National Cooperative Highway Research Program

NCHRP Synthesis 240

Toll Plaza Design

A Synthesis of Highway Practice

Transportation Research Board
National Research Council

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Transportation Research Board Executive Committee Subcommittee for NCHRP

National Cooperative Highway Research Program

Synthesis of Highway Practice 240

Toll Plaza Design

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Systematic, well-designed research provides the most effective approach to the solution of many problems facing highway administrators and engineers. Often, highway problems are of local interest and can best be studied by highway departments individually or in cooperation with their state universities and others. However, the accelerating growth of highway transportation develops increasingly complex problems of wide interest to highway authorities. These problems are best studied through a coordinated program of cooperative research.

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PREFACE

A vast storehouse of information exists on nearly every subject of concern to highway administrators and engineers. Much of this information has resulted from both research and the successful application of solutions to the problems faced by practitioners in their daily work. Because previously there has been no systematic means for compiling such useful information and making it available to the entire community, the American Association of State Highway and Transportation Officials has, through the mechanism of the National Cooperative Highway Research Program, authorized the Transportation Research Board to undertake a continuing project to search out and synthesize useful knowledge from all available sources and to prepare documented reports on current practices in the subject areas of concern.

This synthesis series reports on various practices, making specific recommendations where appropriate but without the detailed directions usually found in handbooks or design manuals. Nonetheless, these documents can serve similar purposes, for each is a compendium of the best knowledge available on those measures found to be the most successful in resolving specific problems. The extent to which these reports are useful will be tempered by the user's knowledge and experience in the particular problem area.

FOREWORD

By Staff
Transportation Research Board

This synthesis presents information on the design of toll plazas at highway, bridge, tunnel, and other transportation facilities. It will be of interest to toll facility managers and other officials, as well as to consultants concerned with the design, operation, and maintenance of toll facilities. It can also be useful to financial personnel, traffic engineers, planners, and security and enforcement personnel. In addition, it provides information to those concerned with environmental issues such as drainage, runoff, lighting, noise, and air quality.

Administrators, engineers, and researchers are continually faced with highway problems on which much information exists, either in the form of reports or in terms of undocumented experience and practice. Unfortunately, this information often is scattered and unevaluated and, as a consequence, in seeking solutions, full information on what has been learned about a problem frequently is not assembled. Costly research findings may go unused, valuable experience may be overlooked, and full consideration may not be given to available practices for solving or alleviating the problem. In an effort to correct this situation, a continuing NCHRP project, carried out by the Transportation Research Board as the research agency, has the objective of reporting on common highway problems and synthesizing available information. The synthesis reports from this endeavor constitute an NCHRP publication series in which various forms of relevant information are assembled into single, concise documents pertaining to specific highway problems or sets of closely related problems.

This report of the Transportation Research Board focuses on the design factors affecting toll plazas, including traffic, toll collection methods, location and configuration of toll plazas, as well as congestion management, operation and maintenance of the facility, and environmental issues. The synthesis includes discussions of existing standards and practices related to toll facility design, including plaza and roadway geometrics, lane configuration, electronic toll collection, capacity, access, communication, safety and security, signing, pavement markings, and new technology.

To develop this synthesis in a comprehensive manner and to ensure inclusion of significant knowledge, the Board analyzed available information assembled from numerous sources, including a large number of state highway and transportation departments. A topic panel of experts in the subject area was established to guide the research in organizing and evaluating the collected data, and to review the final synthesis report.

This synthesis is an immediately useful document that records the practices that were acceptable within the limitations of the knowledge available at the time of its preparation. As the processes of advancement continue, new knowledge can be expected to be added to that now at hand.

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This study was managed by Sally D. Liff, Senior Program Officer, who worked with the consultant, the topic panel, and the Project 20-5 committee in the development and review of the report. Assistance in topic panel selection and project scope development was provided by Stephen F. Maher, Senior Program Officer. Linda S. Mason was responsible for editing and production, assisted by Beth Rosenfeld. Cheryl Keith assisted in meeting logistics and distribution of the questionnaire and draft reports.

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TOLL PLAZA DESIGN

SUMMARY

For centuries, tolls have filled gaps in funding for the construction, maintenance, and rehabilitation of roadways. Public sentiment, for the most part, has been in opposition to such use taxes, arguing for a common right of passage or that tolls represent double taxation.

The single element that distinguishes a toll facility from a publicly financed road, bridge, or tunnel is a toll plaza. Although toll facilities use similar methods of toll collection, each has its own identity. This identity is directly linked to the facility's toll plaza, type of toll system used, plaza location, toll booth and lane configurations, and architectural treatment.

With renewed interest in toll facility construction and renovation and with customer demand for improved services, an assessment of toll plaza design practices was undertaken. The assessment focused on identifying current toll plaza design features, their functions, design criteria, and future needs. By understanding design features, planners and designers may achieve increased efficiency, safety, and economy of toll plaza construction and operation.

An extensive literature and standards search revealed that no general standards exist. The only standards are those developed by individual toll operators, based on their years of experience through improvements or expansion of their facilities. Thus, design practices associated with the following elements vary among facilities and operators:

- Horizontal alignment
- Lighting
- Toll plaza design (toll islands, lanes, booths, and canopies)
- Toll lane configurations
- Placement of in-lane toll equipment
- Pavement markings
- Signing.

Even the configuration of toll collection methods within a toll plaza is unique, linked to customer demands, the toll rate schedule, and the type of toll system.

Although collection methods remained basically unchanged during the last century (i.e., a motorist must stop at a toll booth and render payment), automated collection methods were adopted in the mid to late 1960s. With new technology available in the 1980s, applications of electronic toll collection (ETC) have gained popularity. ETC offers

speedier processing, reduced congestion, lower toll collection costs, improved air quality, and reduced aggravation voiced by patrons over conventional toll payment methods.

In April 1994, a survey of 60 toll operators from across the country was conducted in cooperation with the International Bridge, Tunnel, and Turnpike Association (IBTTA) to ascertain what standards are applied to toll plaza design. Responses were received from 25 operators, who provided information on 45 of the 58 facilities they operate. These facilities represent more than 3,100 mi (4988 km), or 60 percent of the total miles, of toll facilities in the United States. Respondents provided a brief description of the facility, design standards used, and design criteria associated with the following:

- Alignment
- Pavement type
- Lighting
- Drainage
- Environmental issues
- Safety devices
- Canopy characteristics
- Toll booth design
- Toll equipment
- Lane capacity
- Payment methods
- Accessibility
- Traffic control
- The plaza administration building
- Signing
- Toll lane configuration
- Operations
- Enforcement.

The survey indicated little consistency in design features, particularly for toll plaza elements such as toll islands, booths, clearances, and canopies. Also, no definitive correlation could be drawn between plaza horizontal geometry and American Association of State Highway and Transportation Officials (AASHTO) or *Manual on Uniform Traffic Control Devices* (MUTCD) design guidelines. Even lighting levels for transition areas and toll lanes, although typically above those cited for use on approach roadways, overhead signing, and pedestrian facilities, varied widely, as did the placement of in-lane toll equipment. In addition, consistent criteria for gauging the capacity of toll lanes and the level of performance by method of collection and toll rate were not apparent.

Of the toll facilities represented in this survey, 31 were bridges, 5 were tunnels, and 22 were roads. Sixteen were built before 1940; 25 were constructed between 1940 and 1969. Only 11 were constructed in the past 25 years. Of these facilities, 27 are closed systems, 3 use a combination of closed and open systems, and 5 are operated as ticket systems. Forty-six percent of all the facilities that responded to the survey use automated collection machines (ACMs); 16 percent use operator-issued credit cards, most for use by commercial carriers; and 34 percent have an ETC system. Since 1990, the toll plazas at 13 of the 45 facilities were renovated or expanded.

Responses from 35 of the toll operators indicate that some of them rely on widely available professional standards or guidelines for drainage and pavement design and building and electrical codes. However, in terms of plaza geometries (e.g., transition lengths and tapers, toll lane clearances, toll island design, in-lane toll equipment use and placement, signing, pavement markings, lighting, toll booth design, and lane signals), the standards followed are those of individual operators and equipment manufacturers. The standards differ not only among operators but also among the various facilities of one operator and are, for the most part, unique to the facility and the toll operator.

For example, one factor in setting plaza horizontal alignment is the toll lane "envelope" (i.e., the combined width of the toll lane and toll island). Given the toll lane envelope, the number of toll lanes, the site, approach lane geometries, median or barrier width, and plaza configuration, the basic criteria for setting the horizontal plaza geometry can be established.

Survey responses indicate that the typical toll lane width varies from 9 ft (2.7 m) to 12 ft (3.6 m). Sixty-three percent have widths between 10 ft (3.0 m) and 10.5 ft (3.1 m), with a weighted average of 10.9 ft (3.3 m). These widths tend to be skewed because of the age of the facilities and the fact that most of the traffic using these facilities consists of passenger vehicles (two-axle, four-tire). According to toll operators, widths in this range help slow traffic and force the motorist closer to the collector or ACM basket. With wider lanes, drivers tend to pull further to the right, away from the collector or basket. However, operators also note that where heavy truck traffic exists, a minimum width of 10.5 ft (3.2 m) and preferably 11 ft (3.4 m) is necessary to keep the large side-mounted rearview mirrors on truck cabs from hitting the toll booth or the collector's door windscreens.

No conclusions could be drawn regarding the basis for the various designs of toll islands other than the functional intent of the placement of the components. The design of the island is a product of the toll lane equipment, location, size of the booths, presence of a tunnel stairwell, extent of truck traffic, and plaza configuration.

The width of the toll island is determined by the size of the toll booth and the established lateral clearance between the faces of the island curb and the booth. The overall toll island width for most of the facilities is between 6 and 7 ft (1.8 and 2.1 m), with some as wide as 10 ft (3 m) and as narrow as 4 ft (1.2 m). In addition to design, access, operation, and safety concerns, the toll facility operators noted issues related to air, noise, and water quality.

Given the toll industry's interest in ETC for addressing these issues, some efforts are being made by the American Society for Testing and Materials (ASTM), Institute of Electronics and Electrical Engineers (IEEE), Intelligent Transportation Society of America (ITS), International Organization for Standardization (ISO), and IBTTA to develop design standards and a protocol for implementing ETC. Efforts also need to address the method of toll processing and auditing to provide consistent revenue control and administration of customer accounts.

With the help of public-private partnerships, with added impetus toward toll facility construction and ETC methods, consistency in design and collection methods of new toll facilities can help create an almost seamless transition among facilities. Moreover, enhanced operating efficiency and safety could promote greater public acceptance of toll facilities as an alternative to tax-based construction and maintenance of our transportation infrastructure.

CHAPTER ONE

INTRODUCTION

With rising construction costs, growing environmental concerns, and constrained rights-of-way, particularly in more densely populated urban areas, future highway construction opportunities are limited. In 1989, a study by the public, private, and academic communities, Mobility 2000, concluded that more efficient use of our transportation infrastructure must be considered in dealing with increasing urban congestion and declining air quality. The federal and state governments recognize that if our economy is to continue to thrive and compete in a global market, our transportation infrastructure must be improved, maintained, and made more efficient.

In response, Congress adopted the Intermodal Surface Transportation Efficiency Act (ISTEA) in 1991. Under this legislation, the concept of public-private partnerships, including financing options, technology development and deployment, and assistance with operation and maintenance, was fostered to facilitate the reconstruction and improvement of our transportation infrastructure. Moreover, federal funds were made available for the construction and rehabilitation of toll facilities and conversion of existing facilities to tolls. Thus, projects funded by a combination of federal and state matching funds, private investments, developer fees, and toll revenues are emerging. Once again, toll revenues are supplementing traditional tax revenue as a resource to help refurbish our nation's roadway and bridge infrastructure, to ensure its maintenance, and to provide for construction of vital new links.

Although toll facilities—bridges, tunnels, and roads—have been part of our nation's culture since the late 17th century and part of other nations' cultures for centuries before, little published information is readily available on the most essential and distinguishing element of a toll facility—the toll plaza.

Simply defined, toll plazas are designated areas strategically placed along or on the entry to or exit from a toll facility, where patrons pay for passage. Each toll plaza has a unique design, particular to the operating agency. Typically, the design is a product of the method of operation, physical constraints, and traffic demands of the facility and usually is based on engineering judgment and operator standards.

With a renewed emphasis on toll-financed road facilities, a synthesis of current practices in toll plaza design has been assembled to serve as a guide for both designers and operators. It is hoped that such insights into the operating features, geometries, and design criteria currently applied to toll plazas will help provide safer, more efficient, and cost-effective facilities in the future. Moreover, adopting consistency in design in areas such as signing, lane designation, and layout may facilitate motorist acceptance and use of toll facilities as they become more a part of our lives.

Toll collection has not changed drastically in the past century. As in the past, it is driven by economic forces and technological developments to improve the speed and accuracy of the collection and auditing processes, by political pressures, and by the current social environment.

A glossary of terms and list of acronyms and abbreviations frequently used by the toll industry is presented before the appendices. The glossary is intended to provide a common definition of terms for this synthesis.

WHAT IS A TOLL PLAZA?

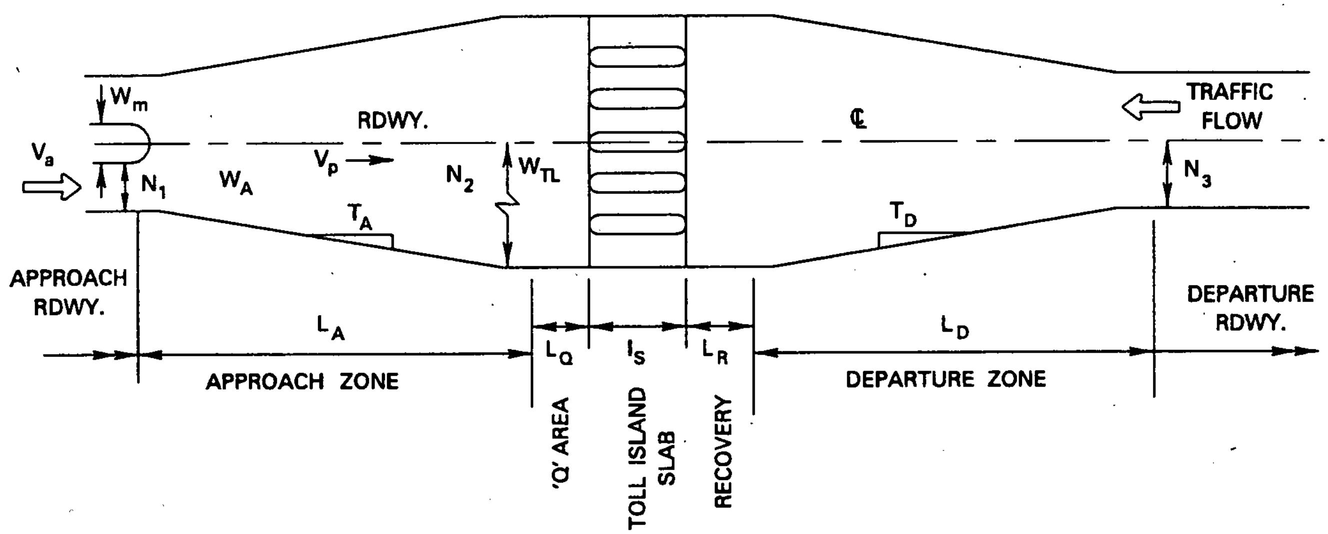
The modern toll plaza is frequently referred to by the media, the public, and even designers as toll lanes, toll gates, toll barriers, and toll booths. Actually, a toll plaza is all of these. However, for the purpose of this synthesis, a toll plaza is defined as the area where tolls are collected. This area starts where the approach roadway pavement widens, continues through the toll barrier or collection point, and ends where the pavement returns to the normal roadway cross section. Where no pavement transitions exist, the physical limits of a toll plaza are defined by the beginning of the approach to the toll island, ending beyond the physical terminus of the toll island. Figure 1 illustrates a typical toll plaza, defining various areas or elements that constitute a plaza. These areas typically include the approach (transition) zone, the queue area, the toll island or barrier, a recovery area, and the departure (transition) zone. In addition, the plaza encompasses all advance toll plaza–related signing and transitional lighting.

TOLL PLAZA CONFIGURATIONS

During the past 50 years, several basic toll plaza configurations have evolved. The configurations are largely determined by traffic demand, the type of toll system, methods of toll collection, the toll rate schedule, and the physical and environmental constraints of the site. Figure 2 depicts some common toll plaza configurations: a two-way barrier, a split barrier, and express/high-occupancy vehicle (HOV) lanes with conventional off-line toll plazas.

TOLL PLAZA CATEGORIES

In general, toll plazas fall into two categories: mainline and ramp. Both can be designed to handle one-way or two-way toll collection. The mainline plaza is a toll lane or series of toll lanes running perpendicular to the traveled roadway. The main-



V_a – Roadway Approach Speed (Posted)
V_p – Plaza Speed (Posted)
N_1 – Number of Approach Travel Lanes
N_2 – Number of Toll Lanes (Under normal conditions in approach direction)
N_3 – Number of Departure Travel Lanes
W_m – Width of Highway Median (If divided)
W_A – Width of Approach Travel Lanes including Shoulders
W_{TL} – Total Width of Typical Toll Lanes (N_2)
T_A – Approach Taper
T_D – Departure Taper
L_A – Length of Approach (Transition) Zone
L_Q – Length of Tangent Queuing Area /Approach Measured between Transition zone and toll island slab
l_S – Length of Toll Island Slab
L_R – Length of Departure (Slab)/Recovery Zone
L_D – Length of Total Departure (Transition) Zone

REFER TO APPENDIX C FOR TOLL OPERATOR SURVEY RESPONSES

FIGURE 1 Toll plaza terminology.

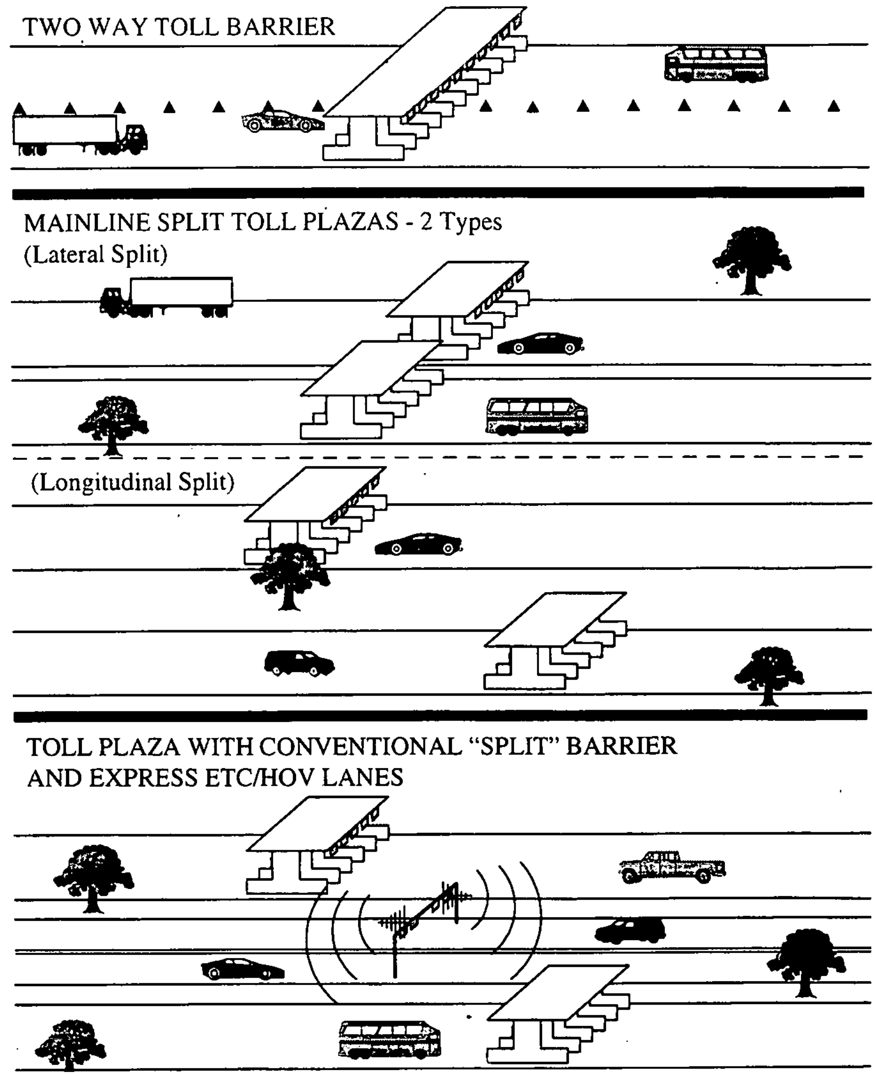


FIGURE 2 Typical toll plaza configurations.

line plaza is primarily used at bridge and tunnel facilities, although this design is sometimes used, alone or in conjunction with ramp plazas, on toll roads. The selection of toll plaza configurations depends on the toll system that is adopted.

Both mainline and ramp plazas can have a split design (i.e., two individual plazas, each serving different directions of travel, usually to reduce the right-of-way required or to fit available space). However, this design eliminates the possibility of using the centermost lanes to collect tolls in either direction, a practice referred to as reversible-lane operation. This practice is frequently used where there are directional traffic peaks at a conventional two-way plaza. A variation of the split plaza concept that recently has been introduced is the deployment of median HOV bypass lanes or express electronic toll collection lanes, with a toll plaza placed on either side of or between the express lanes. The express lanes are or will be tolled electronically, such as those on E-470 in Denver, Colorado; those on the Foothill Transportation Corridor, the San Joaquin Hills, and the Eastern Transportation Corridors in Orange County, California; and those authorized by the Oklahoma Turnpike Authority.

BASIC TOLL PLAZA ELEMENTS

Whether designing a toll facility with a single toll booth serving both directions of travel, such as the facility on the Grosse Isle Bridge in Michigan, or a multilane mainline plaza, such as on the Sam Houston Tollway in Texas, certain basic elements are common to many conventional toll plazas:

- A toll collection point (typically with a booth or automatic coin/ticket machine in each lane),
- Toll islands, and
- A canopy or protective overhang.

Although there is a stark contrast between the toll plazas of the 1950s, as represented by the Garden State Parkway Raritan toll plaza (Figure 3), and the E-470 toll plaza completed in 1991 (Figure 4), the basic elements remain constant.

