants as among the top 3 most effective strategies for reducing speeding. | <ul style="list-style-type: none"> • Can be costly depending on how it is done. • Difficult in areas with high tourist traffic. |
| Paint the speed limit on the pavement in advance of the plaza. | Some agencies reinforce the speed limit by painting it on the pavement in advance of the plaza. | <ul style="list-style-type: none"> • Several workshop participants noted that this is a cost effective solution. • Mixed debate as to effectiveness. Some agencies that had tried this did not find it to be particularly effective while others found it to be quite effective. | <ul style="list-style-type: none"> • Maintenance. • May not be as effective in areas where weather issue cause problems (i.e., sanding or snow plowing). |
| Use regulatory speed limit signs at plazas. | Some agencies have found that changing speed limit signs from advisory to regulatory (black on white) has made a difference in speed limit compliance. | <ul style="list-style-type: none"> • Was selected by only one workshop participants as among the top 3 most effective strategies for reducing speeding. | <ul style="list-style-type: none"> • Must be accompanied by enforcement. |

| Strategy | Description | Rankings from Workshop Participants and Comments on Effectiveness ²⁵ | Concerns / Constraints |
|--|---|---|--|
| <p>Use digital signs displaying real-time speeds at the plaza.</p> | <p>Many agencies use temporary or permanent digital signs displaying real-time speeds to motorists. Some use these signs in the area upstream of the plaza while others use them at the plaza itself.</p> | <ul style="list-style-type: none"> • 6 out of the 20 workshop participants rated this strategy among the top 3 most effective strategies for reducing speeding. • Several participants noted that they had tried this and that it works. One noted that speeds in their ETC lanes were reduced by 1mph, and the other noted that they saw a 70% reduction in speeders. One agency uses it in their express lanes only (where the speed limit is posted at 45 mph) and has found it to be very effective. • One workshop participant commented that they had tried a number of strategies, but it was not until they installed the “Your Speed” indicator signs that they saw a drop in the number of speeders. • Several participants noted that the signs are more effective when the agency uses temporary trailer-mounted signs and moves them around to different locations periodically. | <ul style="list-style-type: none"> • Some agencies have experienced issues with motorists speeding up when these signs are present to see how high of a speed the sign will display. • Sign accuracy was a concern mentioned by a few workshop participants since motorists are not always sure it is “their” speed that was shown. • Sign overload was a concern mentioned by a few workshop participants. • One workshop participant noted that placing the signs near a fixed speed limit sign caused confusion for motorists at their plaza. |

Potential Strategies to Reduce Driver Confusion and Driver Inattention

| Strategy | Description | Rankings from Workshop Participants and Comments on Effectiveness ²⁶ | Concerns / Constraints |
|--|--|--|---|
| <i>Clearly Identifying ETC Lanes</i> | | | |
| Supplement brand name signs such as “SunPass” with generic signs such as “Pre-PAID ONLY” to label ETC lanes. | In areas with heavy visitor traffic there are concerns that many travelers may not be familiar with local ETC product names (such as EZ Pass or SunPass) and may inadvertently enter ETC lanes as a result. | <ul style="list-style-type: none"> Ranked 5th of 16 strategies considered for reducing driver confusion by workshop participants. | <ul style="list-style-type: none"> Can add to information overload. Difficult to select the appropriate term, e.g., “Pre-PAID” may not be universally understood by drivers either. |
| Paint lane numbers on the pavement in advance of the plaza. | To provide drivers more time to maneuver toward the appropriate lanes within a plaza some agencies have undertaken the practice of painting lane numbers into the pavement along the approach to a plaza with corresponding numbers over the various booths. | <ul style="list-style-type: none"> Particularly effective in areas where site lines to plaza are compromised (e.g., along curves). Some agencies that have implemented the practice question its effectiveness; however, customers seem to like it (according to satisfaction surveys). Strategy was ranked in the middle of the pack (7th of 16 strategies considered for reducing confusion) by workshop participants. | <ul style="list-style-type: none"> Concerns that it may lead to information overload. |
| Differentiate ETC lanes from cash or mixed lanes with special pavement markings. | A number of agencies, such as the NY State Thruway use unique pavement markings (such as purple paint) to differentiate ETC from cash or mixed lanes. | <ul style="list-style-type: none"> Strategy was ranked 4th out of 16 strategies considered to reduce driver confusion. Agencies that have implemented the approach feel that it is effective and have received positive customer feedback on the practice. | <ul style="list-style-type: none"> Maintenance of paint / markings, especially in cold weather environments. Restricts ability to re-configure lanes. |
| <i>Informing Motorists of Changing Conditions</i> | | | |