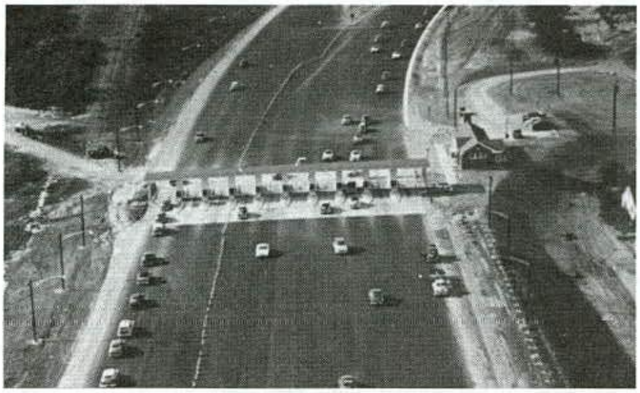


FIGURE 3 Garden State Parkway Raritan toll plaza circa late 1950s (New Jersey Highway Authority).

FIGURE 4 E-470 toll plaza, Denver, Colorado (E-470 Highway Authority).

ORGANIZATION OF SYNTHESIS

Following this introduction, chapter 2 presents a detailed description of the factors that affect toll plaza design. The specific practices of toll facility operators who responded to the survey (Appendix A) are discussed in chapter 3; the effects of increased electronic toll collection are described in chapter 4; and conclusions drawn from the research conducted for this synthesis are presented in chapter 5. A glossary and list of acronyms and abbreviations follow. Responses to the survey are provided in Appendix B. Data provided by survey respondents on plaza layout are displayed in Appendix C, data on toll lane approach elevation in Appendix D, data on toll island types and configurations in Appendix E, and data on toll lane equipment configuration in Appendix F.

CHAPTER TWO

FACTORS AFFECTING TOLL PLAZA DESIGN

The design of a toll plaza is determined by traffic demand, customers, types of toll systems, methods of toll collection, toll rate schedules, and plaza location. These factors dramatically affect the configuration, size, and layout of the plaza. In addition, operation and maintenance of the plaza and its staffing are functions of the collection methods and toll system choice. These factors help define spatial needs for plaza support facilities.

Aside from quantifiable factors, a number of functional issues dictate toll plaza design:

- Capacity options,
- Environmental issues,
- Enforcement,
- Security,
- Accessibility, and
- Configuration of payment methods.

TRAFFIC DEMAND AND THE CUSTOMER

When considering the design of a toll plaza, not only must volume, the nature, and makeup of demand traffic be considered, but also the profile of the customer. For example, on any interstate facility, there typically is a large percentage of first-time and infrequent users and commercial traffic. In contrast, in an urban corridor, the majority of traffic comprises commuter and local business on weekdays and social and recreational trips on weekends. In any case, each customer's toll charge, method of payment, and familiarity with the payment methods and toll systems may differ substantially, particularly if the facility serves visitors from other areas where toll facilities are less prevalent.

Thus, when designing a toll plaza, it is essential to know not only peak traffic demand, including vehicle mix, but also trip purpose and nearby land use, particularly where special traffic generators, such as sports arenas, are nearby. These facilities tend to generate unusual peak traffic demands. A profile of daily, weekend, and holiday users should be developed. The traffic profile should include hourly volumes, frequency of use, and traffic classification. This information is vital in determining methods of collection, lane configurations for payment, and, ultimately, the number of toll lanes needed. If an hourly profile is not feasible, peak hour or peak traffic demand estimates for the design year—typically projected for 20 years from the start of design—can be used.

TYPES OF TOLL SYSTEMS

There are primarily two types of toll systems: open and closed. The closed toll system can be subdivided into the following:

- A closed cash system, such as that used at bridges and tunnels and on sections of the Garden State Parkway in New Jersey and the southern and northern sections of the Florida Turnpike System; and
- A closed ticket system, such as that used on the New York State Thruway, New Jersey Turnpike, Pennsylvania Turnpike, and the central section of the Florida Turnpike System.

Open Toll System

An open toll system is one in which not all patrons are charged a toll. Typically, such a system is used in an urban area where local traffic is permitted to travel free, while through traffic is charged. In such a system, the toll plaza generally is located at the edge of the urban area, where a majority of long-distance travelers are committed to the facility, with a minimum likelihood of switching to a parallel free route, or at the busiest section of the tollway.

Closed Toll System

In a closed toll system, patrons typically pay their share of the facility's operating and maintenance costs, plus debt service based on miles of travel on the facility and type of vehicle. Thus, there are no "free-rides." In a closed ticket toll system, plazas are located at all entry and exit points, with the patron receiving a ticket upon entering the system. Upon exiting, the patron surrenders the ticket to the collector and is charged a prescribed fee from the point of entry to the point of exit, based on the vehicle's classification and distance traveled.

With a closed cash system, the premise is similar except that a cash toll typically is paid upon exiting and at strategically placed mainline plazas along the toll road. This toll also is based on vehicle class and density as well as the average vehicle miles traveled. A bridge or tunnel facility toll plaza usually is defined as a closed cash toll system because all users are charged a toll either in both directions or one way. In the one-way configuration, the toll usually is twice the two-way charge because the patron usually has little flexibility in selecting an alternate free route.

The major differences between the open and closed systems are operating cost and the initial investment in toll plazas. The closed system, whether ticket or cash, has more collection points and more collectors than an open system. Depending on the amount of automation, the closed cash system can have a lower operating cost than a system that is ticket based. Also, the processing rate for a cash transaction versus payment of a ticket is generally quicker, resulting in greater toll lane throughput.

The closed ticket system has the advantage of requiring just two stops—one on entering and another on exiting the system. In an open system, again depending on the length of the trip, the motorist may encounter several collection points. The ticket system's major disadvantage is interchange construction cost and right-of-way. For efficiency and savings in toll plaza operations, entry and exit lanes usually are consolidated into a single plaza requiring construction of a trumpet interchange at intermediate exit and entry points. Such a design usually is more costly, because of the area required and the necessity for structures to bridge the main roadways, than slip and loop ramp designs, commonly used in a cash or open system.

METHODS OF TOLL COLLECTION

Until the late 1980s, there were primarily two methods of toll collection—manual and automatic. The method a patron chooses depends on his or her familiarity with the toll facility, frequency of use, and availability of exact change.

Manual Collection

Manual collection requires a toll collector or attendant. Based on vehicle classification as defined by the facility's toll schedule, and usually classified by the collector, a cash toll is received by the collector. The collector, who also makes change, may accept and sell scrip, tickets, coupons, or tokens issued by the agency or allow the customer to charge the toll using an agency-issued magnetic strip credit card (mag card). Mag card accounts, such as those issued by the Massachusetts, Pennsylvania, and Florida Turnpike authorities, usually are issued to large commercial carriers.

Automatic Toll Collection

Automatic toll collection is based on the use of automatic coin machines (ACMs), which were introduced to the toll industry in the early 1960s. ACMs can accept both coins and tokens issued by the operating agency. The coins and tokens are discretely counted by their weight and size (diameter and thickness) and, in some ACMs, by metallic composition. Some ACMs manufactured by French and Japanese firms accept payment by paper currency, through the use of bill readers, and provide change.

Depending on the toll rate, the use of automated coin or token collection instead of manual collection reduces transaction and processing times, as well as operating costs. ACMs are more efficient than manual collection methods at locations where the exact cash toll is less than one dollar and where tokens are used. According to Florida Turnpike authorities, ACM use diminishes as the toll increases to more than 50 cents because the processing time increases incrementally as more coins and tokens must be processed.

ACMs usually are installed in a toll lane designated for a particular vehicle class. However, if mixed vehicle usage is permitted, as on the Garden State Parkway, which permits buses to use token lanes, the difference in vehicle type and the charge is registered by height sensors. The Atlantic City Expressway in southern New Jersey permits trucks to use its unattended exit ramps by setting aside separate passenger vehicle and truck toll lanes. Each lane is equipped with an ACM, with a prescribed toll payment. A height clearance restrictor prevents trucks from using the lower cost passenger vehicle lanes.

In Canada, a combination manual and automatic lane is used frequently. Here, the collector makes change and exchanges currency. The patron then deposits the toll in the ACM basket. This system is basically self-auditing, allowing for little error in daily toll lane receipts, but is less effective in terms of operating cost savings and throughput. Many toll facilities, such as those on the Garden State Parkway and the Florida Turnpike, frequently are equipped for multiple toll collection options. This arrangement permits the toll supervisor to better accommodate different patron and traffic demands and minimizes staffing costs.

Electronic Toll Collection

Electronic toll collection (ETC), originally referred to as automatic vehicle identification (AVI), entered the toll arena around 1986 as a demonstration test on the Dallas North Tollway, the Metropolitan Transportation Authority (MTA) Bridges and Tunnels in New York (formerly the Triborough Bridge and Tunnel Authority), the Verrazano Narrows and Triborough Bridges in New York, and the San Diego–Coronado Bay Bridge. ETC is a system that automatically identifies a vehicle equipped with a valid encoded data tag or transponder as it moves through a toll lane or checkpoint. The ETC system then posts a debit or charge to a patron's account, without the patron having to stop to pay the toll. The first revenue application of ETC began in January 1989 on the Crescent City Connection in New Orleans, followed by the Dallas North Tollway in June 1989. Earlier versions based on optical scanners existed as early as 1973 on Delaware River Port Authority bridges and later were replaced by laser bar code scanners.

It is postulated that ETC increases toll lane throughput because vehicles do not need to stop to pay a toll. ETC enhances auditing capability and toll enforcement, while reducing operating costs. The system uses an electronic tag or transponder, which is mounted on the vehicle and powered by an internal or external source, depending on the application and manufacturer. A unique patron identification number encrypted in the device is read by a radio frequency/microwave or surface acoustic wave antenna/reader mounted in the toll lane. The patron's ID usually is compared with a listing of valid and invalid numbers stored in the lane controller or plaza computer, which is periodically updated by the system. If the patron's account is valid, the account is debited by the toll charge for the class of vehicle to which the device has been assigned. The patron account balance is maintained either in a centralized banking database or clearinghouse, much like a credit card account, or directly in the tag/transponder.

The latter process is similar to the transit debit fare card used by the Washington, D.C., Metrorail and the New York City Transit Authority. To enroll in an ETC system, patrons must establish an account with the operating agency, which requires initial funds to be placed in the central account or on the transponder directly. These funds are then replenished automatically at a predetermined threshold by direct credit card or bank account withdrawal or by cash payment—this is referred to as a prepaid account. The other option in a centralized system is to submit monthly invoices to the patron—this is known as postbilling.

The use of ETC focuses on expediting toll payment, thereby decreasing congestion and delays at toll plazas and reducing agency toll collection costs. However, increases in vehicle throughput depend on whether ETC is available in mixed-use toll lanes (i.e., in conjunction with manual and automatic methods of collection) and in dedicated lanes. Dedicated lanes may use existing toll lanes through a barrier designated for low-speed ETC pass-through only. Another form of dedicated ETC lanes is express lanes. Here, ETC-equipped vehicles are read and tolled at collection points along designated mainline travel lanes at prevailing highway speed. These lanes bypass the typical toll plaza, such as on E-470 and on California's Orange County Transportation Corridors.

Throughput in an express lane is limited by the capacity of the travel lane, ETC market penetration, and use during peak traffic periods. ETC throughput at existing toll plazas is somewhat constricted by vehicle operating speeds in the dedicated lanes, differences in toll payment methods in mixed-use lanes, downstream capacity constraints, and the location of the lanes with respect to plaza queues, which may block access to them. More information regarding ETC systems can be found in *NCHRP Synthesis 194: Electronic Toll and Traffic Management Systems,* published by the Transportation Research Board.

LANE CAPACITY

Capacity is a subjective description for maximum lane throughput. Toll authorities measure capacity in terms of the maximum number of vehicles that can pass through a toll lane. A study conducted by the Virginia Transportation Research Council for the Virginia Department of Transportation in 1990 developed capacity values based on the premise that a toll plaza creates an interrupted vehicle flow. In Virginia, therefore, vehicle density in the approach zone of the plaza is defined as an appropriate measure of capacity (*1*). On toll facilities in other states, such as facilities on the Garden State Parkway, capacity is defined by queue length and average vehicle delay. The delay values were adopted from signalized intersection level of service (LOS) criteria presented in the 1985 *Highway Capacity Manual* (HCM) to establish an acceptable LOS (2).

The authors determined that optimum throughput is achieved when there are eight vehicles per lane in queue waiting to be processed. Based on lane throughputs for the various collection methods, an acceptable delay for design is equated to be no more than 40 sec per vehicle. This value is equivalent to an HCM LOS "D," which is the accepted value for a signalized intersection approach design in an urban area. For a more suburban or rural area, LOS "C" is considered acceptable.

Another method for determining lane capacity for manual and automatic collection methods is presented in the Illinois Tollway's *Toll Plaza Design Manual,* dated July 15, 1991. This method was based on a study for optimization of toll plazas prepared for the authority, which relies on design flow rates. These rates are predicated on observed service or processing time distributions, using cumulative distribution functions to arrive at average and standard deviations of service time. To account for variations in the lateral displacement of traffic to extreme left and right toll lanes at a toll plaza, a lateral distribution coefficient is applied. This coefficient is based on the efficiency of extreme left and right toll lane throughputs, compared with similar, more directly accessible lanes.

The process relies on the selection of a throughput design percentile (Illinois uses 50 percent for manual lanes and 70 percent for automatic lanes). A series of nomographs based on the number of approach lanes are used to determine the "percentage of manual captives," which is based on the percentage of commercial traffic, manual lane users (all vehicles), and passenger cars in the manual lanes. From these factors, the number of required manual and automatic lanes or gates is estimated (*3*). An example is presented in Figures 5a and 5b.

Studies of toll lane capacity typically have been related to the method of collection. However, there are a number of nonquantifiable factors that lead to substantial variations in the processing rates for toll lanes with the same toll payment methods. The following factors were evident from a study conducted for the New Jersey Highway Authority in 1991 and 1992 on optimizing toll collection at its mainline plazas (*9*, p. 4):

- A driver's familiarity with the toll facility
- Methods of payment available and the amount of the toll
- Size of the toll plaza with respect to the line of sight or decision sight distance
- Space available for making adjustments in toll lane selection and traffic queues encountered
- Differences in patron profiles (e.g., commuters versus recreational users) and their preferences for methods of payment
- Proximity of adjacent exit and entry ramps to a mainline toll plaza
- Adequacy and conciseness of plaza informational signing to help the patron make advance decisions
- Attitude and efficiency of individual toll collectors
- Geometries of the plaza approach transition area
- Placement of toll collection methods among lanes or lane configuration and the number of toll lanes
- Recognition of the status of each lane by the driver, particularly at night or during periods of impaired visibility
- Extremes in weather.

STAFFING

Staffing of a typical toll plaza is a function of the number of manual toll lanes operated during various times of the day and

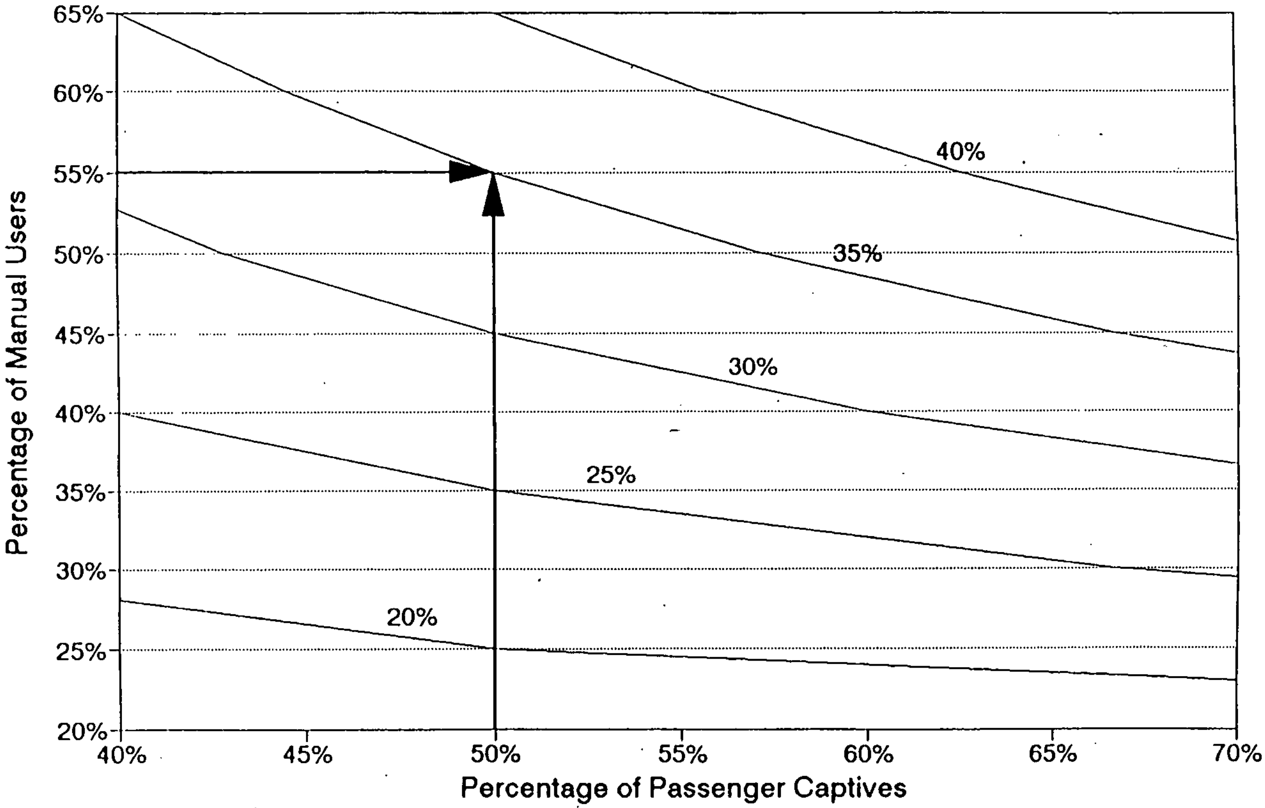


FIGURE 5a Percentage of manual captives (*15*, p. 17).

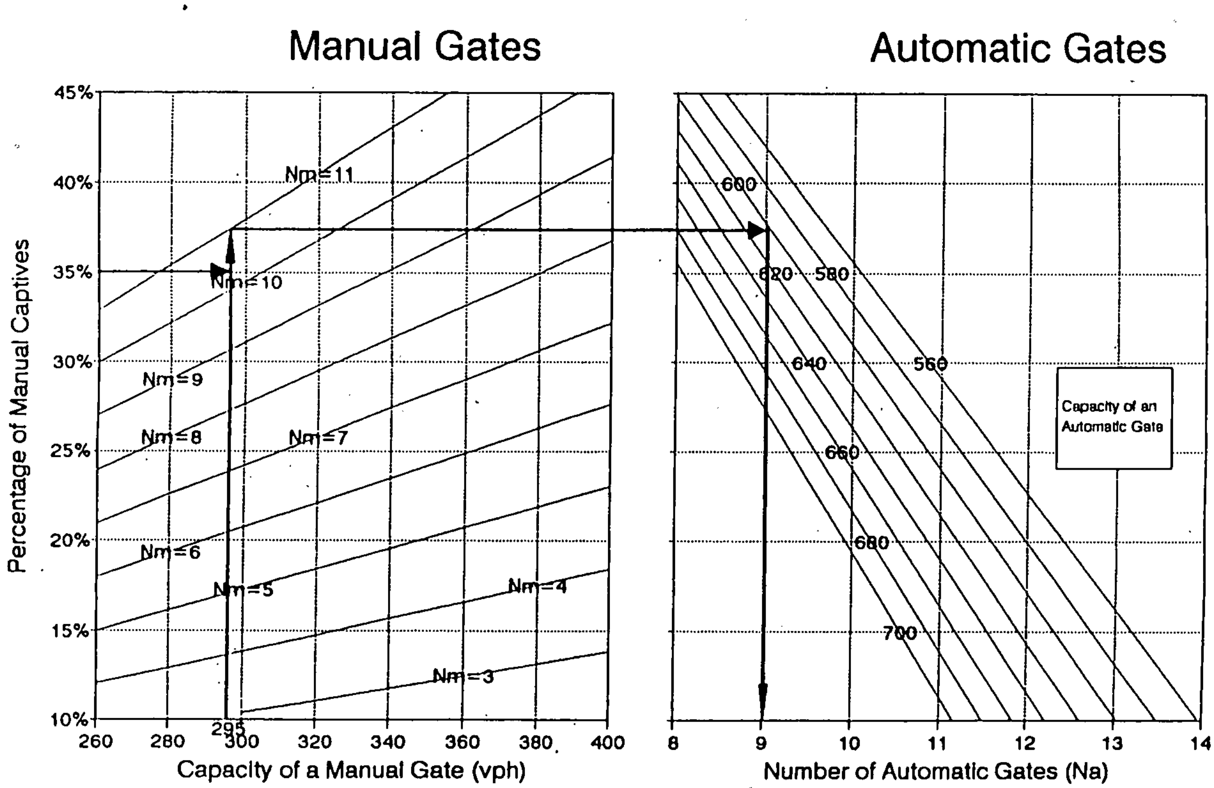


FIGURE 5b Determination of the number of manual and automatic gates (*15*, p.18).

other toll operations requirements, including the collector's tour of duty in a lane, relief practices, and plaza supervision. Toll operations is responsible for collecting tolls, verifying revenue collected, and reconciling tolls after each shift with axle and vehicle count records. Depending on the type and size of the facility, a number of functions besides toll operations need to be considered to determine the size of toll plaza support facilities. For a stand-alone plaza/facility, these functions generally reside with toll operations at the plaza.

Administration

Administration is responsible for personnel matters, purchasing for the facility, and overall operation and maintenance of the facility.

Finance

Finance performs general accounting—payroll and budget, verification of daily toll receipts and traffic, and preparation of bank deposits.

Maintenance

Maintenance is in charge of keeping the buildings, toll plazas, grounds, and toll equipment in safe and good operating condition. This includes the mechanical, communications, electrical, electronics, and computer components at the toll plaza. However, in certain instances, maintenance may be handled by a contractor.

Security

Security falls into two categories—toll security and plaza security. Typically, security measures are accommodated through the deployment of surveillance cameras, access devices, and intrusion detection alarm systems. Some large facilities, such as those operated by the Delaware River Port Authority, employ toll security personnel who also monitor the toll lanes and sensitive areas in the toll plaza building, such as the collector's count room, the banking room/vault areas, and loading docks, by using closed circuit television. On the Florida Turnpike, this function is handled by supervisory personnel. In addition, police may be stationed at toll facilities to provide general security. Their presence largely depends on the area in which the facility is located, the agency's practices and organizational structures, and the size of the facility/plaza.

PLAZA LOCATION

The location of a toll plaza is determined by the type of toll system. In a closed ticket system, plazas are located at each point of entry and exit. In a closed cash system, plazas are located at ramp entry and exit points and along the mainline, and a mainline plaza is used at bridge and tunnel facilities. In an open system, mainline and ramp plazas are strategically located primarily to intercept through traffic and are placed where a majority of this traffic is least likely to divert to alternative free routes.

The plaza should be accessible to and from the toll facility's mainline plaza or from a local road adjacent to the mainline or a ramp plaza. This will facilitate access by personnel and reduce their round-trip travel. Moreover, it is preferable to locate a plaza where it has easy access to public utility connections to provide improved system integrity and to facilitate construction. The plaza should be located away from residential areas and other sensitive air and noise receptors and where lighting spillover may be adversely received. The majority of facilities are located on a tangent segment of roadway or on a gentle curve with adequate sight distance for the roadway design speed.

The selection of a site involves a number of design decisions and revenue considerations. These include the following:

- Available rights-of-way
- Topography
- Environmental concerns and impacts
- Feasibility of potential abatement measures
- Number of toll lanes and methods of toll collection
- Space for potential reversible lane operation and roadway transitions
- Support facilities such as a plaza administration or utility building and parking for employees.

As discussed earlier, these factors also determine plaza configuration options.

TOLL RATES AND SCHEDULE

Toll rates posted in a toll schedule are based on many considerations, including the potential for traffic diverting to free roadways in the travel corridor, cost of the project, type of patrons, operation and maintenance costs, reserve requirements, and debt service coverage on bond principal and interest. The toll rates and schedule, in turn, dictate the methods of collection and, when compared with various peak traffic demands, determine the number of toll lanes to be provided.

For open and closed cash systems, toll rates usually are based on vehicle class and the number of axles. For audit purposes, classification equipment is placed in the toll lane to measure axle counts and determine vehicle separation to ensure that the proper toll rates are charged. In addition, some facilities, such as those on the Pennsylvania and Ohio Turnpikes, use vehicle profiling and weight for preclassification audit purposes. Other toll facilities, such as the Peace Bridge in Buffalo, New York, and the Detroit-Windsor Tunnel in Michigan, also use gross vehicle weight to set tolls for commercial vehicles. Such systems require special plaza designs, including longer toll lanes to accommodate beam scales or weigh-in-motion equipment, vehicle profilers, and separators.

Toll discount programs have been adopted in major urban areas to encourage ridesharing, thereby reducing congestion and improving air quality. Typical programs focus on high-occupancy vehicles such as car and van pools and transit vehicles. These programs use tickets, tokens, or ETC to facilitate processing. Based on discussions with New York State Thruway officials, the New Jersey Highway Authority, and the Delaware River Port Authority, ETC and token programs account for 50 to 90 percent of their typical weekday, peak commuter period toll payments(*2,4*).

Because toll rates may affect lane capacity, rates may be set based on optimizing lane throughput. For example, the use of automated coin collecting equipment becomes less efficient as the number of coins needed for toll payment increases. An unattended lane will achieve greater usage if the toll is in 25-cent increments versus 20- or 30-cent increments. Similarly, change can be made more quickly at a manual lane for a 75-cent toll versus an 80-cent toll.

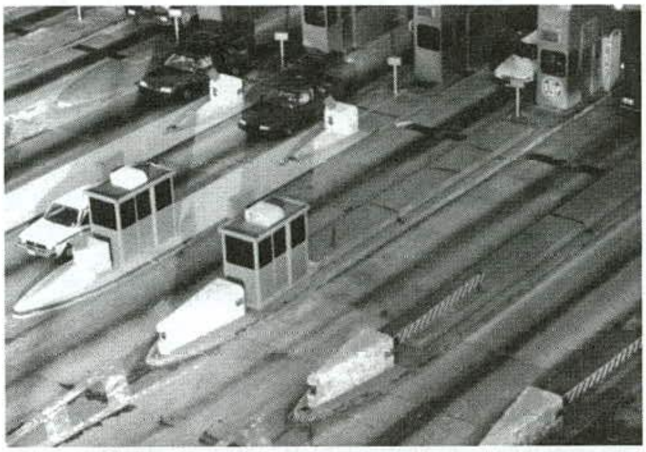


FIGURE 7 Tandem toll booth installation, Pennsylvania Turnpike Valley Forge interchange (Pennsylvania Turnpike Commission).

CONGESTION MANAGEMENT

When traffic demand exceeds the capacity or throughput of a toll plaza, excessive delays and adverse environmental impacts may result. This is a common experience with older facilities in developed urban corridors. For new toll plazas that are (1) in areas that lack sufficient rights-of-way, (2) very expensive to construct, or (3) confronted by environmental constraints, operational and innovative design measures have been successful in addressing capacity needs to manage demand and congestion. Such constraints can be overcome through the adoption of enhanced toll collection techniques, as discussed in the previous section, or by providing additional capacity.

Capacity constraints also can occur outside the normal facility design peak traffic hour as a result of special traffic generators or seasonal traffic demands, which usually render the peak period toll collection configuration inadequate. Several options can increase the capacity of the toll plaza, including reversible lanes, one-way tolling, tandem booths, and branch toll lanes. Three of these options are depicted in Figures 6 through 8.

FIGURE 8 Branch toll lanes, Garden State Parkway Bergen toll plaza. Note the branch toll lanes both before and after the mainline toll plaza (New Jersey Highway Authority).

FIGURE 6 Example of a one-way toll conversion, Walt Whitman Bridge toll plaza, Philadelphia, Pennsylvania. Tolls are collected in the direction of oncoming traffic in the photo; traffic going in the other direction pays no toll (congestion due to bridge construction).

Reversible Lanes

Reversible lanes have been used successfully at two-way mainline and ramp plazas, such as those on the Florida Turnpike and Garden State Parkway, and at two-way bridge and tunnel toll barriers where a permanent median barrier does not separate opposing traffic flow. To initiate reversible lanes, there must be a significant difference in the peak and off-peak directional traffic volumes. By using traffic cones or moveable barriers, additional capacity can be obtained by placing redundant toll collection equipment and lane use signs and signals in a requisite number of center toll lanes. The direction of collection is then reversed to accommodate anticipated peak traffic demand. The success of this reversal technique depends on adequate staffing and the proper balance of toll collection methods across the plaza. In addition, there must be sufficient room in the approach and departure transition zones to handle shifts in traffic approach and departure.

One-Way Tolling

One-way tolling is another option that has been successfully used by toll operators across the country, particularly at bridges and tunnels. One-way toll operations have been adopted successfully by the Port Authority of New York and New Jersey, MTA Bridges and Tunnels in New York, Delaware River Port Authority, Maryland Transportation Authority, Golden Gate Bridge Highway and Transportation District in California, and Florida Turnpike System. This technique is applicable to mainline plazas, primarily on bridge and tunnel facilities where alternative crossings are not available or are too distant to sustain appreciable toll diversions.

Similar to the reversible-lane concept, one-way tolling provides additional lanes in the selected direction. Toll lanes in the opposing direction are converted to process tolls on a permanent basis. The reversible-lane concept reduces the number of toll lanes and the accompanying cost of operations by decreasing toll collection staff. In addition, maintenance staff needed for changing traffic control devices is eliminated. Figure 6 depicts a typical one-way toll conversion at the Walt Whitman Bridge Toll Plaza in Philadelphia. The facility was converted to one-way tolling westbound (in the direction of the photo). Thus, six toll lanes in the eastbound direction were made toll free, providing 16 toll lanes for use during the morning westbound commuter peak.

Tandem Toll Booths

The concept of tandem toll booths, which was adopted in 1981 at the Golden Gate Bridge, involves the use of two manual toll booths placed in line in the same toll lane, permitting simultaneous processing of two vehicles. The intent of the technique according to a study undertaken by the Golden Gate Bridge Highway and Transportation District was to reduce the headway time between vehicles in a toll lane, thus reducing the processing rate per vehicle (*5*). This concept, shown in Figure 7, also has been used on the Pennsylvania Turnpike and Florida Turnpike.

Headway time is measured from when a motorist has completed his or her transaction and begins to pull away from the toll collector's door to the arrival of the next vehicle. The Golden Gate Bridge study concluded that if the spacing between tandem booths is increased to permit more than one vehicle to be in the toll lane behind the leading toll booth, additional savings in headway time could be achieved. The theoretical increase in lane capacity using the tandem toll booth arrangement was estimated to be between 15 and 25 percent (*5*).

Branch Toll Lanes

Branch toll lanes were successfully introduced by MTA Bridges and Tunnels on its bridges in New York City around 1980. The concept primarily involves expanding the plaza's transition zones to construct two or three additional toll lanes, which are accessible by directing traffic through an inoperable toll lane in the main plaza—a feeder lane or a "host lane"—or by constructing a bypass lane to the left or right of the main plaza.

The New Jersey Highway Authority (NJHA) adopted the branch toll lane concept in 1990 and improved its design. The New Jersey Turnpike also adopted the use of branch toll lanes at its interchange with the Garden State Parkway (Interchange 11) in Woodbridge to speed peak AM commuter ticket distribution and commuter bus entry. The branch lanes provide the same methods of toll collection as the main plaza and, according to NJHA, a single host lane can accommodate up to 1,100 vehicles per hour to a two-lane branch and 1,600 vehicles per hour to a three-lane branch by using a bypass lane as the feeder lane. According to NJHA, a two-lane branch provides a 25 to 30 percent increase in lane throughput at the main plaza, compared with the throughput of a host lane that previously was operated as a conventional manual lane. Branch lanes have been installed on both the approach and departure sides of the main plaza, as shown in Figure 8, as well as on the left and right ends of a split barrier.

The main attribute of the branch lane concept is that plaza capacity can be increased with little or no widening for construction. Branch lanes also can be erected relatively quickly, at a fraction of the cost of widening the main toll plaza (*6*). Construction of branch lanes requires no additional rights-of-way and generally does not require environmental studies or approvals.

OPERATION AND MAINTENANCE

As described briefly in the section on staffing, decisions regarding operation and maintenance can affect toll plaza design, particularly in terms of spatial needs for support facilities. For example, in a plaza administration building, on-site banking (counting and wrapping money for deposit) might be eliminated in favor of direct bank pick-up and counting, including verification of coin/token vault and collector deposits.

For many new toll facilities, such as those on the Orange County (California) Transportation Corridors, E-470 (Colorado), the Coleman Bridge (Virginia), and the Central Artery/Tunnel Project (Boston), an operations and maintenance (O&M) design report was prepared for the facility's owner before the design process began. This report provides details on the systems and methods of operation and maintenance for all aspects of the project, particularly for toll collection. Thus, the organizational structure and staff, functional relationships, policies, operating procedures, systems, and toll collection methods are defined for the toll designers so that plaza location, lane configurations, toll equipment requirements, and attendant facilities can be assessed and developed to meet the needs of the operator. The O&M report is a "living document" that is updated during the design process and that later can be used as the basis for the facility's operations and maintenance procedures and policy manuals.

ENVIRONMENTAL ISSUES

Besides soil erosion, wetlands, and water quality issues that may be encountered during construction or expansion of a toll plaza, air quality is a major concern not only for compliance with the 1990 Clean Air Act Amendments (CAAA) but also as an occupational health and safety issue for employees. In addition, noise generated by toll plaza traffic and plaza lighting spillover must be considered in the design process.

Air quality modeling of various toll plaza configurations by Lovegrove and Wolf suggests that a design that creates an overlap in the high-emission departure zones is the least desirable configuration; a split plaza where the approach zones overlap is preferable (*7*). A recent study conducted for the Oklahoma Turnpike concluded that the adoption of ETC has lowered carbon monoxide (CO) concentrations in the highway's toll plazas by reducing queuing, idling, and acceleration and deceleration (*8*).

Exposure of the toll collectors to CO emissions also is a major consideration in the design process. Studies of typical air quality patterns in and around toll booths were first conducted for Washington state in 1972 at the Evergreen Point Bridge. The study concluded that CO exhaust emissions tend to concentrate in toll lanes as a result of acceleration and vehicle idling. To prevent such contaminants from being drawn into the toll booth, a positive ventilation system was devised and tested. The system draws fresh air from a source located away from the plaza and conditions the air before diffusing it into the toll booths, creating an outward pressure that blocks the contaminated air from entering the booth (*9*). Positive ventilation, or positive pressure airflow, systems are used at all new mainline plazas on the Florida Turnpike and at the Newport Bridge Toll Plaza in Rhode Island.

A unique approach for dispersing emissions from beneath a toll canopy was deployed on E-470 in Denver. The canopy (see Figure 4), which is designed to mirror the Rocky Mountains, is louvered to allow emissions to be vented up and out of the toll lanes. Monitors are located in the booths and the canopy to record CO levels. In addition, the use of express ETC lanes lowers CO concentrations in the E-470 toll plaza area (*10*).

Highway Noise

Highway noise is another sensitive environmental issue that requires analysis and mitigation. Such noise is a function of traffic volume, vehicle mix, speed, tire composition, pavement surface, grade and topography, wind direction, atmospheric conditions, and the location of sensitive receptors. Typically, where truck speeds increase, vehicles accelerate, and engines must work harder, noise levels increase (*11*). Noise walls, setbacks, berms, dense vegetation, and depressed roadway profiles and tunnel sections can reduce decibel (dB) levels so that they are acceptable to the receptor. The use of ETC in bypass lanes should further reduce dB levels at the source because of a decrease in vehicle acceleration.

Water Quality

Water quality usually is not considered a potential environmental issue by toll plaza designers. However, given the large expanse of pavement within a toll plaza and the heavy use and concentration of grime, dirt, and oil left by countless vehicle movements, a potential exists for a large amount of contaminated runoff to find its way into the plaza's drainage system. By considering traffic volume, the percentage of commercial vehicles, and the size of the plaza, the amount of oil, salt, and other contaminants can be estimated. Possible actions to treat contaminated runoff before it is discharged into local waterways or aquifers warrant assessment. Also, a somewhat overlooked source of contaminants is the periodic washing and flushing of the toll lanes, booth exteriors, and canopy ceiling performed as part of a maintenance program. The wash and rinse water become laden with contaminants from vehicle exhaust, drivetrains, brakes, and tires, as well as dirt, sand, and even salt that vehicles track into the lanes.

There are many simple solutions, including the use of settling basins, oil/water separators, and grassed drainage swales or buffer areas into which the runoff can be discharged. Such design treatments were not considered for most toll facilities constructed in the 1950s and 1960s. However, new facilities or improvements to existing ones must comply with current federal and state environmental regulations, which are more stringent and require treatment of runoff to maintain water quality. Treatment of this sort is widely used on new European highways. In Florida, all roadway runoff is directed to retention/detention areas.

LIGHTING

Roadway and Canopy Lighting

Because a toll plaza is an area of intense activity and decision, high levels of lighting are used to increase driver safety and awareness. Depending on the size of the plaza and its location with respect to residential and other sensitive receptors, various types of lighting systems need to be investigated to provide uniform coverage, eliminate harsh glare on approaching motorists, and reduce lighting spillover into surrounding areas. In the approach and departure zones, mast arm-mounted down lighting, back shields, and cobra lighting may be used to achieve these objectives. More intense canopy down lighting and booth lighting is used to help define the toll plaza and lanes for improved driver recognition. High mast lighting, which reduces the number of poles and therefore the number of obstructions, may be used effectively in open plaza areas. With proper shielding and aiming, high mast lighting may be used in urban areas.

Barrier and Plaza Hazard Lighting

Some facilities use warning and hazard lighting to increase driver safety and awareness, particularly where adverse atmospheric conditions are prevalent. For example, because the toll plaza at the Golden Gate Bridge is frequently shrouded by fog, flashing warning lights are used on the approaches to warn motorists of the impending toll plaza. Others facilities, such as the San Diego–Coronado Bay Bridge, use airport runway–type lighting in the pavement to illuminate the approach lanes during periods of poor visibility. Similarly, the Garden State Parkway uses strobe lights mounted on the toll canopy to illuminate its mainline plazas in areas prone to poor visibility. Other facilities, such as those on the Delaware Turnpike, use flashing yellow warning lights mounted on the approach to the toll island crash barrier to draw motorists' attention to the approaching toll plaza.

TOLL AUDIT—DETECTION AND ENFORCEMENT

With the advent of automated and electronic toll collection, the potential for increased toll violations has become a concern among toll operators.

Today, despite sophisticated audit systems, alarms, and even automatic gates, the problem still persists. The percentage of toll violations is almost impossible to gauge because such statistics are closely guarded by toll operators, who grapple with the problem almost daily. Recently, in planning and designing a new ETC toll enforcement system for the Garden State Parkway, estimates of 2 percent of the daily traffic using a plaza were recommended for sizing the data capture and storage requirements for the system (*12*).

Because the majority of violations occur in automated lanes during commuter and seasonal peaks and at unattended ramp plazas, the actual number of violations for a particular period may be much higher. Also, if a driver is unfamiliar with ETC and is not provided with clear lane use information, the problem is heightened. Such problems were experienced upon the opening of the Express ETC Only lanes on E-470 in Denver and the dedicated E-ZPass pass-through lanes used on the New York State Thruway. One method to alleviate this problem is the deployment of clear, distinctive signing using a combination of symbols, color, and a legend over the ETC lanes. These messages help alert motorists of the toll and help them identify toll lanes. Such signing adopted for the New York State Thruway to foster greater driver awareness is shown in Figures 9a and 9b.

FIGURE 9a Canopy-mounted changeable message sign, Tappan Zee Bridge toll plaza. Symbols, colors, and legends are used to inform motorists of lane payment methods (New York State Thruway).

FIGURE 9b Electronic toll collection (ETC) lane advance sign, Spring Valley Toll Plaza, New York State Thruway (informs motorists on location of E-ZPass lanes).

Numerous measures have been used to identify, detect, and prevent toll violations, including the following:

- Installation of audible alarms and flashing red lights atop island traffic signals. These devices are triggered when a vehicle that has entered a toll lane proceeds to exit the toll lane before the transaction is registered.
- Installation of automatic gates. These devices add approximately 1 to 1.5 sec to the vehicle processing rate and are actuated when a successful transaction is registered by the lane controller.
- Monitoring of toll transactions by means of one-way glass. This technique permits facility personnel and police to periodically watch transactions and record the license plate numbers of violators. The glass is installed in the booth above the ACMs. This practice is used on the Garden State Parkway.
- Stationing of police periodically at high violation areas.
- Publication of the names of chronic violators who have been prosecuted.
- Installation of surveillance cameras at high violation, unattended ramp locations.

All these methods of toll violation detection and enforcement have had some degree of success (known only to the toll operators). The duration of success varies by method. Some methods only have a short-term impact, such as a periodic police presence and publishing violators' names. Some operators believe that the use of automatic gates is the ultimate deterrent. However, toll gates are frequently seen as a cause of further delay by the public. Therefore, public pressure usually results in gate removal or nonoperation during peak traffic periods.

With the advent of ETC and in an effort to serve its patrons and protect the interests of its bondholders, toll operators have turned to video enforcement systems (VESs). These systems use high-resolution low-lux cameras or cameras equipped with strobe lights to record toll transactions in unattended lanes on a continuous basis or a still frame triggered when a violation occurs. The camera captures either a slow scan video, a still picture, or a computerized, enhanced photo of the vehicle's rear license plate. Depending on state legislation, which must be enacted to permit the use of such enforcement measures, a photo as simple as one that contains the vehicle's rear license plate may be admissible in court (New York state). Other jurisdictions may require a photo of the rear of the vehicle as well as the status of the patron fare indicator and island traffic signal at the time of the violation or a photo of the driver. Thus, the design of a VES is largely driven by legal requirements. The photos typically are time and date stamped and the toll plaza, lane number, and the nature of the violation are overlaid on the photo.

The use of VES is gaining wide popularity, particularly as part of dedicated and express toll lane installations for ETC. Although current technology extols the virtue of these systems, which are said to be capable of accurately recording license plates at highway speeds, some pitfalls still need to be overcome, including the following:

- The cost of additional equipment and staff needed to process violations captured by VES;
- Recording plates of vehicles following at extremely close headways, particularly when vehicle heights may be considerably different;
- Reading or imaging a plate that is dull, worn, covered with dirt, or otherwise obscured, particularly in regions prone to ice and snow;
- Accessing a database to identify violators; and
- Legislation to make the vehicle owner responsible for the violation unless the driver can be identified.

In addition to these issues, the problems encountered when using VES for commercial vehicle toll enforcement are more complex. For instance, the license plates on a tractor-trailer usually are different from passenger car plates, and, in many instances, tractor-trailers are registered to different owners and registered in different states. This problem is compounded when a number of plates are mounted on the rear of either or both units (a problem also encountered with long-haul buses). Therefore, the front plates on the tractor unit must be photographed.

If commercial vehicles are permitted to mix with private passenger vehicles in dedicated pass-through lanes, the commercial vehicle height and overall size can block a camera's line of sight to a passenger vehicle that may have triggered a violation. Similarly, in an express lane on a multilane facility where the cameras are overhead, a similar problem prevails. Here, the chances of capturing the front plate of the tractor in such a situation is marginal. For these reasons, use of dedicated ETC pass-through or express lanes restricted to private passenger vehicles should be considered until surveillance measures become more reliable. Commercial traffic equipped with ETC devices can be directed to use attended lanes equipped for ETC or dedicated commercial vehicle lanes such as those at the Lincoln Tunnel Toll Plaza in Weehawkin, New Jersey. Here, buses using the contraflow express bus lanes on I-495 are channeled through an exclusive bus-only lane at the toll plaza.

SECURITY

There are three distinct levels of security at a toll plaza: dealing with toll receipts, ensuring safety at the facility, and ensuring the safety of the toll collector. Security of toll receipts is accomplished using a series of checks and balances. In-lane toll auditing equipment is used to reconcile toll collector deposits and ACM vault cash/token counts with tour-of-duty reports, vehicle axle counts, and vehicle weight and vehicle profile data. In addition, surveillance cameras sometimes oversee in-lane toll transactions and monitor areas in the toll administration building where toll receipts are present to reconcile inconsistencies in the internal audit process.

Toll receipt security also needs to address the security and discharge of the toll collector's cash drawers used in the toll lane, deposits of toll receipts, counting of toll revenues, and banking. In the attended toll booths, dual, locked cash drawers usually are provided in the collector's counter to allow attendants to leave their cash in the booth while on break. The relief collector can use the second drawer for his or her cash tray.