²⁶ Within each strategy grouping, workshop participants were asked to select and rank the three strategies that they believed to have the greatest potential to improve safety for workers and customers at toll plazas. Some of this ranking information is provided here; the full details of the rankings are provided in Appendix G. Note that at the workshop, the strategies discussed here were presented in a category entitled “Driver Confusion and Distraction.”

| Strategy | Description | Rankings from Workshop Participants and Comments on Effectiveness ²⁶ | Concerns / Constraints |
|--|--|--|--|
| Use variable message signs (VMS) to inform drivers of plaza conditions. | An increasing number of agencies are using variable message signs on the mainline to inform drivers of unexpected traffic conditions (e.g., incidents, maintenance, etc.). Few agencies use these signs specifically for plaza conditions. | <ul style="list-style-type: none"> • Effective method of informing travelers of unexpected conditions. • Received the highest number of top three votes as an effective strategy for reducing driver confusion (out of 16 strategies considered). | <ul style="list-style-type: none"> • Requires active surveillance and management. • Expensive to install and maintain. |
| Use digital signs in advance of plaza to indicate which lanes are currently ETC. | For plazas where lane configurations change throughout the day at least one agency has implemented the use of digital signs in advance of the plaza that indicate which lanes are ETC. | <ul style="list-style-type: none"> • Ranked 2nd of 16 strategies considered for reducing driver confusion by workshop participants. • Helps to move lane selection decision back to mainline lanes. | <ul style="list-style-type: none"> • Can create additional confusion. • Must be actively updated. • Added maintenance costs and issues. |
| Position maintenance trucks with flashing lights and flaggers at end of long queues. | Use high visibility maintenance trucks and / or flaggers at the end of long, unexpected queues that extend beyond the sight of the plaza. | <ul style="list-style-type: none"> • Considered to be very effective when implemented, but ranked low by workshop participants. | <ul style="list-style-type: none"> • Resource-intensive. |
| Create a buffer lane between bi-directional traffic where physical barriers do not exist. | A number of plazas change the number of bi-directional lanes throughout the day and thus do not have physical separation between the travel directions. The use of a buffer lane (or unused lane) can help to separate these opposing traffic flows. | <ul style="list-style-type: none"> • Felt to be an effective strategy if traffic demands and plaza capacity supported taking one lane out of operation. • Tied for 15th of the 16 strategies considered for reducing driver confusion by workshop participants. | <ul style="list-style-type: none"> • Many plazas do not have the excess capacity to support this. |
| Informing Motorists of Lane Closures | | | |
| Include signs on gates upstream of the plaza to convey to motorists when a lane is closed. | While a number of agencies use no more than a traffic cone to indicate lane closures, others use more conspicuous indicators such as STOP signs, LANE CLOSED signs, large red X signs, etc. | <ul style="list-style-type: none"> • Signs are felt to work best in concert with physical gates. • Strategy received the 5th highest (out of 16) number of votes for most effective strategies by workshop participants. | <ul style="list-style-type: none"> • Signs may be difficult to affix current gates. • May be expensive to retro-fit. |
| Mitigating Sensory Overload | | | |
| Determine sign messaging based on feedback from motorists. | Make use of surveys, focus groups and other formal feedback mechanisms to design and select sign messages. | <ul style="list-style-type: none"> • Ranked last of the solutions considered for reducing driver confusion by workshop participants. | <ul style="list-style-type: none"> • Costly. • Difficult to capture visitors' inputs. |