Bank-type, taped video surveillance generally is used within the toll plaza administration building. Cameras monitor secure areas (where money is handled) and external entry/exit doors, including the tunnel access door. Video surveillance also is used at high-risk, remote, and unattended ramps primarily to deter theft and vandalism, such as on the Sawgrass Expressway in Florida. These cameras are monitored by the plaza supervisor or by local police assigned to the facility. Intrusion detection devices are placed on all points of building and equipment cabinet entry such as ACM vault doors, the plaza computer room, and the loading dock. Various staff security levels for access are a standard practice of toll agencies. Access card use, including point of entry, time, and date, frequently is recorded by the plaza computer. The access report records passage into secure areas of the building, opening of toll equipment cabinets, and activation of computer and toll terminals.

Staff security is becoming recognized as an issue, particularly in urban areas and at isolated plazas. A number of security devices, including video surveillance cameras, silent alarms, bulletproof toll booth glass, and bill alarms are being used to deter crime and to protect both the toll collector and the customer in the event of a dispute.

ACCESSIBILITY

Accessibility to toll plaza facilities such as the parking area, plaza administration building, toll booths, toll lanes, and access tunnel is frequently overlooked. Access to parking either onsite as provided at most facilities or in a remote lot is a fundamental concern and is determined by the location of the plaza and availability of space. The location of a mainline plaza with respect to adjacent interchanges and communities, as well as to adjacent local roads, is important for providing direct access from the mainline plaza or restricting access to the local road.

In keeping with public building access codes, the plaza administration building and sidewalks must be suitable for the physically challenged. However, the need to provide access to the toll lanes, booths, and access tunnel are determined by state mandates and the possibility for employment of physically challenged individuals in various toll positions, depending on the authority's or agency's job requirements. In some newer facilities such as the Holland Tunnel's Jersey City, New Jersey, toll plaza, elevator access to each booth is provided from the administration building utility area, which forms the toll canopy. On the Orange County Transportation Corridors in California, both the toll islands and booths are being designed for wheelchair access. Additional studies on the need to provide complete access for physically challenged employees and the means to do so need to be conducted.

Toll Lane and Booth Access

Conventional access to toll lanes and booths is a critical factor in plaza design. At a low-volume, low-speed ramp or mainline plaza, access tunnels are neither economically nor operationally viable. Here, personnel gain access to toll booths by crossing the toll lanes. Typically, a walkway is created across each toll island, and the crosswalk is placed in front of the booth to ensure that the driver of the vehicle and the person crossing can see each other and have eye contact.

Access to most booths is through a collector's side door. For safety reasons in the event of a vehicle mishap in the toll lane, a second door or escape hatch is provided. One arrangement is to provide a door into the adjacent lane. This method is used in older booths because of limited space in the booth and the confines of the toll island. Usually in such booths, access to the rear of the booth is restricted by a counter or toll equipment. Some newer booths have rear doors for both access and egress. Other booths are equipped with emergency secondary hatches for exiting.

A means to alert collectors who are crossing toll lanes to oncoming traffic, particularly where an HOV or ETC bypass lane is present, must be considered. Usually signing, color changes on adjacent booth walls, and plastic-coated yellow safety chains used as barriers or gates are used to remind collectors and other personnel to observe safety precautions.

Tunnels

Toll lane access tunnels usually are installed at high-volume, high-speed mainline plazas. Access to these tunnels usually is limited to every second or third toll island. The stairwell usually descends into the island toward the toll booth to take advantage of the location of the tunnel beneath the toll booths. Some toll facilities, such as Florida Turnpike mainline plazas, have the stairwell entry adjacent to the booth so that personnel do not have to walk into the lane to gain access to the stairwell entrance.

The stairwell can be located on either side of a toll island. Figure 10 shows a toll island tunnel stairwell on the former Norfolk–Virginia Beach Expressway, in which the stairwell rises away from the toll booth. Tunnels provide not only safer toll lane access for personnel, but also a point of access for

FIGURE 10 Typical toll island tunnel stairwells, former Norfolk–Virginia Beach Expressway. Stairwells are located on every other island.

utilities, data and communication lines, and security for personnel and cash receipts. The tunnel provides an alternate location for ACM lane vaults and even lane controller cabinets, which can be serviced directly from the tunnel without the need for staff to cross active traffic lanes.

ACM Cabinets

At plazas without service tunnels, the coin vaults are in the ACM cabinet. Servicing must be done from the toll lane or from inside the booth. Because of the vault weight, usually limited to about 70 lb (32 kg) when full, the supervisor or designated collector uses a small cart to transport full and empty vaults. Although the toll lane being serviced is closed during the vault exchange, access across the plaza from the administration building must be provided. This access includes a depressed curb and ramp from the building and direct access to a secure full-vault storage room or to a dumbwaiter or elevator if the vault room is on another floor.

Access also needs to be provided to the building vault, to pick up collectors' deposit bags, and to the cash/token vaults. A secure loading dock or port is usually provided to facilitate transfer of full vaults to a bank courier's vehicle. Empty vault storage and the cart, likewise, must be stored to ensure access to the lanes or tunnel. This storage area should be outside the secure area.

Parking

Parking may be provided either on-site or off-site, depending on the size of the toll plaza, staffing, space available, and the plaza's location with respect to adjacent local roads and interchanges. Off-site or remote parking usually requires that a shuttle be provided to the plaza administration building. At facilities in which one to three toll collectors are assigned to a ramp plaza, on-site parking may be provided in a pull-off located on the departure side of the plaza if the right-of-way is restricted. For larger plazas, a parking lot generally is constructed adjacent to the plaza administration building. Access to this lot can be directly from the mainline or from an interchange entry-exit ramp. If the plaza is adjacent to a local road, direct secured access may be provided without the need for personnel to enter or exit from the facility roadway. Such parking typically is placed in a fenced area, which separates it from the plaza. A locked gate can be incorporated in the fence to provide access for emergency vehicles into the facility.

Access to the plaza administration building can be provided from the lot through a secure employee entry so that employees do not have to pass through the plaza entry foyer. The staff entrance should lead to the nonsecure staff facilities in the administration building, where lockers, a lounge, or a lunchroom may be located.

Plaza Administration Building

Public access to the toll plaza administration building usually is prohibited or discouraged for reasons of security, limited parking space, and safety. Where ticket/token or ETC sales are rendered at the administration building, such as at the Fort McHenry Tunnel in Baltimore, a small public foyer, pay phone, and sales window with a secure entry from the plaza can be provided.

LANE CONFIGURATION (METHODS OF PAYMENT)

Lane configuration refers to the agency's policy on arranging toll lanes at a toll plaza according to the methods of toll collection. Lane arrangement reflects the toll system, time of day, day of the week, patron profiles, traffic demand, location of adjacent entry and exit ramps, method of toll collection, and patrons' preferences for payment. Therefore, layout tends to differ from agency to agency and even from facility to facility.

Some toll operators group automated collection at the left side of the toll plaza while providing full service on the right. This pattern tends to follow the convention on the roadway, in which slower traffic keeps right and faster traffic uses the left lanes. However, such a configuration can create problems for motorists who find themselves in need of change but are stuck in the left lanes. Advance signing and clear designation of lane use at the toll plaza must be deployed to reduce such instances. During off-peak traffic periods, particularly at night, manual collection may be provided in the center toll lanes of a two-way plaza to reduce staff and provide added security by grouping collectors. At a split or one-way plaza, manual collection generally is concentrated in the right lanes near the plaza administration building.

NJHA, operator of the Garden State Parkway, uses a pattern of alternate groupings of toll collection methods. The agency currently uses four collection methods: manual, ACM exact change, ACM token, and a combination of the last two. According to NJHA, the grouping of methods provides patrons in any approaching traffic lane during peak traffic periods the opportunity to use all payment methods without having to alter their path by more than one to two lanes to either side. This lateral distribution was confirmed in a 1991 study of toll plaza optimization conducted at five of the parkway's mainline toll plazas (*2*, p. 44).

The lane configuration or proportion of automatic, manual, and ETC lanes may need to be adjusted during the day depending on traffic volume and the types of patron being served. Therefore, anticipating the need for such flexibility is essential in specifying toll equipment for each lane, sizing the toll barrier, and determining staffing.

The introduction of tandem lanes, branch lanes, HOV bypass lanes, and dedicated ETC lanes makes the selection of a configuration more difficult. Branch and tandem lanes typically are placed at the right and left extremes of the toll plaza, with the branch lanes offering all methods of collection available at the main plaza. Tandem lanes are found in manual lanes and offer attended collection. To optimize throughput, HOV and other bypass lanes usually are placed at the extreme ends of the plaza. Here, the lanes avoid blocking access by waiting vehicle queues and are better defined for personnel safety. Dedicated ETC lanes are usually located adjacent to automatic lanes to reduce the impact of differential speeds between vehicles departing these lanes. Another approach, which is used on the Florida Turnpike, places dedicated ETC lanes in direct line with the approach travel lanes to facilitate access and toll processing. Because of concern for safety and the impact of differential speeds, operators such as the New York State Thruway Authority and the Texas Turnpike Authority have instituted strictly enforced speed limits through their dedicated ETC lanes.

CHAPTER THREE

CURRENT TOLL FACILITY DESIGN PRACTICES

STANDARDS AND PRACTICES

A literature search was conducted to obtain data on current toll plaza design standards, guidelines, and practices in the United States. After an extensive review of articles, research papers, and design publications, it became apparent that little published information on design criteria is available to the public. Therefore, for this synthesis, a compilation of design elements, geometries, and practices was obtained by a survey of present toll operators.

TOLL OPERATOR SURVEY

A survey questionnaire (Appendix A) was developed to acquire information from various toll operators in the United States regarding the design of their toll plazas. The questionnaire was organized into three parts:

- Facility background, including name, type, location, toll collection methods, size, and year of construction or renovation;
- Design standards and guidelines used by the facility operator to design existing and new facilities and improvements; and
- Elements such as plaza geometries, toll island and booth elevations and clearances, pavement design, lighting, drainage, environmental issues, architectural treatments, safety devices, canopy functions, toll booth design, lane equipment layout, toll collection equipment, lane capacity, toll plaza access, traffic control devices, administration building functions, signing, lane configurations, reversible operations, enforcement methods, and accessibility for disabled persons.

The survey was administered by TRB, with the cooperation of the International Bridge, Tunnel, and Turnpike Association (IBTTA), to the association's members in the United States on April 13, 1994. Currently, more than 60 U.S. toll operators with more than 200 toll bridges, toll tunnels, and toll road facilities are members of IBTTA. Responses were received from 25 operators with 58 toll facilities (45 are referenced in the survey responses). These facilities represent more than 3,150 mi (5,069 km), or 60 percent, of the toll mileage in the nation, excluding seven facilities currently under construction. The facilities are spread over 15 states. A summary of responses is presented in Appendix B.

The facilities range in size from the 0.8 mi (1.3 km) long Peace Bridge in Buffalo, New York, to the Florida Turnpike, with 1,714 lane miles (2,758 km) of toll roads and 404 toll lanes. An additional 208 toll lanes are being constructed on the Florida Turnpike System as part of five new toll roads (included in Florida's response) scheduled for opening by the year 2000. This will add 434.3 lane miles (699 km) to the system, with an additional 10 mainline plazas and 49 ramp plazas.

Of the toll facilities represented in this survey, 31 are toll bridges, 5 are toll tunnels, and 22 are toll roads. Sixteen were built before 1940, and 25 were constructed between 1940 and 1969. Only 11 were constructed in the past 25 years. Of these facilities, 27 are closed systems, and three employ a combination of closed and open systems. Five are operated as ticket systems.

Forty-six percent of the facilities responding to the survey use ACMs, 16 percent use operator-issued credit cards mostly for use by commercial carriers, and 34 percent have an electronic toll collection (ETC) system. Since 1990, the toll plazas at 13 of the 45 facilities were renovated or expanded. Table 1 presents a breakout of the methods of toll collection and payment used by the facilities surveyed, according to the type of toll system.

A review of responses from 35 toll facilities indicated that some operators rely on widely available professional standards or guidelines for drainage and pavement design and building and electrical codes. However, in terms of plaza geometries (e.g., transition lengths and tapers, toll lane clearances, toll island design, in-lane toll equipment use and placement, signing, pavement markings, lighting, toll booth design, and lane signals), the standards followed are those of the individual operators and equipment manufacturers. The standards differ not only between operators but also between the individual facilities run by an operator. The standards are, for the most part, unique to the facility and toll operator. The following sections provide a compilation of standards and practices.

PLAZA GEOMETRICS

Plaza geometrics fall into several categories: pavement horizontal and vertical alignment, toll lane clearances, and toll island design. For discussion, the definitions of toll plaza layout in Figure 1 and those presented in Figures 13 and 15 will be referenced.

Horizontal Alignment (Pavement Transitions or Tapers)

Geometric data on toll plaza layout were submitted by 35 of the responding facilities. These data are summarized in Appen-

TABLE 1
TOLL SYSTEMS—METHODS OF TOLL COLLECTION AND PAYMENT (PROFILE OF 54 TOLL FACILITIES)

Methods/Payment	Closed (Cash)	Open[a]	Combined[b]	Closed (Ticket)[c]
Manual				
Cash	21	27	1	5
Scrip/ticket	12	19	—	—
Credit card	2	7	—	4
Exact change	1	11	—	—
Automatic				
Exact change	17	14	1	—
Token	8	4	1	—
With AVI	—	4	—	—
ETC	8	9	—	—

[a,c]Three closed (ticket) systems also operate open cash systems (data for the open system are included separately).

[b]Combined includes open and closed cash systems.

dix C by type of facility and by mainline and ramp plazas. (The identification number in the first row corresponds to the facilities that responded. The facilities and codes are listed in Appendix B.)

The approach and departure transition lengths, T_A and T_D, both with and without the Q area, and recovery zone lengths, L_Q and L_R, depicted in Figure 1, were compared with accepted design practices. These included those in the AASHTO publication, *A Policy on Geometric Design of Highways and Streets*, such as the following:

- Pavement transitions,
- Taper lengths of acceleration and deceleration lanes, and
- Lengths of lane shifts calculated by using the 1988 federal *Manual on Uniform Traffic Control Devices* (MUTCD) taper formula $WS^2/60$ (for speeds less than or equal to 40 mph (64 km/hr)) and taper formula WS (for speeds greater than 40 mph (64 km/hr)) for approach lengths and by using 100 ft (30 m) for each lane reduction on the departure or merge side.

In addition, stopping and decision sight distance criteria as set forth in AASHTO geometric guidelines were examined (*11,13*). In no case could a comparison be made.

Given vehicle operations in a conventional toll plaza, which intrinsically involve interruption of traffic flow, the definitions of standard criteria for lane transitions and taper and for acceleration/deceleration lanes are not met. In addition, these lane designs and those for lane shifts in the MUTCD typically are applied to merging or diverging traffic with respect to mainline operating speeds or continuation of speed through a shift, which does not occur in a toll plaza. Sight distances also are not directly applicable to setting transition zone lengths because they define a driver's line of sight to an object that is 6 in. above the pavement surface. This, of course, is not the case with a toll plaza because of its canopy structure and lighting, which typically are visible for some distance. However, such factors must be considered in establishing plaza geometry.

Some operating authorities, such as the New Jersey Turnpike Authority (NJTA), establish a fixed distance in setting horizontal alignments for their facilities. The NJTA Design Manual depicts basic horizontal alignment for its mainline and ramp toll plaza in terms of a distance "500 feet (152 m) from the plaza centerline to either the ramp nose split or normal roadway width." The manual further describes the right edge line at a standard plaza as having a "taper symmetrical from the ramp nose to the end of the toll plaza slab. Equal reverse curves are generally used for plaza edge geometry in order to attain such a taper"(*14*).

The Illinois State Toll Highway Authority (ISTHA) defines plaza horizontal alignment in its design manual in two parts: approach geometry and departure geometry. The approach geometry, shown in Figure 11, consists of two reverse curves and a tapered tangent section located between them. (This is similar to the design described for the New Jersey Turnpike, where the transition section is preceded by a tangent section perpendicular to the toll plaza.) These elements form what is referred to as the approach storage area (approach transition and Q zones). The criteria used to establish their geometry are as follows:

- A tangent sufficient to store six semitrailers is established prior to the toll plaza (the queue area) (WB-50s).
- The radius for Curve 1 between the storage tangent and the taper is set at 500 ft (152 m).
- The slope of the diagonal taper is n:1 and is set by the safe stopping sight distance based on a comfortable deceleration rate from the average running speed between the end of Curve 2 and the beginning of Curve 1, using the values in Table 2 developed by ISTHA's consultant.
- The radius for Curve 2, which provides the transition from the approach roadway, is determined using the design speed in accordance with the AASHTO minimum safe radius formula $R_{min} = V^2/15\ (e + f)$, again using the values in Table 2 (*15*).

On the departure side, the design geometry of the departing right edge line, shown in Figure 12, likewise uses a segment perpendicular to the plaza and two reverse curves connected by a tangent, followed by a 50:1 direct taper into the departure roadway. The criteria are similar to the approach transition except:

- The minimum length of the perpendicular tangent section is determined by setting a distance from the end of the toll island to a point so that the selected design vehicle can clear the toll island and proceed into the departure roadway.
- Curve 1 is set at a 1,000-ft (304.8-m) radius.
- The length of the departure lane is such that a departing vehicle can reach highway running speed after leaving the toll lane at a point where the plaza width is equal to the through-lane widths plus one additional lane. This distance is based on standard uniform vehicle acceleration through the departure area. Acceleration, which is assumed to be 70 percent of full acceleration as defined by AASHTO geometric guidelines, is calculated by the uniform acceleration formula.

Curve 2, similar to the approach side, is set following the mini-

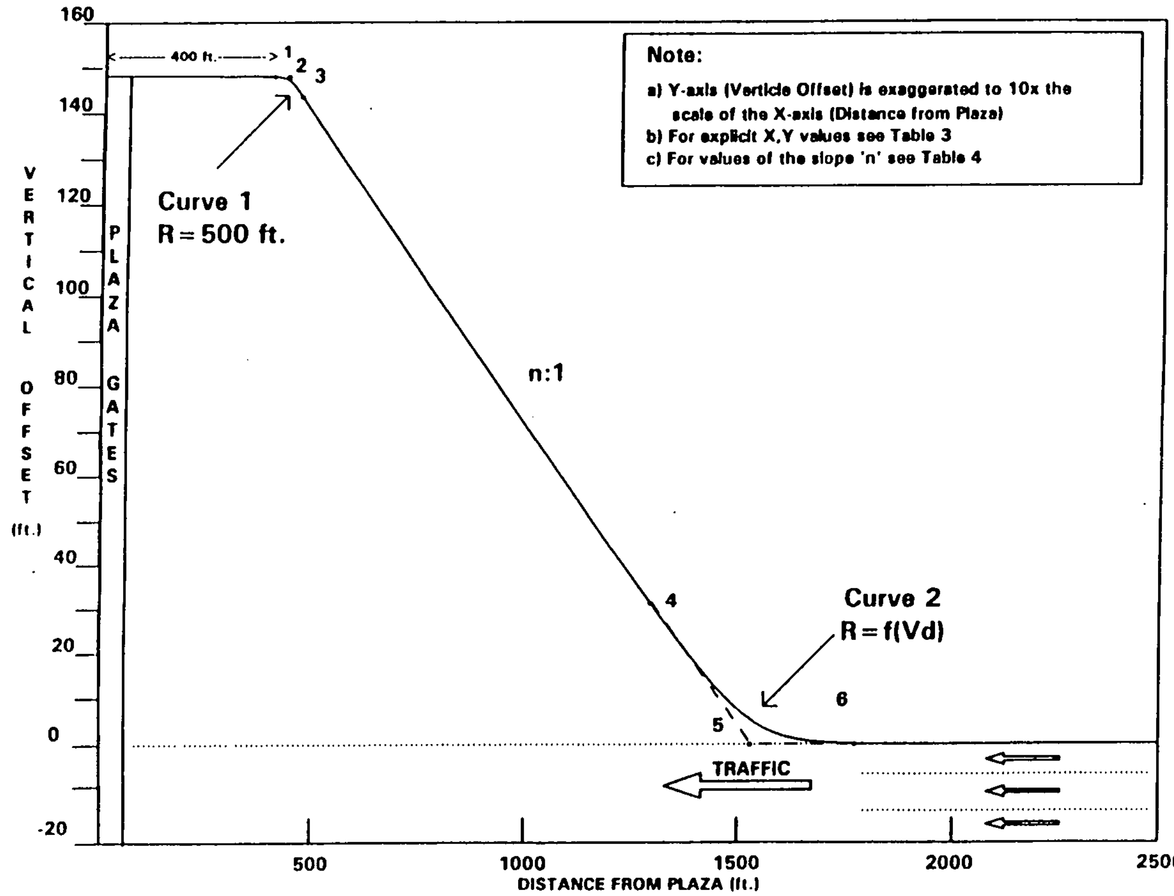


FIGURE 11 Approach to a toll plaza, edge of pavement line (*15*, p. 47).

mum radius of curvature in accordance with AASHTO and criteria presented in Table 3 using design speed (*15*, p. 50–54).

Toll Lane Envelope

Another factor in setting plaza horizontal alignment is the toll lane "envelope," which is the combined width of the toll lane (W_l) and toll island (W_i), as shown in Figure 13. Given the toll lane envelope and the numbers of toll lanes, the site, approach lane geometries, median or plaza width, and plaza configuration, the basic criteria for setting the horizontal plaza geometry can be established.

According to AASHTO geometric guidelines, the desirable width of a traffic lane on a free-flowing high-speed principal arterial should be 12 ft (3.6 m). However, under interrupted flow conditions (exhibited at a toll plaza) at

TABLE 2
APPROACH TO A TOLL PLAZA—MAXIMUM PERMITTED SLOPE, LENGTH, AND MINIMUM EDGE OF PAVEMENT RADIUS (*15*, p. 49)

Design Speed (mph)	Running Speed (mph)	Side Friction[a]	C^b (ft/sec^3)	Slope of Taper (n:1)	Minimum Length of Taper (ft)	Minimum Radius 2 (ft)	Minimum Degree of Curve 2 (0)
50	44	0.155	1.95	5.5:1	450	1700	3.37
55	47	0.145	1.80	6.0:1	550	2000	2.86
60	51	0.135	1.65	6.5:1	650	2600	2.20
65	55	0.130	1.50	7.0:1	750	3100	1.85
70	58	0.125	1.35	7.5:1	850	3600	1.59

[a]From *Illinois State Toll Highway Authority (ISTHA) Design Manual*, the side friction factor was developed by K&D Facilities Resource Corp. This factor represents an adjustment factor that is applied to the AASHTO minimum safe radius formula, $R_{min} V^2/15(e+f)$.

[b]From *ISTHA Design Manual*, the C factor was developed by K&D Facilities Resource Corp. This factor is a coefficient for use in determining approach geometry.

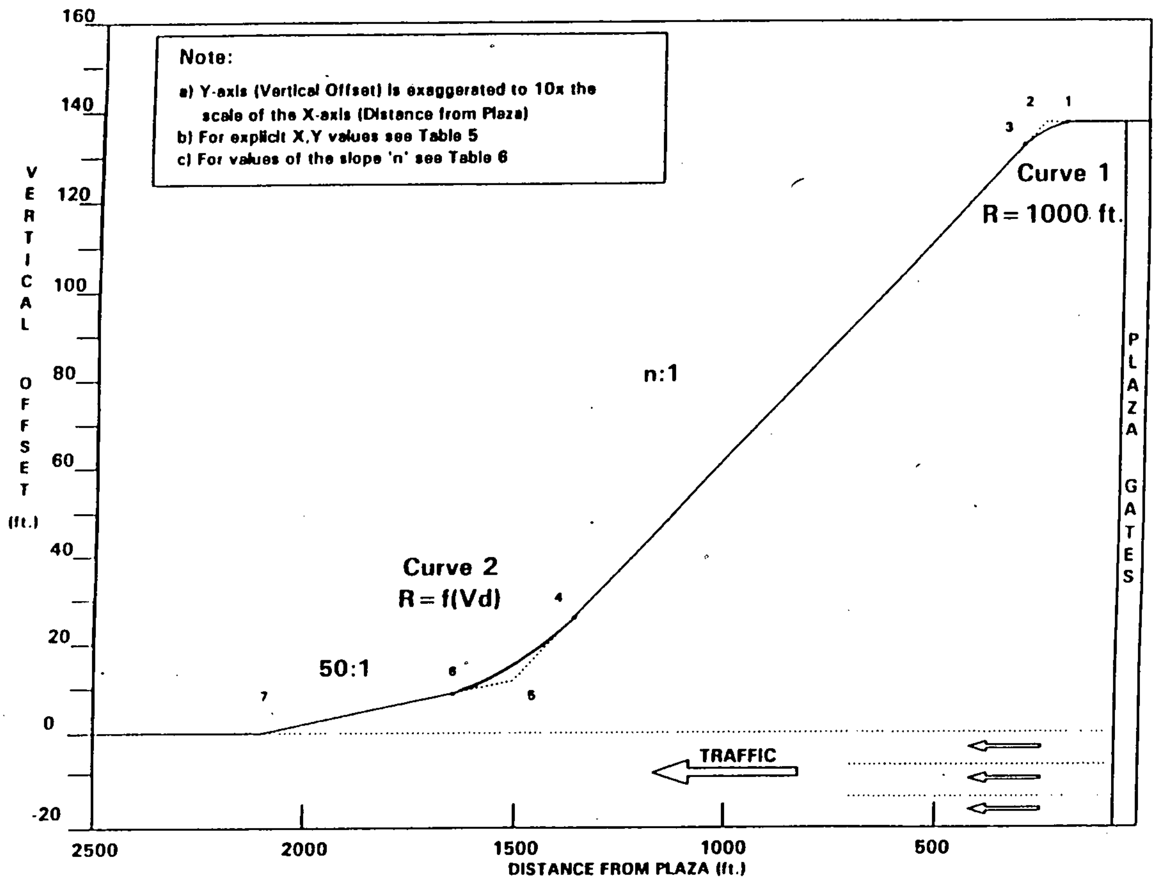


FIGURE 12 Departure from a toll plaza, edge of pavement line (*15*, p. 52).

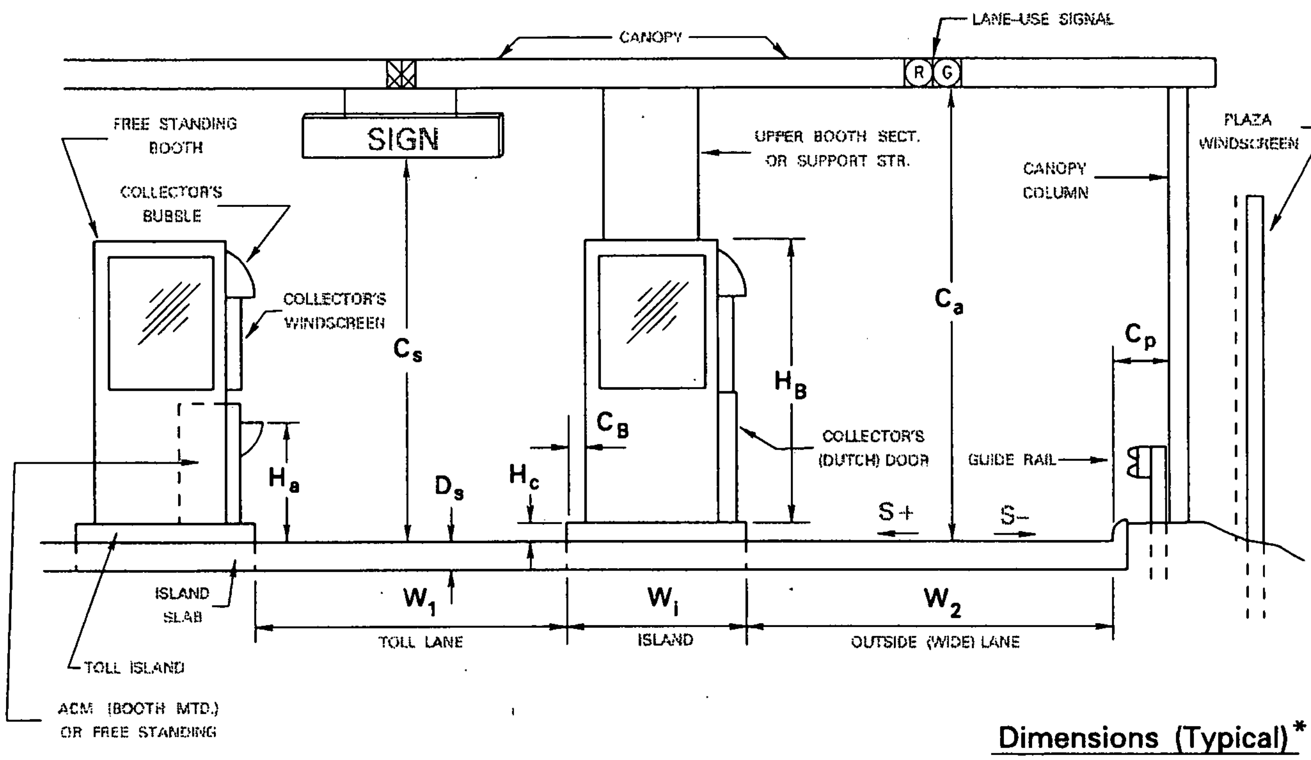
speeds less than 40 mph, (64 km/hr) narrower widths are normally considered acceptable—10 to 11 ft (3.0 to 3.4 m). If heavy truck traffic is anticipated, an additional foot in width is recommended (*11*).

The operator survey indicated that the typical toll lane width (W_1) varies from 9 ft (2.7 m) to 12 ft (3.6 m). Sixty-three percent have widths between 10 ft (3.0 m) and 10.5 ft (3.1 m), with the weighted average being 10.9 ft (3.3 m) (Appendix C). These widths tend to be skewed because of the age of the facilities and the fact that the vast majority of traffic using these facilities consists of passenger vehicles (two-axle, four-tire). According to toll operators, widths in this range help slow traffic and force the motorist closer to the collector or ACM basket. With wider lanes, drivers tend to pull further to the right, away from the collector or basket. However, operators also note that where heavy truck traffic exists, a minimum width of 10.5 ft (3.2 m) and preferably 11 ft (3.4 m) is recommended to keep the large side-mounted rearview mirrors on truck cabs from hitting the toll booth or a collector's door windscreens.

The outside or far right lanes at a toll plaza are generally wider than the standard toll lanes. This is done to permit extra-wide loads, snow plows, maintenance vehicles, and construction vehicles to pass through the plaza. Seventy-five percent of the toll facilities indicated outside lane widths (W_2) between 12 ft (3.6 m) and 18 ft (5.5 m), with several having lanes up to 34 ft and 1 in. (10.4m) in width. Bypass lanes are used by some operators to permit oversized loads to be escorted around the toll plaza.

TABLE 3
DEPARTURE FROM A TOLL PLAZA—MAXIMUM PERMITTED SLOPE OF TAPER (*15*, p. 54)

Design Speed (mph)	Average Travel Speed (mph)	Full Acceleration (mph/sec)	Minimum Acceleration Length (ft)	Calculated Taper	Maximum Design Taper	Minimum Radius (ft)
50	44	1.95	730	3.2	4:1	1700
60	51	1.65	1100	6.5	7:1	2600
70	58	1.35	1500	9.8	10:1	3600



Dimensions (Typical)*

C_a	—	Minimum Clearance measured from pavement to bottom of Canopy	16′–3″
C_s	—	Clearance to underside of suspended Sign	14′–2″
C_B	—	Lateral Clearance between curb face and Booth	13″
C_p	—	Lateral Clearance between curb face and Canopy Column	ND
H_B	—	Height of Booth	9.5′
H_c	—	Height of Exposed Curb face	6″–9″
H_a	—	Height of ACM Basket Lip above pavement	33″–38″
W_i	—	Width of toll island (Typ.)	6′–7′
W_1	—	Width of typical toll lane	10.9′ (11′)
W_2	—	Width of outside (Extra Wide) Toll Lane	15.75′ (16′)
D_s	—	Depth of Concrete Toll Lane Slab	8″–12″
S+/S–	—	Cross Slope of Toll Lane Pavement	0–2%

* VALUES REPRESENT WEIGHTED AVERAGES FOR RESPONDING FACILITIES (SEE APPENDIX D)

ND – NO DATA

FIGURE 13 Typical toll lane, approach elevation.

Vertical Alignment

Vertical alignment includes vertical curves, grades, cross slopes, and clearances (Ca, Cs). The following briefly describes the general practices of the surveyed facilities.

- Vertical curves—Typically no vertical curves are used through the centerline of the plaza.
- Grades—A 0.5 percent profile grade away from the centerline of the plaza is sometimes used. The majority of respondents (82 percent) use a 0 to 1 percent grade in the toll lane, whereas on the approaches, 70 percent have grades of less than or equal to 2 percent, and 63 percent have grades of less than or equal to 1 percent.
- Cross slopes—According to AASHTO geometric guidelines, cross slopes up to 2 percent are barely perceptible to the driver and have little impact on steering (*11*). Within the toll lanes, the majority of surveyed facilities have such cross slopes, with some approaching 2.5 percent. Likewise, in the transition zones, similar cross slopes are used. For wide plazas, the cross slope is gradually increased toward the outside edge lines to avoid excessive slopes, which might create discomfort for the driver. The slope must be sufficient to facilitate runoff and to avoid ponding of water. The choice of cross slope or vertical profile to promote runoff is determined by local conditions and practices.
- Clearances—According to AASHTO geometric guidelines, "most states permit vehicle heights including load to be between 13.5 and 14.5 ft. (4.1 and 4.4 m). The clear height of all structures above pavements and shoulders should be at least 1 ft. (0.3 m) greater than the legal height. The recommended minimum is 14.5 ft. (4.4 m), and the desirable is 16.5 ft. (5.0 m)" (*11*). These values are guidelines, which may vary depending on the route. For example, on parkways where travel is restricted to two-axle, four-tire private passenger vehicles, clearances can be reduced to an absolute minimum of 12.5 ft (3.8 m), with a desirable clearance of 15 ft (4.6 m) (*11*).

In toll lanes, the vertical clearance to the underside of the canopy must take into account any suspended signs, cameras, ETC antennas, and detection devices. Of the surveyed toll facilities, 90 percent responded that the clearance from the top of the pavement to the underside of the canopy (Ca) exceeded 14.5 ft (4.4 m), with most having a clearance of 16.25 ft (5.0 m). Fifty-six percent reported that the clearance to the bottom of suspended signs (Cs) exceeded 14.2 ft (4.3 m). The range of clearances to the canopy underside (Ca) was from 13.5 ft (4.1 m) to 21.67 ft (6.6 m), whereas to the bottom of a sign, the lowest value was 11.08 ft (3.38 m).

To detect overheight vehicles, some operators have installed telltales or infrared/optical height detection in the toll lanes. Vehicle profilers, either mounted on posts in advance of the toll booth or as overhead scanners intended for an advanced vehicle classification (AVC) system, can also be used.

TOLL ISLANDS

Toll islands can be defined as raised platforms usually made of concrete that include some form of crash protection or attenuation devices on the approach to the toll booth or free-standing ACM. The type and configuration of a toll island is determined largely by when it was constructed, the speed and make-up of the approaching traffic, and the plaza configuration.

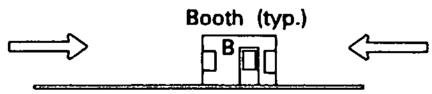
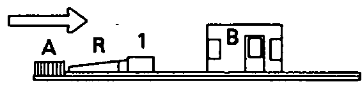
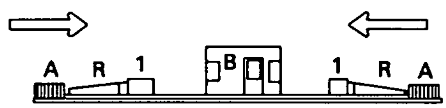
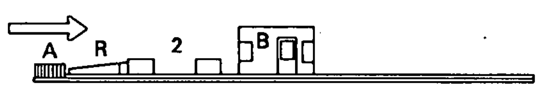
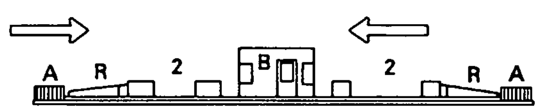
Toll islands can be categorized into five types, depending on the configuration of protective devices used and the direction of traffic. Figure 14 depicts the five types of toll islands, ranging from a simple platform without crash protection to a double crash block system with impact attenuators on both sides of the booth. There are 36 configurations or arrangements of devices within these five types of islands. Of these configurations, 27 are used by the 46 facilities that responded to the survey question. The data are tabulated in Appendix D. The first column in the appendix refers to the facility ID; the second and third columns list the type and configuration that corresponds to Figure 14. The dimensions (e.g., Al, Rl, and CB_2) relate to Figure 15.

Of the responding facilities, 17 have installed impact attenuators such as the GREAT System Hex Foam or Hydro-Cells, which are designed to decrease the momentum of an 8,000-lb (3629-kg) vehicle traveling at 45 mph (72 km/hr). Some facilities such as the Florida Turnpike use highway approach speed. All but 14 of the facilities use approach ramparts (a sloped concrete ramp, sometimes rounded in sectional view, used to redirect an errant vehicle) in conjunction with the attenuator or a crash block system.

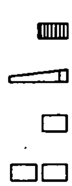
A single crash block usually is found in older facilities where the volume of truck traffic is low. The double block system, seen on newer facilities, is intended to prevent a large vehicle, which may override or penetrate the attenuator and first block, from hitting the booth. In some instances, the double block system creates a gap before the booth, which helps prevent a vehicle from striking a booth in which a stairwell is not located between the crash devices head-on. This is possible where the leading end of the island is elongated, necessitated by the location of preclassification toll equipment in advance of the collection point. Here, the second block provides protection for the collector. The Delaware Turnpike, on the other hand, uses a dual set of ramparts and blocks on both sides of its mainline plaza booths.

The average height of a block is about 3 ft (0.9 m). Blocks range in size from 1 ft, 8 in. (0.5 m) to 8 ft (2.4 m) in length. The longer blocks typically replace the rampart in newer designs to close the space between the attenuator and the booth. The toll islands for which data were collected range in total length from 20 ft (6.1 m) to 127.75 ft (38.9 m).

After reviewing the variations in configurations and approach speed, no conclusion could be drawn regarding the basis for the various island designs other than the functional intent of the placement of the components. The design of the island is a product of the toll lane equipment, its location, size of the booth, presence of a tunnel stairwell, extent of truck traffic, and plaza configuration. Figure 16 is a detailed illustration of a toll plaza island and typical sections for a Type 5-R21R island configu-

TYPE		CONFIGURATION*		
1	 w/wo End Protection (N)	**N** – No Crash Protection **C** – Concrete Bollards / Other		
2	 Single Crash Barrier (AR1) – 1 Direction	**1** R **R1**	**A1** AR **AR1**	
3	 Single Crash Barrier (AR11RA) – 2 Direction	**11** **R11R** **R11**	A11 **AR11R** **AR11** **AR1R**	A11A **AR11RA** **A11R**
4	 Double Crash Barrier (AR2) – 1 Direction	**2** **R2** **2R**	AR2	A2
5	 Double Crash Barrier (AR22RA) – 2 Direction	**R21** **R22R** R22 **22R**	**R21R** **AR22R** A22 **AR22** **AR21R**	**A21** AR22RA **A22A** **AR21RA**

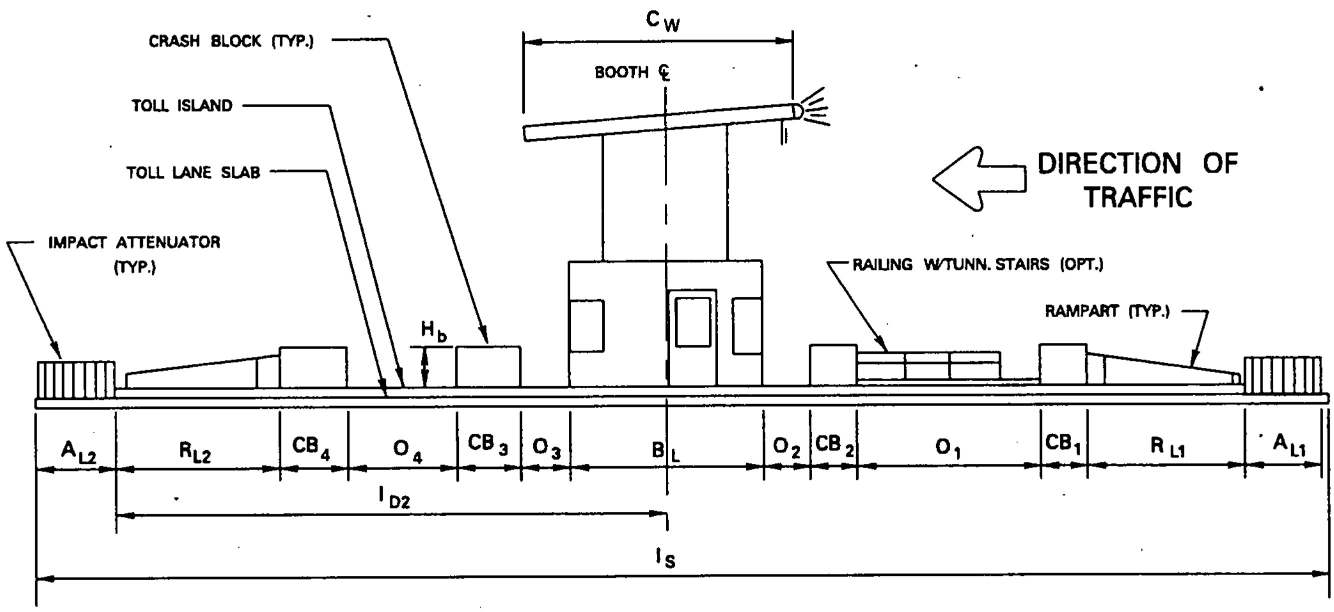
LEGEND



A	IMPACT ATTENUATOR
R	RAMPART
1	CRASH BLOCK
2	DOUBLE CRASH BLOCK

* NOTE: Configurations shown in bold represent those reported by operators in response to survey.

FIGURE 14 Typical toll island, types and configurations.



A_{L1}	–	Attenuator Length
A_{L2}	–	Attenuator Length
R_{L1}	–	Approach Rampart length or distance between Attenuator and Crash Block
CB_1	–	Crash Block Length
O_1	–	Opening between double Crash Blocks
CB_2	–	Second Crash Block Length
O_2	–	Opening between Crash Block/Attenuator and Booth
B_L	–	Booth Length
O_3	–	Opening between Booth and Crash Block/Attenuator on Departure Side
CB_3	–	Crash Block Length (Departure Side)
O_4	–	Opening between Double Crash Block (Departure Side)
CB_4	–	Second Crash Block Length (Departure Side)
R_{L2}	–	Length of Rampart (Departure Side)
I_{D2}	–	Length of Island (Departure Side)
C_W	–	Width of Canopy
I_S	–	Length of Concrete Toll Island Slab
H_b	–	Height of Crash Block (measured from top of island)

REFER TO APPENDIX E FOR SUMMARY OF TOLL OPERATOR'S SURVEY RESPONSE

FIGURE 15 Typical toll island and booth elevation, side view.