| Strategy | Description | Rankings from Workshop Participants and Comments on Effectiveness ²⁶ | Concerns / Constraints |
|--|--|---|--|
| Ban the use of advertisements on or near plazas. | Agencies have conflicting policies with regard to advertisements in and around toll plazas, with some even having ads on the booths themselves. This has created questions about information overload and caused a number of agencies to ban such signs. | <ul style="list-style-type: none"> • Debates continue as to whether or not such advertisements contribute to unsafe conditions; however, the majority of agencies agree that having fewer signs contributes to increased safety. • Ranked in the bottom 3rd of all strategies considered for their effectiveness in reducing driver confusion by workshop participants. | <ul style="list-style-type: none"> • Banning advertising reduces revenues. |
| <i>Increasing Conspicuity of Facilities and Workers</i> | | | |
| Use signs to warn drivers about the potential for workers in the roadway. | Many agencies use signs such as SLOW DOWN - PROTECT OUR WORKERS or pedestrian crossing signs to protect workers. | <ul style="list-style-type: none"> • Ranked 3rd of 30 solutions considered by workshop participants for reducing driver exposure. • Collectors like them. | <ul style="list-style-type: none"> • Adds to visual clutter and driver confusion. |
| Use white strobe lights at plazas to highlight facilities during inclement weather. | A number of agencies use special lighting, such as strobe lighting, to increase the conspicuity of toll plazas, especially during inclement weather such as fog. | <ul style="list-style-type: none"> • May be most effective in areas with severe weather such as fog. • Ranked 9 of 16 (tied) strategies considered for reducing driver confusion by workshop participants. | <ul style="list-style-type: none"> • None identified. |
| <i>Reducing the Incidence of Vehicles Stopping or Backing Up in High-Speed Lanes</i> | | | |
| Use a tall barrier wall to prevent motorists in high-speed lanes from stopping and crossing lanes to staffed booths. | Drivers who inadvertently enter ETC lanes or whose transponder malfunctions often exit their vehicles and cross lanes to reach staffed booths. The installation of taller barrier walls can help to cut down on this dangerous practice. | <ul style="list-style-type: none"> • Agencies that have implemented this practice have found it to be very effective in preventing customers from both crossing lanes and from stopping in the first place. • Ranked 2nd of 16 (tied with one other) strategies considered for reducing driver confusion by workshop participants. • As a by-product, may cut down on rubber-necking. | <ul style="list-style-type: none"> • May limit ability to detect incidents and monitor ETC lanes. |

| Strategy | Description | Rankings from Workshop Participants and Comments on Effectiveness ²⁶ | Concerns / Constraints |
|--|---|--|--|
| Eliminate violation warning signs. | Some agencies have eliminated or reduced the conspicuity of toll violation warning signs in ETC lanes to discourage non-ETC drivers from stopping and either backing up or exiting their vehicles to reach a staffed booth. | <ul style="list-style-type: none"> • Ranked second last (tied) of all strategies considered for reducing driver confusion by workshop participants. • Practice may help to reduce unsafe actions, but does not eliminate them. | <ul style="list-style-type: none"> • Questions as to effectiveness of approach. • Some concerns about legislative consequences of not providing warnings of violation prosecution. |
| Post STAY IN VEHICLE signs at booths. | Such signs should help to prevent drivers from exiting their vehicles in ETC lanes and attempting to walk to staffed lanes. | <ul style="list-style-type: none"> • Doubts as to the effectiveness of such signs. • Relatively low cost. • Ranked 7th (tied) of 16 solutions considered for reducing driver confusion by workshop participants. | <ul style="list-style-type: none"> • Creates additional sign “clutter.” • Questions as to whether or not patrons actually read them. |
| Install a PA system at unmanned booths to enable communication with drivers. | In order to address drivers that stop at unmanned booths some agencies have installed public address systems | <ul style="list-style-type: none"> • Considered to be very effective by agencies that have implemented. • Ranked 6th of 16 strategies considered by workshop participants for reducing driver confusion. | <ul style="list-style-type: none"> • May not be cost-effective. • May not work very well in noisy environments. |