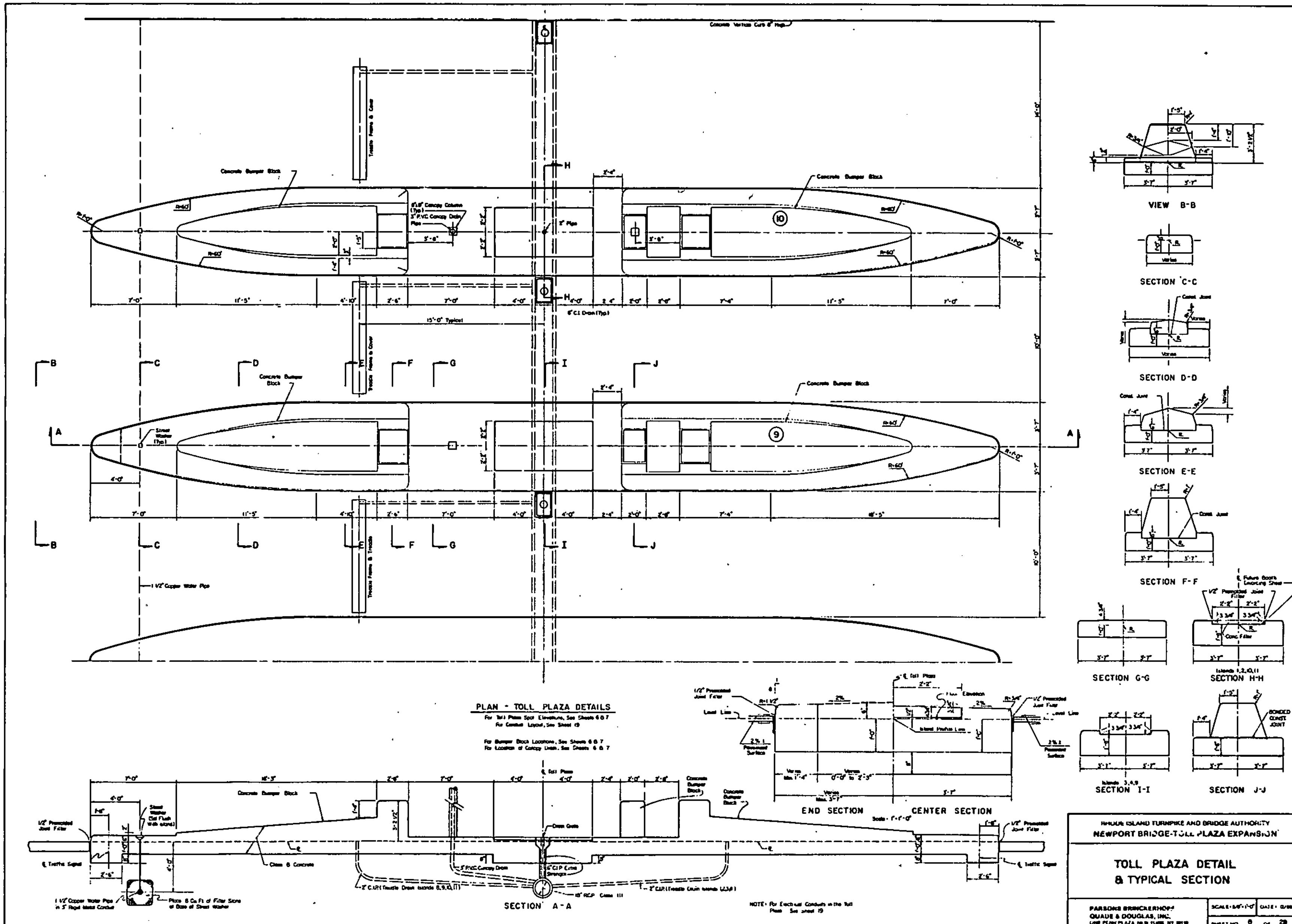


FIGURE 16 Toll plaza island detail and typical sections, Newport Bridge, Rhode Island.

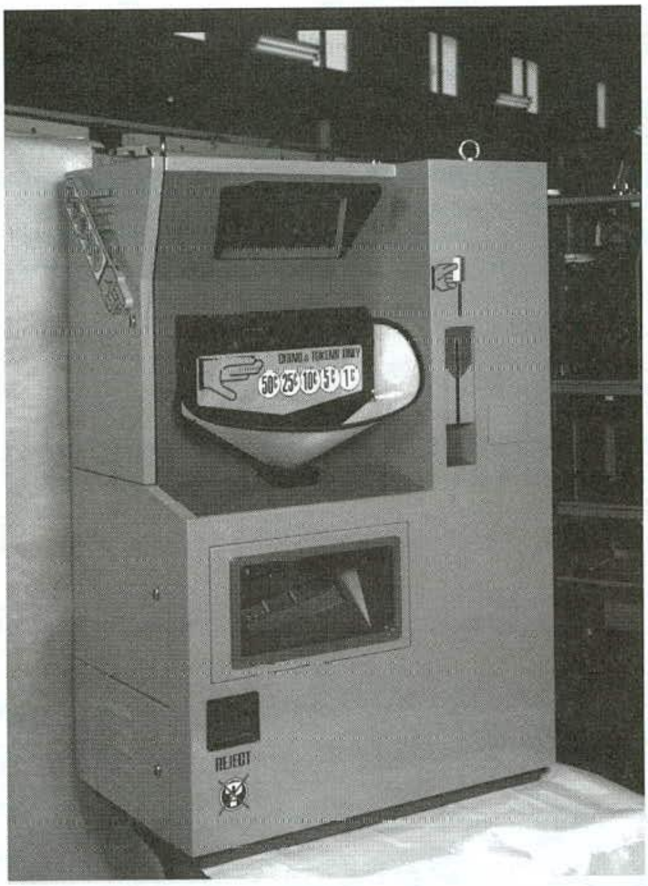


FIGURE 17a Automatic coin machine (ACM) with magnetic card swipe reader to be used on E-470 and by the Orlando–Orange County Florida Expressway Authority.

FIGURE 17b Dual-height (high and low) automatic ticket dispenser (ATD) used on the Pennsylvania Turnpike, intercom, and steel bollard used to protect dispenser (Pennsylvania Turnpike Commission).

ration used at the Rhode Island Turnpike and Bridge Authority's Newport Bridge toll plaza.

The width of the toll island is determined by the size of the toll booth and the established lateral clearance between the face of the island curb and the booth face (C_B). The overall toll island width for the majority of the responding facilities was between 6 and 7 ft (1.8 to 2.1 m), with some as wide as 10 ft (3 m) and as narrow as 4 ft (1.2 m).

According to AASHTO geometric guidelines, a minimum offset to an obstruction where curbs are provided on an urban arterial is 1.5 ft (.46 m) (*11*). Approximately 70 percent of the 46 responding facilities indicated that they have clearances of 1 ft (.3 m) to 1.5 ft (.46 m). The reason for such an offset is to reduce the distance between the driver and collector or ACM, thus facilitating the payment transaction. The edge of an ACM coin basket or an automatic ticket dispenser (ATD), as seen in Figures 17a and 17b, respectively, is usually mounted even with or just behind the face of the curb to ease driver payment.

Because of its proximity to the toll lane, the ACM basket is made of a plastic material to minimize damage to a vehicle if struck. Concrete filled steel bollards are sometimes used to protect these devices, as evidenced by the high-low ATD installation on the Pennsylvania Turnpike (Figure 17b). The offset also provides room to install a collector's dutch door, which allows the collector to move another 6 in. (15 cm) to 9 in. (23 cm) closer toward the lane, and to mount wind screens and a bubble over the collector's door to protect him or her from the elements during the collection process.

According to AASHTO, "Barrier curbs are relatively high and steep to inhibit or at least discourage vehicles from leaving the roadway. ... They range from 6 to 9 in. (15 to 23 cm) in height" (*11*). This criterion is directly applicable to the design of toll island curbing and is substantiated by the survey data as the minimum and desired values for Hc (see Figure 13).

PAVEMENT

As described in AASHTO geometric guidelines, a pavement section "is determined by the value, composition of traffic, soil characteristics, weather, performance of pavements, availability of materials, energy conservation, initial cost and overall annual maintenance and service life cost" (*11*). For this reason, concrete pavement is used in the toll lanes and island area by 85 percent of the surveyed facilities, whereas the remainder use combinations of asphalt and concrete.

Concrete surface is the preferred pavement material in toll lanes for the following reasons:

- To prevent pavement rutting caused by high-traffic volume and an almost fixed wheel track created through a toll lane;
- To reduce damage caused by the possible discharge of vehicle oils, fuel, and grease;
- To prevent washboarding and undulation of the riding surface created by the impact of braking and acceleration;
- To ensure the integrity of in-lane toll equipment such as treadles and loops;
- To facilitate maintenance (washing); and
- To serve as the roof of a toll tunnel.

Concrete toll lane pavement usually is designed with transverse and longitudinal interlocking joints to allow for expansion and contraction over a wide area. Some facilities use a bridge-type design whereby concrete approach slabs are constructed on either side of the toll lane or island slabs. This provides a transition between the approach and departure zone pavements and reduces the direct impact on the toll lane.

The approach and departure zones are extensions of the main roadway; therefore, they are usually designed to use the same material as the roadway surface. In transition areas, 58 percent of the responding facilities use asphalt or a combination of asphalt and concrete.

LIGHTING

As geometries and environmental complexity increase in a toll plaza, visual information regarding vehicles, people, and structures becomes more critical. As a result of differences in brightness, known as contrast, lighting enhances the driver's ability to detect objects. However, depending on the angle of lighting and its location with respect to the approaching driver, glare may adversely affect a driver's vision. This also is the case with oncoming vehicle headlights. Each of these conditions must be considered in lighting transition areas and the toll plaza. In addition, the design should incorporate the need to "transition" the driver's eye from the ambient lighting of the main roadway to the more intense lighting at the toll plaza and vice versa.

Luminaire design and placement is based primarily "on the area of coverage (i.e., the width and length of area to be lighted and the allowed beam angle)" (*16*). The intensity of the light is "classified on the basis of vertical light distribution, the ability to spread light along the length of the roadway" (*16*).

The intensity of illumination is measured by foot candles, which is defined as "the unit of illumination when the unit length is 1 ft.; 1 lumen distributed uniformly over an area of one square foot" (*16*, p. 634). Pavement surface illuminance is measured in horizontal foot candles, which is "One lumen distributed over a horizontal surface 1 foot square in area" (*16*, p. 634).

Within a toll plaza area, depending on its size, lighting can be achieved by using 30- to 50-ft (9.1- to 15.2-m) poles with mast arms and "cobra" luminaire heads or by using clusters of flood lights mounted directly on the poles, as pictured in Figures 18a through 18c, respectively. Use of standard lighting poles with mast arms requires a number of poles to be placed adjacent to the roadway edge line, which creates obstacles and a possible displeasing visual array. For large areas, high mast lighting up to 100 ft (30.5 m) in height is most efficient (Figure 18c). This lighting uses fewer poles to form a uniform light distribution.

Lighting sources vary in terms of the following:

- Luminous efficiency (number of lumens per watt of energy expended);
- Color rendition (color quality);
- Lamp life (number of operating hours); and
- Optical control.

There are several lamp sources available, including mercury vapor, metal halide, tungsten filament, incandescent, fluorescent, and high- and low-pressure sodium.

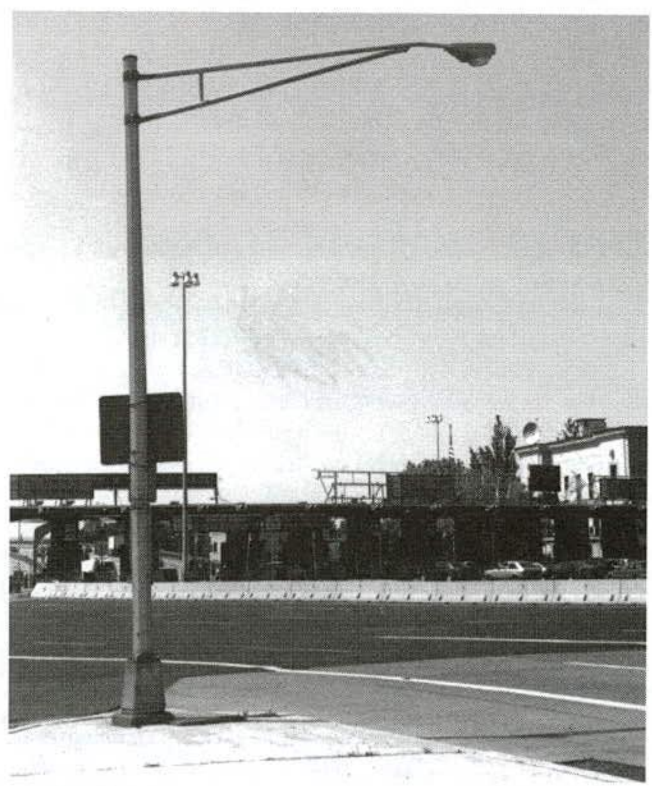


FIGURE 18a Standard mast arm with cobra-head luminaire, Benjamin Franklin Bridge toll plaza, Camden, New Jersey (Delaware River Port Authority).

FIGURE 18b Thirty- to 35-ft (10-m) pole with offset cobra head luminaire.

For a toll plaza environment with a wide cross section, a high mast lighting concept using 50- to 100-ft (15.2- to 30.5-m) poles usually is considered. Care must be exercised in the selection of such a concept if a plaza is near a residential area. This concept, however, does provide improved safety (i.e., fewer poles means fewer opportunities for collision, and aesthetics are enhanced by eliminating numerous luminaire poles) (*16*, p. 631).

Lighting Levels

Design criteria recommended for average maintained intensity of luminance and for illuminance on freeways and expressways by area classification and pavement type (R1), as adapted from the American National Standards Institute (ANSI) and Illuminating Engineering Society (IES), is presented in Table

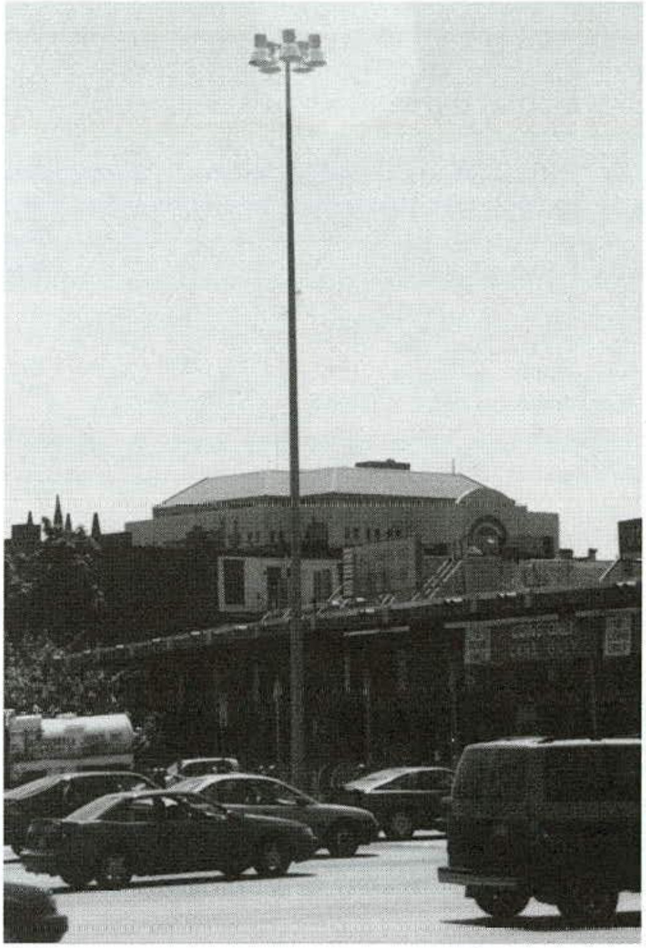


FIGURE 18c High-mast light assembly, Benjamin Franklin Bridge toll plaza (Delaware River Port Authority).

4. In addition, the table contains average maintained illuminance levels for selected pedestrian facilities. These values for pedestrian tunnel illumination are used to compare toll plaza lighting levels. Figure 19 compares these ANSI/IES-recommended minimum values of horizontal illuminance with reported lighting levels for approach and departure transition areas and in toll lanes. A third set of values for overhead roadway sign lighting derived from the *1992 Traffic and Transportation Engineering Handbook* also are used for comparison. It is apparent that the lighting in transition zones for most responding toll facilities exceeds the minimum recommended values for mainline roadways (0.4–0.9 foot candles) and that more than 80 percent of the toll lanes exceed the safe levels recommended by the Institute of Transportation Engineers for pedestrian facilities (1.0–4.0 foot candles) but are below the illuminance prescribed for overhead signing (20–80 foot candles).

Lamps/Intensity

Of the 34 facilities reporting data, 31 use sodium lamps, 75 percent of which are 250- to 1,000-W units used in transition areas. In the toll lanes, 14 of the 25 facilities also rely on so-

TABLE 4
SELECTED LEVELS OF AVERAGE LUMINANCE AND ILLUMINANCE (ADAPTED FROM *17*, TABLES 10-3 AND 10-4 (AS ADAPTED FROM ANSI/IES RP-8, 1983))

Urban Area Road Classification	Average Luminance[a] (L_{avg}) (cd/ft^2)	Average Illuminance (E_{avg})[b] (foot-candles)
Freeway (Mainline/Ramp)		
Class A	0.06	0.6
Class B	0.04	0.4
Expressway Commercial area	0.09	0.9
Intermediate area	0.07	0.7
Residential area	0.06	0.6
Pedestrian Areas	**Minimum Average Horizontal Levels (foot-candles)**	**Average Vertical Levels for Special Security (foot-candles)**
Roadside Sidewalks/Bikeways		
Commercial area	0.9	2.0
Intermediate area	0.6	1.0
Residential area	0.2	0.5
Pedestrian tunnel	4.0	5.0

[a]Disability glare restriction: vailing luminance (L_v)—ratio of L_v maximum to average pavement luminance 0.3 to 1.0.

[b]Pavement classification R1—illuminance uniformity ratios (E_{avg} to E) 3 to 1.

dium lamps ranging in intensity from 100 to 400 W, whereas 4 facilities use florescent tubes ranging between 40 and 200 W.

Lighting Standards (Mountings)

The lighting structures most commonly used by facilities are 35- to 50-ft (10.7- to 15.2-m) poles with cobra heads (50 percent) and high mast lighting (36 percent). Toll lane lighting is predominately mounted in or suspended from the canopy ceiling.

DRAINAGE

In setting the vertical and horizontal geometry of a plaza, drainage becomes an important consideration. Water must not be allowed to accumulate or pond in the large expanses of the approach and departure zones nor in the relatively flat toll lanes. Design practice described earlier dictates that plaza profiles generally must not exceed 2 percent, whereas cross slopes can approach 2.5 percent.

Within the transition zones, 87 percent of the facilities reported using a closed pipe system or a combination of pipes and open swales. Longitudinal drains alone or in combination with transverse drains are mainly used. Transverse drains create a trough across the plaza or toll lanes. They frequently create a need for additional maintenance and offer restricted capacity. A number of facilities have abandoned them or prohibit their construction. For toll lanes, more than 55 percent of the facilities reported using curb inlets, treadle drains or both.

UTILITIES

A toll plaza, particularly a large mainline one, must be considered a self-sufficient facility with all the basic requirements for heating, air conditioning, lighting, power, communications, water, and sanitary facilities.

Heating and Air Conditioning

Depending on climate, heating and air conditioning can be essential in toll booths. If booths are not occupied most of the day, automatic thermostats regulated by the plaza supervisor or computer according to the daily work schedule are used to minimize cost. In-lane adjustments are also being provided to suit individual attendant's preferences.

Water

Water is supplied, either from a public water supply or well, to service the utility building and grounds as well as for spigots in each toll lane to facilitate high-pressure washing of the lanes, booths, and canopy.

Sanitary Facilities

These facilities likewise are connected to a public system or to an on-site septic system. At some sites, such as at a remote bridge in a coastal area, chemical units with storage tanks are used.

Power

Power is one of the most crucial utilities from both a safety and a security standpoint. A power supply is necessary to provide power for the building; lighting, heating, and air handling systems; toll equipment; and booths. Critical systems, such as toll plaza, toll lane, and toll booth lighting, and critical equipment, such as toll equipment and computer systems, must be maintained in the event of a power outage. Therefore, these power loads are connected to an uninterrupted power supply (UPS) system (generally an array of batteries), which provides temporary power upon loss of service until an on-site generator comes on-line. The generator typically is a large-capacity diesel unit capable of supplying essential power until service can be restored. At present installations, lane controllers are equipped with battery backup to sustain operations for 24 to 72 hr in a standalone mode.

TOLL PLAZA LIGHTING LEVELS - TYPICAL*

LOCATION	REFERENCE STANDARDS									
LIGHTING LEVEL (footcandles)	0.0-1.0	1.1-2.0	2.1-3.0	3.0-5.0	5.1-7.0	7.1-10	11-15	16-20	20-40	40-60	60-80
Freeway **	0.4-0.6										
Expressway/Parkway **	0.6-0.9										
Pedestrian Sidewalk/Tunnels **		1.0 - 4.0									
Signs (Rural) **									20-40		
Signs (Commercial) **										40-60	
Signs (CBD) **											60-80
	PERCENT (%) OF RESPONDING FACILITIES										
Approach Zone +	14	36	4	25	11	4		4	4		
Toll Lane +		9	14	14	5	27	9	9	9		5
Departure Zone +	16	32	4	28	8	4		4	4 (35-50)		

+ Number of Responses:
- Approach Zone - 28
- Toll Lane - 22
- Departure Zone - 25.

* Source: Operator Survey Responses, 1994.
** Source: Traffic and Transportation Engineering Handbook, ITE, Washington D.C. 1992 pp 320-321 Tables 10-3, 10-4, p 32 Table 10-6.

FIGURE 19 Comparison of illumination levels on approach and departure transitions and in toll lanes at surveyed toll facilities.

COMMUNICATIONS DEVICES

Telephones

Telephones are installed in the administration building and toll booths, with the latter units generally restricted to direct lines depending on the location and size of the plaza. Public phones are usually provided in the building lounge or employee area and on the departure side of the toll plaza.

Two-Way Radio

Radio communication is provided in larger toll facilities to provide a direct link among headquarters, police, and maintenance units. Remote locations and smaller facilities also use radios as alternate communications devices in case of an emergency.

Intercoms

Intercoms were reported to be used by most operators as an internal communications system between collectors in the lane and the plaza supervisor and within the administration building. The system allows supervisors not only to speak with staff but also to listen if a collector is having difficulty with a patron. Similarly, some facilities such as the Pennsylvania Turnpike have intercoms in their automatic ticket entry lanes for patrons in need of assistance. Newer systems can accommodate both telephones and intercoms in a single system.

TOLL BOOTHS

Toll booths serve as a shelter for toll attendants as they collect tolls and dispense tickets. Booths are either freestanding (mounted on the island) or serve as a structural support for a canopy. Most booths are single-ended structures (i.e., they have counters only at one end for collectors to use to process traffic in one direction). Double-ended booths, in which counters with toll equipment and cash drawers are at both ends, are used at plazas with reversible lanes. Based on survey responses, booths range in size from 20 to 222.8 ft^2 (1.9 to 20.7 m^2). The widths vary from 2.5 ft (0.8 m) to 7 ft, 8 in. (2.4 m). Lengths vary from 6 ft (1.8 m) to 28 ft, 8 in. (8.7 m).

Booths typically are framed with a plate/rolled steel, stainless steel, or aluminum exterior and interior skin. Most walls are insulated. Most booths are equipped with electric under-the-counter heaters or hot water units. Air conditioning units are distributed equally between booth-mounted units and central systems. (For environmental reasons, the location of booth-mounted units must be selected carefully to reduce the chances of drawing exhaust fumes into the booth.) Both types of air conditioning units should have filters that are easily accessible to permit regular cleaning. Of 21 facilities that reported use of positive ventilation systems (systems that provide pressurized air to a booth to prevent contaminated air from being drawn into the booth), 15 draw fresh air from a remote location.

In colder climates where deicing materials are used, booth shells are sometimes protected from corrosion by a base molding of stainless steel or a granite base and brick veneer.

The booth floor usually consists of concrete poured after the booth is installed in the toll island, covered by a rubber mat to cushion the hard surface, serve as a static protector, and reduce dampness. Ninety percent of the booths are equipped with two doors or a door and an escape hatch in case personnel must exit quickly.

Either sliding doors or doors hinged with a dutch door, or half-height door, are used at the collector's entry, which protrude several inches beyond the booth side to place the collector closer to the patron. Adjustable vertical windscreens and overhead bubbles to protect the collector from wind and precipitation are used by nearly 75 percent of the responding facilities.

Windows usually consist of insulated, tinted glass or Plexiglas covered with venetian blinds to reduce sun glare and heat buildup. Some facilities reported using safety or tempered glass and even bulletproof glass in certain high-crime areas.

The major interior fixtures and equipment found in toll booths are shown in Figure 20, a typical single-ended toll booth. In some instances, unusual fixtures or furnishings can be found in booths such as chairs, portable TVs, toilets, sinks, and refrigerators. These booths generally are single-attendant facilities with no utility building. Such a booth, therefore, is sized and equipped to be a "toll house" rather than a toll booth. Examples can be found at some older facilities such as the Townsend and Grassy Sound Toll Bridges operated by the Cape May County Bridge Commission in New Jersey. Another fixture becoming more standard in toll booths, primarily in urban areas and isolated areas, is a silent alarm, which is linked to a nearby toll plaza administration building or local police. The alarm is used in conjunction with video surveillance cameras to record altercations.

CANOPY

The canopy is the roof over the toll booth or toll lanes. According to toll operators, the purposes of the canopy are as follows:

- Shield patrons and toll attendants from the elements;
- Serve as a mounting frame for signs, lighting, and lane signals;
- Define the location of the toll plaza for motorists; and
- Provide a chase for toll lane computer, communications, and power cables.

Following are the primary design considerations used to determine the size and shape of the canopy:

- The angle of wind-driven precipitation;
- The sun's path;
- Aesthetic considerations; and
- Local architectural requirements.

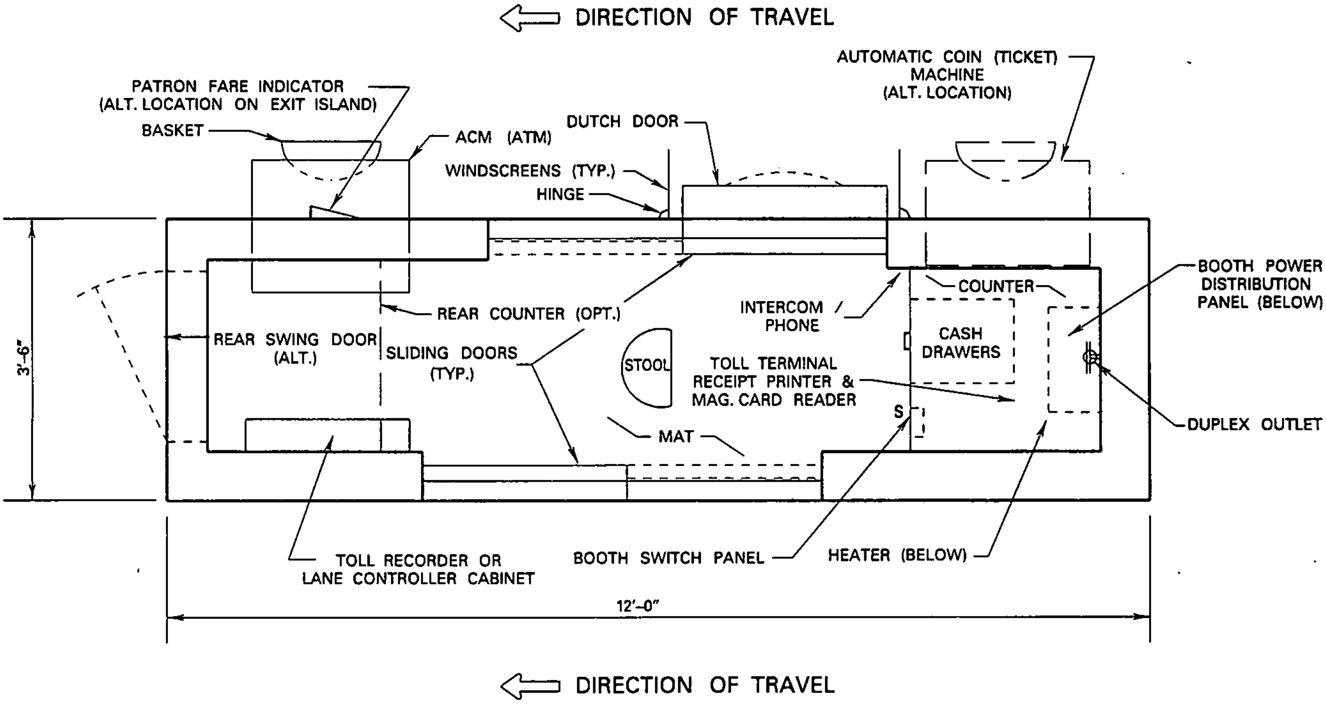


FIGURE 20 Typical single-ended toll booth (for collection in one direction of travel).

The shape of the canopy varies widely from a simple flat-pitched roof (Figure 3) to an A-frame concept used on E-470 (Figure 4). The canopy also may be sloped following the cross slope of the plaza for aesthetic reasons and to facilitate drainage. The longitudinal length of the canopies at the surveyed facilities range from an 18-ft unit spanning a 16-ft (4.9-m) booth on the Bear Mountain Bridge in New York state to a 72-ft, 9-in. (22.1-m) structure covering a 10-ft, 11 in. (3.3-m) booth on an Orlando-Orange Expressway mainline plaza. (See Appendix E for other dimensions.)

Canopy structure can be as simple as a steel roof frame with a stainless steel fascia, covered with corrugated, galvanized sheeting and built-up roofing, such as the structure of the branch lane canopy used on the Garden State Parkway. Other canopy structures vary from a more modern metal-clad deep roof (Figure 21a) used on the Florida Turnpike to the concrete fascia and structure used at the George Washington Bridge toll plaza in Fort Lee, New Jersey (Figure 21b).

Canopies serve a number of other functions, such as a pedestrian walkway at the Chesapeake Bay Bridge Tunnel toll plaza (Figure 21c), or as the location for plaza utility rooms and a toll lane access walkway at the Holland Tunnel toll plaza (Figure 21d). In another instance, a toll lane canopy was created by placing the toll lanes beneath a pedestrian/equestrian overpass at the Dumbarton Bridge east of San Francisco. Others facilities, such as the Ocean City-Longport Toll Bridge south of Atlantic City (Figure 21e), rely on a simple toll house structure with eaves as a result of aesthetic concerns of the surrounding residential community.

SAFETY DEVICES

As described in the previous section on toll island geometries, a variety of safety devices are used on the traffic approach ends of toll islands. These devices include the following:

- Concrete-filled steel bollards or steel I-beams;
- Concrete ramparts (sloped concrete shapes);
- Barrier shapes;
- Concrete crash blocks (single or tandem);
- Impact attenuators such as the GREAT System, Hex Foam, and Hydro-Cells; and
- Frangible devices such as sand barrels.

The impact attenuator has been deployed in the past 10 to 15 years to reduce the impact of an errant vehicle, damage to the vehicle, and injury to its occupant, while according added protection for the toll collector. Attenuators generally are designed for a 45 mph (73 km/hr) impact of an 8,000 lb (3629-kg) vehicle. Other devices, such as those used on the Florida Turnpike, are designed for roadway approach speed.

The toll operators overwhelmingly stated that the purpose of such safety devices is to protect the toll attendant. A majority also responded that these devices are intended to minimize damage to a vehicle colliding with the toll booth and damage to the toll lane. The operators also noted that the devices are used to redirect a vehicle back into the toll lane when struck from the side. These safety devices, as shown earlier, are placed in a

FIGURE 21a Metal-clad canopy, Florida Turnpike ramp toll plaza (Parsons Brinckerhoff, New York).

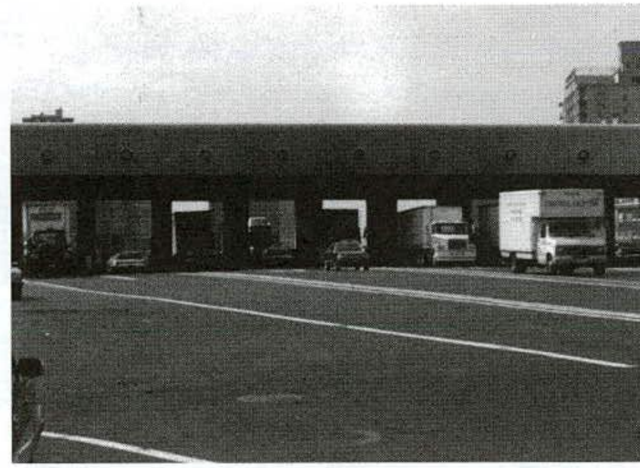


FIGURE 21b Concrete canopy, George Washington Bridge toll plaza, Fort Lee, New Jersey.

FIGURE 21c Pedestrian walkway over canopy, Chesapeake Bay Bridge–Tunnel toll plaza, Virginia.

FIGURE 21d Overhead utility rooms and toll lane access, Holland Tunnel toll plaza (Port Authority of New York and New Jersey).

FIGURE 21e "Toll house" designed for surrounding residential area, Ocean City–Longport toll bridge, Ocean City, New Jersey (Cape May County Bridge Commission).

number of configurations. They typically are placed only on the traffic approach side of the toll plaza in a directional toll plaza at which traffic in the opposing direction is physically separated.

ENVIRONMENTAL ISSUES—REMEDIAL PRACTICES

According to the toll operator survey, the most pressing environmental issues affecting their facilities are almost equally divided between air quality and noise, with water quality ranked third. The primary types of remedial measures taken to reduce the adverse impact of toll plazas on these environmental issues are presented in Table 5.

The choice of mitigating measures is largely a factor of the plaza's site, economics, space available, and environmental agency regulations. Environmental issues cannot be overlooked, and their resolution needs to incorporate input from the local community.

TABLE 5
ENVIRONMENTAL ISSUES—REMEDIAL PRACTICES

Remedial Action	No. of Responses	Typical Examples
Noise Levels		
Construction of noise wall	17	Garden State Parkway, Bear Mountain Bridge
Planting of trees	13	E-470, Illinois Toll Road
Installation of landscaping	7	Oklahoma Turnpike, Newburg Beacon Bridge
Air Quality		
Installation of positive booth ventilation	21	Goethals Bridge, West Virginia Turnpike
Increased toll barrier throughput by adding lanes or installing ETC	8	Indiana Toll Road, New York State Thruway
Water Quality		
Creation of wetland buffers	10	Florida Turnpike
Installation of oil/water separators	9	George Washington Bridge, Holland Tunnel, Orlando–Orange Expressway
Installation of settlement ponds/swale	5	Garden State Parkway, Florida Turnpike, E-470
Construction of closed drainage systems with settlement chambers	5	Bear Mountain Bridge

In addition to taking remedial actions, a few facilities engage in a proactive approach by installing CO monitors and hydrocarbon analyzers in the toll booths and tunnels to regularly monitor emission levels. These devices help regulate ventilation and alert the plaza supervisor to possible problems.

IN-LANE EQUIPMENT

In-lane equipment refers to vehicle detection and classification devices, such as treadles, vehicle loops, profile identifiers, vehicle separators, scales, overheight sensors, and ETC antennas/transceivers in a toll lane. In addition, these devices include surveillance and toll enforcement systems, traffic control devices, and toll payment indicators. Table 6 lists the various lane equipment common to toll lanes and the percentage of each device used, based on the major methods of collection, by the 45 responding toll facilities. (The percentages may add to more than 100 percent for facilities at which more than one type of collection method is available in a lane.) A brief description of each of these devices follows.

Approach Closure Gate

A wood, metal, or fiberglass approach closure gate (usually manually operated) with reflective diagonal striping is used to close a lane when not in use. Sometimes a flashing amber/red light or hazard marker is affixed to the top or center of the gate for added visibility.

Audit Treadle (Contact Type)

A contact-type audit treadle is an axle classification device installed in the toll lane in a metal frame. The pad or cover contains two to four electrical contacts, each covered by high-impact rubber strips. In a four-contact unit, two of the strips record forward motion while the other two count reverse movements based on the order in which the contacts are closed. Treadles typically come in 8- to 10-ft (2.4- to 3.0-m) lengths, with or without integral curb junction boxes, and with a drain at one or both ends.

Audit Treadle (Piezoelectric)

A piezoelectric audit treadle is a thin sensor consisting of a copper core and a copper outer sheathing separated by a piezoelectric insulator. When subjected to a wheel pressure, the sensor produces a voltage between the core and sheathing that is proportional to the applied force. In a treadle application, the piezoelectric is placed in a rubberized strip that is similar to the contact strips in a standard treadle; typically two or four strips are placed in the treadle gate. If combined with speed detection, the piezoelectric can be used as a weigh-in-motion (WIM) to compute vehicle axle weights.

Audit Treadle (Optical)

An optical audit treadle consists of an optical strip through which light is passed. Upon interruption of the light, an axle count is registered.

Beam Scale

A beam scale is a balance beam installed in a structural frame in a commercial vehicle toll lane, with a metal suspended platform used to weigh vehicles in a static manner. A beam scale is used at facilities where the toll rate is based on gross vehicle weight.

Weigh-in-Motion

A WIM is a piezoelectric, hydraulic load switch or bending plate scale installed in a toll lane or in a roadway travel lane to measure the axle load of a vehicle as it passes at low or highway speeds.

Vehicle Separator/Profile Identifier

A vehicle separator/profile identifier is an ultrasonic, radar, light curtain, or microwave scanning device either mounted

TABLE 6
TOLL LANE EQUIPMENT USE (BASED ON RESPONSES FROM 47 FACILITIES)

	Collection Methods			Responses	
Devices	Manual	Automatic	ETC	Used	Not Used
Approach Closure Gate	49	34	2	51	49
Entry/Arming Loops	28	45	17	57	43
Treadles					
Two-contact	30	26	24	—	—
Four-contact	62	17	11	—	—
Piezoelectric tube	2	—	2	—	—
Optical	8	6	2	—	—
Beam Scale	4	—	—	4	96
Weigh-in-Motion (WIM)	6	2	1	6	94
Vehicle Separator (VS)	17	11	12	21	79
Overhead Fare Indicator (OHI)	36	11	4	36	64
Height Sensor	11	4	2	15	85
Horizontal Height Bar	2	—	—	2	98
VMS (canopy-mounted)	19	11	6	19	81
Lane-Use Signal (LUS)	91	60	12	91	9
ETC Antenna	17	12	26	26	74
Transaction Loop	30	21	36	40	60
Exit Loop	21	42	17	70	30
Patron Fare Indicator	92	36	8	96	4
ETC Driver Feedback Indicator	8	6	15	15	85
Island Traffic Signal (ITS)	36	66	11	83	17
Alarm	34	57	12	77	23
Automatic Exit Gate	2	51	11	53	47
Surveillance Camera	49	21	11	51	49
Video Enforcement System	17	12	23	30	70

overhead or on a pole on the approach side of a toll lane. The device is used to physically differentiate between vehicles. A combination of an inductance loop and treadle sometimes is used for this purpose. The scanner can also be used as a vehicle profiler/identifier that creates an electronic image of the vehicle for automatic classification as part of a pre- or post-classification system.

Overhead Indicator

An overhead indicator (OHI) is an illuminated display typically mounted on the upper part of the booth or the canopy fascia in line of sight to the toll plaza supervisor's room. The OHI, which automatically displays the vehicle classification entered by the toll collector, is used by the supervisor to observe toll transactions and monitor the attendant. An OHI can be replaced by installation of supervisor console displays and video surveillance cameras.

Height Sensor

A height sensor is an optical or infrared sensor mounted at a predetermined height to monitor overheight vehicles and to classify vehicles not typically found at a facility. The latter sensor can reset an ACM or, in combination with the treadle, register a difference in vehicle class (e.g., a bus or a commercial vehicle permitted to use an automatic lane). A height sensor provides an audit check that is registered in the lane traffic report.

Horizontal Height Bar

A horizontal bar is a height clearance restrictor consisting of a horizontal bar placed above a toll lane at a prescribed height to deter commercial vehicles from using designated passenger vehicle lanes and to restrict overheight vehicles.

Variable Message Sign

A variable message sign is a fiber-optic, disk/light matrix or LED illuminated sign used before toll plazas or mounted in toll lanes to provide information on lane status and payment methods. When used on open roads, multiword messages on roadway/traffic conditions and important motorist alerts can be posted. At a toll plaza, the letter height may vary from 12 to 18 in. (30 to 45 cm), depending on approach speed and surroundings.

Changeable Message Sign

A changeable message sign is a rotating drum, neon tube (such as those used on the New Jersey Turnpike), or other device that can only display a fixed number of predetermined messages. These devices are generally used on canopies, along the mainline roadway, and on ramps to alert motorists to changes in traffic conditions and road usage.

Overhead Lane Signal

An overhead lane signal consists of standard 8- or 12-in. (20- to 30-cm) circular traffic signals or lane-use signals in red/green or combinations of colors. These signals consist of red X's and green down arrows, either displayed singularly or in a single section. The signals are mounted over the center of a toll lane to indicate the status of the lane, whether it is open or closed. On a toll plaza with no physical barrier between approaching and departing traffic, a single red indicator or red X is displayed on the departure side of nonreversible lanes.

ETC Antenna

An ETC antenna, a radio frequency or acoustic wave antenna mounted in the toll lane, is used to focus a signal emitted by a transceiver to allow reception and transmission of transponder/tag information between the vehicle and a lane reader or controller. The antenna can be in the form of an embedded pavement loop.

Transaction Loop

A transaction loop, a vehicle detector loop embedded in the toll lane, is used to detect and monitor the presence of a vehicle at the collection point. Once the driver of the vehicle pays the toll and clears the loop, the system is cleared and available for the next transaction.

Entry/Arming Loop

An entry/arming loop is a vehicle detector loop embedded where the toll lane approach begins. These loops typically are used to activate or alert the collection system of an impending transaction.

Exit Loop

An exit loop is a vehicle loop detector typically used to close the gate or change the signal to red. The exit loop usually is positioned at least a vehicle length from the transaction loop, with its back edge slightly ahead or even with an automatic gate arm or an island traffic signal. An exit loop also can be used to trigger a video enforcement system (VES) or to activate an audible/flashing alarm if a vehicle transaction is not registered and the motorist proceeds.

Patron Fare Indicator

A patron fare indicator (Figure 22), a disc matrix or flip disc, microprocessor-actuated, illuminated display indicates the toll amount charged or the decreasing amount of the toll in an ACM as the coins are processed. The indicator is mounted either on the side of the booth, ahead of the collection point, or on a post on the toll island, ahead of the collection point, facing the driver.

FIGURE 22 Patron fare indicator (PFI), Benjamin Franklin Bridge toll plaza, Camden, New Jersey (Delaware River Port Authority).

ETC Driver Feedback Indicator

An ETC driver feedback indicator (DFI) is a micro-processor-actuated disc matrix, flip disc, or blank-out sign with a fixed message (ETC program name).The DFI is used to display a series of messages to the motorist regarding his or her ETC account status (e.g., ACCOUNT LOW, ACCOUNT INVALID, or AMOUNT PAID/$XX.XX). The DFI is mounted in advance of an island traffic signal, facing the driver. Figure 23a shows a

FIGURE 23a ETC driver feedback indicator (New York State Thruway Authority).

typical installation at the Tappan Zee Bridge toll plaza in an E-ZPass lane.

Island Traffic Signal with Optional Audible/Visual Alarm

An island traffic signal consists of a two- or three-section traffic signal head mounted on a post at the departure end of the toll island in automatic or ETC toll lanes to signal a patron to stop and pay the toll. On completion of the transaction, the lane controller causes the signal to turn green, releasing the vehicle. If payment is not made or is incomplete, the signal remains red. If the vehicle proceeds through the red signal, an optional audible and/or flashing light atop the signal is actuated.

Automatic Exit Gate

An automatic exit gate is a motorized hydraulic or magnetic gate, with a breakaway wood or frangible PVC or fiberglass arm, installed at the departure end of a toll lane, usually in an automatic lane. These gates have been used by some operators in ETC applications. The gate is raised when activated by the lane controller as a toll transaction is completed or when a vehicle is detected. Closure is actuated by the exit loop.

Video Surveillance Camera

Video surveillance cameras, such as those used by banks, are used by the plaza supervisor or toll security/audit personnel to monitor and record transactions in a toll lane. Normally, one fixed camera is mounted on the departure side of the canopy. At remote locations, in unattended lanes, and in areas prone to vandalism or crime, these surveillance cameras run continuously. They are monitored by personnel at adjacent larger plazas or by police off-site.

Violation Enforcement System Camera

A VES camera, a low-lux camera or one with a strobe, infrared, or incandescent light source, is used to record the rear license plate of a toll violator, typically in an automatic or ETC lane. The camera takes a still frame, records a slow scan video or creates a video image in a digital or analog format depending on the clarity required and the data communications interface.

A VES camera, which usually is mounted on the roof of a toll booth, on the underside of a canopy, or on the toll island, is focused on the rear of a departing vehicle. The camera is linked to a video recorder or image processor and lane controller so that the taped violation can be stamped with the date and time the violation occurred. The tape can be used to view the violation or to process a violation notice. Data on the violation are stored by the enforcement computer.

Figure 23b shows a typical VES installation. Figure 23c shows such an installation at the New York State Thruway Tappan Zee Bridge toll plaza.

In-Lane Equipment Required

The purpose of in-lane equipment is to confirm a vehicle's classification, initiate the transaction, confirm payment, terminate the transaction or signal, and record a violation. Thus, the equipment required to maintain this sequence of functions varies by toll collection method, as shown in Figure 24. The figure also contains typical dimensions used for placement of these devices. The range of dimensions as reported by the responding toll facilities is tabulated in Appendix F. Placement of these devices varies depending on the manufacturer, the operator, and toll schedule/audit criteria (e.g., use of pre- or post-classification).

TOLL COLLECTION EQUIPMENT

Toll collection equipment encompasses all devices used to collect and process tolls and record toll transactions. These devices include freestanding equipment mounted on the toll island and equipment installed in the booth, such as the following:

- Toll collector terminals
- Magnetic card readers or key slots
- Receipt printers
- Bar code readers (incorporating laser scanners)
- Automatic coin machines
- Automatic ticket dispensers.

Data lines for this equipment are connected to a wiring distribution block usually placed in a toll lane cabinet. The cabinet, which can be located in the booth, tunnel, or computer room, is connected to the lane controller. In-lane toll equipment also is wired into this cabinet.

The lane controller is a dedicated microprocessor that monitors and operates toll equipment and records toll transactions. In the event of a power failure or communications break with the plaza computer, the lane controller, typically equipped with its own battery supply, can operate as a standalone processor capable of storing lane transactions for 24 to 72 hr. Transactions are downloaded either in real time or pooled to a central plaza computer for storage and printing of reports.

Toll collection methods and equipment used in a lane vary by the toll rate schedule, type of toll system, and patrons. Nearly 50 percent of the toll operators surveyed use a combination of manual and automatic equipment in a lane to provide flexibility to meet different demands. Those who have ETC (about 10 to 15 percent) have a combination of dedicated and mixed-use lanes (a single lane with ETC and manual or automatic modes). Both the New York State Thruway and Dallas North Tollway prefer dedicated ETC lanes because of the potential in mixed-use lanes for rear-end collisions when vehicles stopping to pay a toll conflict with ETC users who are not likely to stop.

Most toll collection equipment is installed in the toll booth, with the exception of a freestanding ACM or ATD (without a booth). Some facilities have an ACM or ATD located before or after the toll booth, where multiple methods of collection or

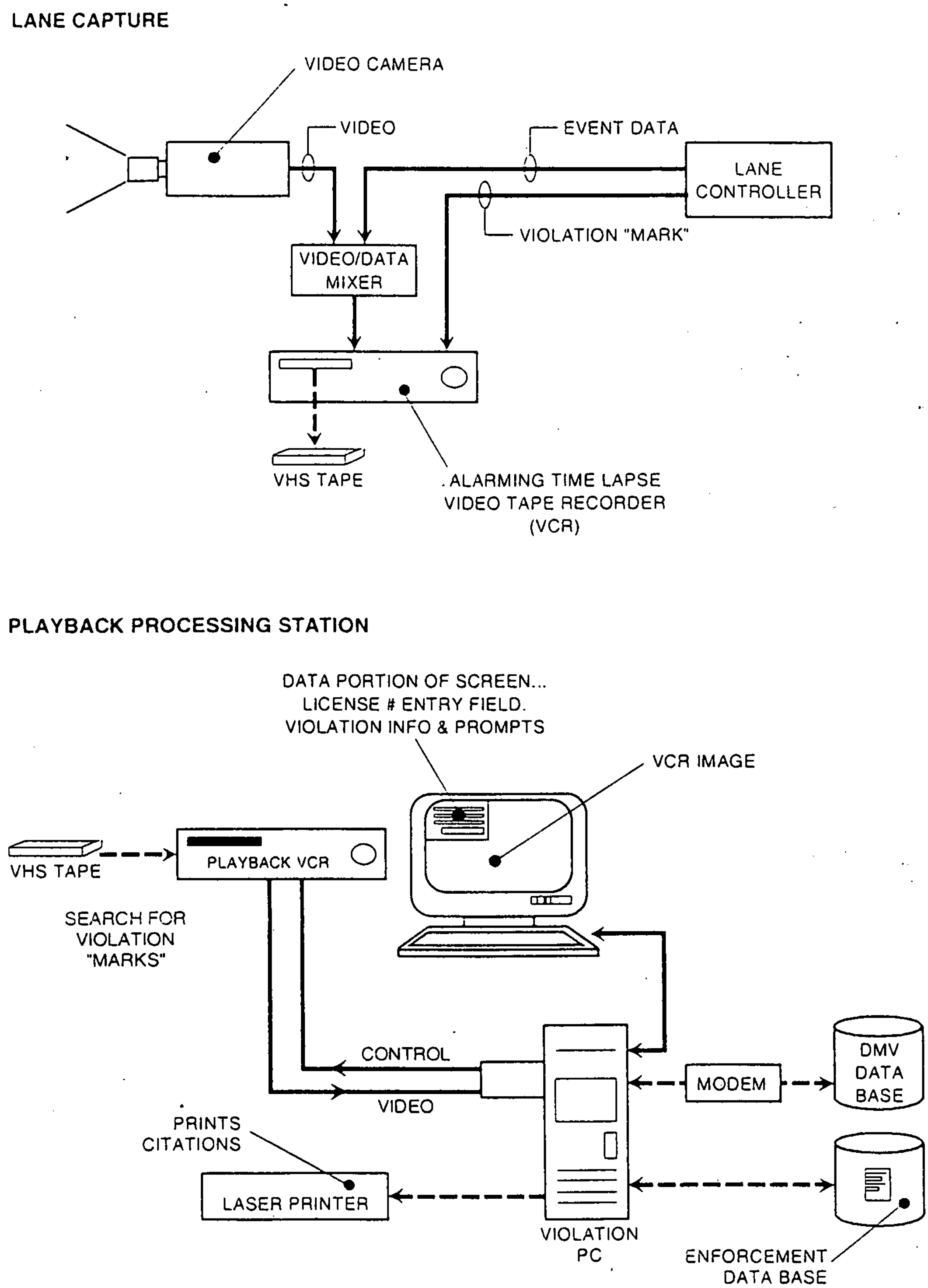


FIGURE 23b Video enforcement system (VES) (Cubic Automatic Revenue Collection Group, San Diego, California).

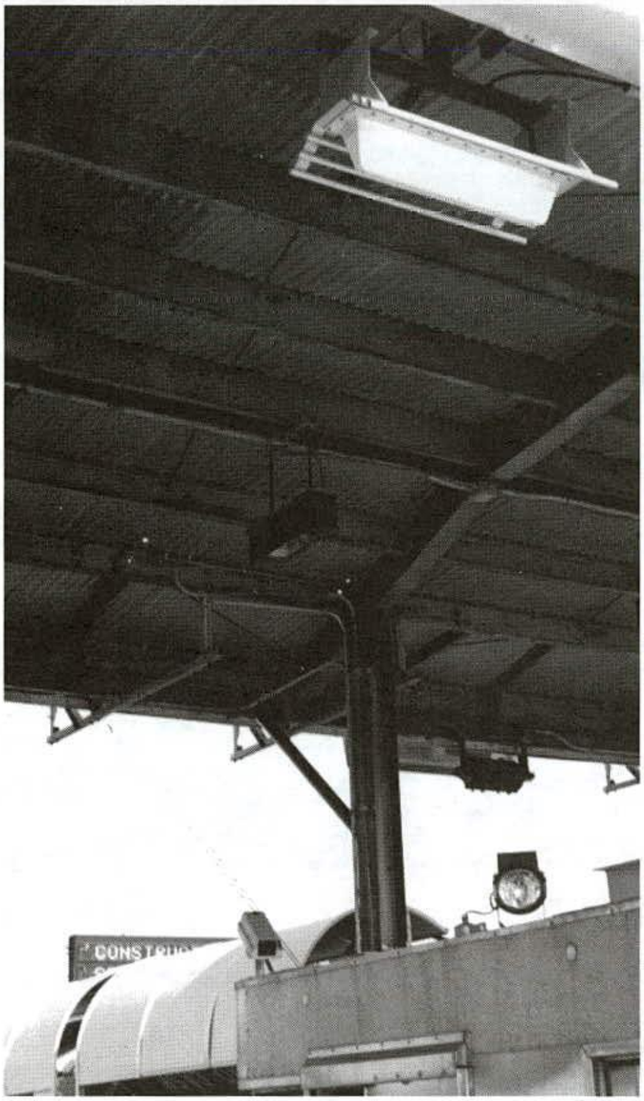


FIGURE 23c VES lane installation, E-ZPass (ETC) lane, Tappan Zee Bridge toll plaza Note the booth-mounted camera and strobe light as well as the ETC antenna (top right) (New York State Thruway Authority).

ticket dispensing are available. Toll collection equipment typically found in a manual, automatic, or ETC lane and used in conjunction with in-lane equipment is described in the following sections.

Toll Collector Terminal

A toll collector terminal (TCT), as shown in Figure 25a, is also known as a button box or collector classification unit. The terminal has designated classification or function buttons, a numeric keypad, touch screen, or touch pad by which the toll attendant enters the classification of a vehicle that has entered the toll lane. The classification is based on a prescribed toll schedule (usually determined by the number of axles). The TCT prompts the attendant for information, including completion of payment, and prints receipts. The keypad, function buttons, or touch pad also may allow the attendant to control the gate and the island traffic signal and to open and close the lane.

The terminal permits a reclassification in case of an error before the transaction is completed. A TCT also may compute and display a toll based on a ticket scan or a fixed rate based on a preclassification system that automatically registers the vehicle class once it has entered the toll lane, or the classification can be entered manually. The attendant verifies the transaction on the TCT, which communicates the transaction history through the lane controller to the plaza computer.

Magnetic Card Reader

A magnetic (credit) card reader, generally a swipe-through reader, is an integral part of the collector terminal. The reader permits the attendant to log on (key in) to operate a lane or to log off (key out) to close a lane. It also permits the use of facility credit cards for toll payment and nonrevenue passage.

Receipt Printer

A receipt printer is a high-speed device capable of printing 150 to 220 lines per minute, by using a dot matrix printer or by imprinting a roll of standard receipt paper (adding machine tape) or a heat-sensitive paper with a date-time stamp, toll amount, toll lane and plaza identification, and facility name or log. Receipt printers can be incorporated in ACMs; however, they tend to slow the processing rate. Therefore, they are not used at high-volume facilities. Patrons who need a receipt are encouraged in advance by overhead signs to use attended full-service lanes. The receipt printer interfaces directly with the toll terminal or ACM and the lane controller by communication links.

Bar Code Reader

The bar code reader (Figure 25b) is one of the earliest, low-cost ETC and automatic vehicle identification (AVI) systems. The reader uses a laser scanner that reads a bar code affixed to the side of a vehicle traveling at speeds up to 35 mph. It is mounted on the approach side of the toll lane and can be used alone or in conjunction with an ACM to speed up toll processing, particularly at facilities whose toll rates exceed $1 or at facilities with a discount program. (Such a configuration, used on Delaware River Port Authority bridges, is shown in Figure 25c.) The scanner, a complex device with built-in humidity control, is capable of rejecting counterfeit bar codes. The scanner, whose cost is comparable to that of an ACM, is easy to maintain.

Automatic Coin Machine

An ACM (Figure 17a) is an electronic coin/token processor that collects, counts, evaluates, and stores various denominations of coins and tokens. The unit comes with a coin basket to

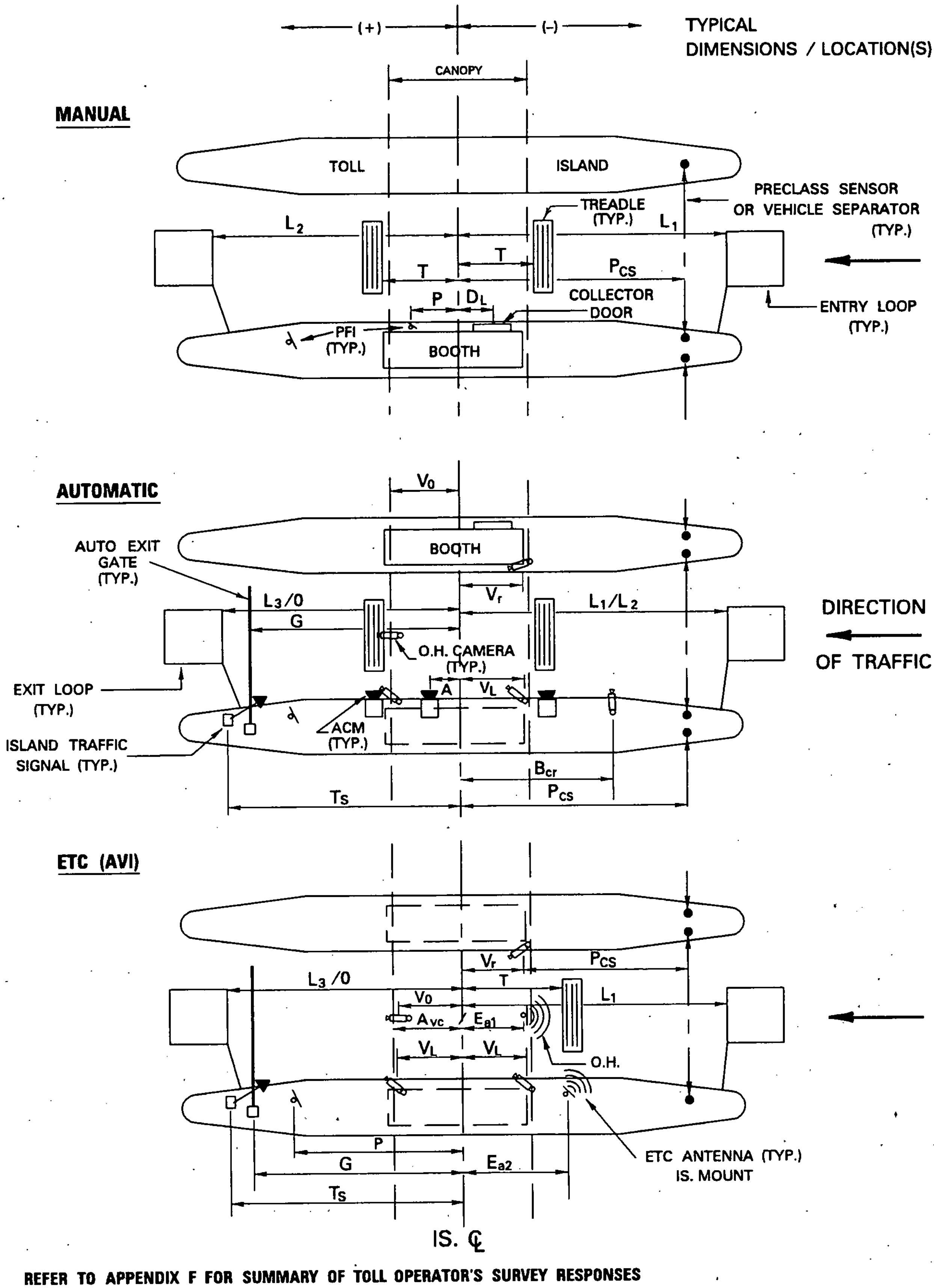


FIGURE 24 Typical toll lane equipment configurations.

FIGURE 25a Toll collection terminal (TCT) with magnetic card swipe reader mounted on the right (Cubic Automatic Revenue Collection Group, San Diego, California).

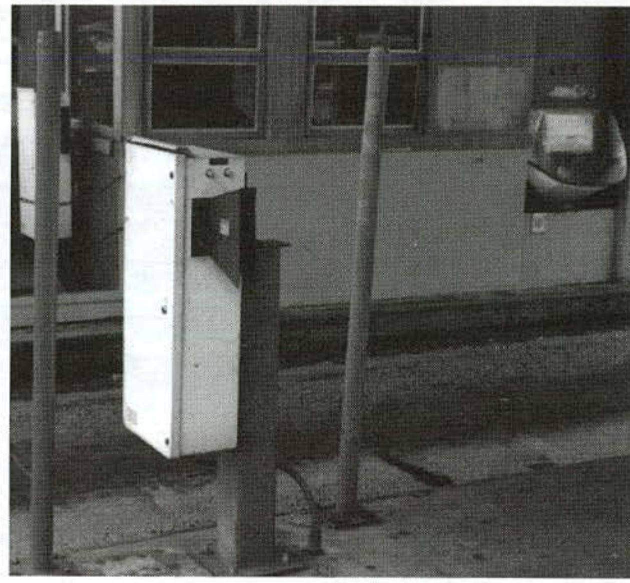


FIGURE 25b Laser bar code reader (Delaware River Port Authority).

receive deposits and a coin sorting and microprocessing delineator that evaluates the currency by size (diameter and thickness), weight, and metallic content. Slugs either can be returned or deposited into a reject compartment. The coins are collected in the order of deposit, with the last transactions visible at the rear of the unit.

All processed coins and tokens are deposited in a cash vault, which is accessible from the bottom rear of the ACM, in a booth-mounted or freestanding island cabinet. The vaults can store several thousand coins and tokens. Most operators replace the vaults when their weight reaches 70 to 100 lb (31.8 to 45.4 kg). Coin/token vaults can be located in a tunnel, where they are connected by drop tubes to the ACM located in the toll lane above. An automatic switch diverts coins from a full vault (by weight sensor) into an empty vault in a multivault system.

The ACM connects directly to the lane controller or has its own lane controller to handle toll reporting in conjunction with data from the lane audit/classification equipment. The processing rate can be adjusted slightly to establish throughput levels. The typical ACM basket, as reported by the responding toll operators, is mounted 34 to 38 in. (86 to 96 cm) above the pavement surface and is even with the face of the toll island curb (see Figure 13).

Some toll facilities, such as those at international border crossings, particularly in Canada, as well as the Dulles Toll Road and Georgia 400, use toll attendants and ACMs jointly in a lane. The attendant provides change as all transactions are made using the ACM. This system is purported to provide tight audit control and facilitates currency exchange in areas in which different monetary systems prevail.

FIGURE 25c Automatic coin machine (ACM) used in conjunction with laser bar code reader and automatic gate, Benjamin Franklin Bridge toll plaza, Camden, New Jersey (Delaware River Port Authority).

Bill Changer

A bill changer is a relatively new adaptation of a change-making device commonly found on vending machines and in transit facilities. Bill changers can handle denominations from $1 to $10 depending on the toll rate, providing change by means of a return hopper in either coins or tokens. The processing rate depends on the condition of the currency, adherence to the insertion criteria, and the familiarity and dexterity of the patron in using such a system. Bill changers are used in Europe, but because of low processing rates and lack of reliability, they not popular at U.S. toll facilities.

Automatic Ticket Dispenser

On ticket toll systems, the automatic ticket dispenser (ATD) dispatches a ticket that is coded with a time and date stamp and point of entry. The ticket also shows the toll schedule associated with the vehicle class for all points of exit, based on the entry point. The ATD is usually set to operate in a single-vehicle-class environment with a single ticket dispensing slot. The ticket is automatically dispensed when a vehicle enters a transaction loop or treadle in advance of the ATD. The rate of ticket dispensing can be adjusted to control throughput based on the detection location, thereby allowing metering rates to be established for entering vehicles. The unit can be booth mounted or freestanding.

Multiple ticket dispensing slots can be provided on an ATD. High-low slots are used to accommodate private passenger vehicles (commonly referred to as Class 1 vehicles) and higher class commercial vehicles (trucks and buses). Thus, multiple vehicle classes can be accommodated through a single entry lane. Intercoms are incorporated by some facilities in both the ATDs and ACMs to provide motorist assistance. Figure 17b shows a high-low ticket dispenser used on the Pennsylvania Turnpike.

LANE CAPACITY

As discussed in chapter 2, lane capacity varies widely depending on the type of toll system, method of collection, toll rate, vehicle mix, type of patron, use of gates, geometry of the plaza, driver behavior and familiarity, attitude and efficiency of the attendant, and nature of the transaction (e.g., ETC, change, receipt, information, or purchase). Table 7 presents the range and average values for capacity reported by the surveyed toll operators. These values are referenced to the type of collection method, use of multiple coins, ticket entry and payment, and special lanes such as bypass, tandem, branch toll, and ETC.

TOLL PLAZA ACCESS

Parking

More than 90 percent of the surveyed toll operators provide on-site parking for employees. Access to these lots typically is from mainline or local roads. The latter depends on the location of the plaza. The security of a local access road needs to be addressed during design. For the five facilities with remote parking, van service is provided at three, whereas the other two reported that their sites are within walking distance.

Toll Lane Access

Of the 45 facilities from which data were collected, more than 75 percent reported that collectors and other personnel walk across the plaza to their assigned toll lanes. For the 19 facilities with tunnels, four reported that personnel use them for toll lane access. The others allow personnel to walk across the plaza or use the tunnel. (The Lincoln Tunnel reported that it has a tunnel but that it is used for utilities only. No toll island stairwells are provided for personnel.)

ACM Vault Servicing

Thirty-one of the 45 surveyed facilities reported having ACMs. Of these facilities, 45 percent have vaults located in the access tunnel. In addition, 23 of the 31 facilities reported having in-lane vaults. Therefore, 74 percent of all vault servicing is done from the toll island or inside a booth.

TRAFFIC CONTROL DEVICES

Within a toll plaza, a number of traffic control devices, including pavement marking; cones, pylons, and stanchions; signals; and various signs typically are used to guide motorists to a preferred toll lane, help them select payment method, and alert them to reduce their speed. The use of these devices is described in the following sections.

Pavement Markings

Pavement markings such as lane lines, gore striping, and transverse lines are used by 61 percent of the surveyed toll facilities to channel vehicles in the plaza transition and gore areas, by guiding motorists to selected toll lanes and alerting them to reduce their approach speed. Transverse markings placed across the approach transition zone at gradually reduced spacing slow drivers down. If a driver does not slow down, the reduced spacing gives him or her the illusion that the vehicle is accelerating. A typical transverse marking pattern used by the New Jersey Highway Authority is shown in Figure 26 (*18*).

Gore striping typically is a painted extension of the toll island curb at the approach to a toll lane. The right toll island curb (driver's side) is extended parallel to oncoming traffic, and the left curb of the same island is extended on a diagonal to intercept it. Lane lines are usually extended back to the approach travel lanes from every third or fourth toll lane, depending on the ratio of approach travel lanes to toll lanes normally available to traffic. Where reversible lanes are used, cones, pylons, or stanchions are used to supplement or replace lane lines.

Cones, Pylons, Stanchions, and Moveable Barriers

These devices are used in reversible lane operations and in dedicated ETC lanes. Cones are placed in a toll lane to signify that the lane is closed, in conjunction with a red lane signal where approach closure gates are not used. If a positive barrier between opposing approach traffic flows is needed for added safety, moveable concrete barriers might be used. However, moving these devices requires a specially designed barrier-moving vehicle that can shift the interconnected barrier sections up to 18 ft laterally. Such a vehicle travels at about 6 mph and is generally used on long sections of reversible roadway such as on the Tappan Zee Bridge in New York.

Overhead Lane Signals

Responses from the toll operators indicate that 95 percent

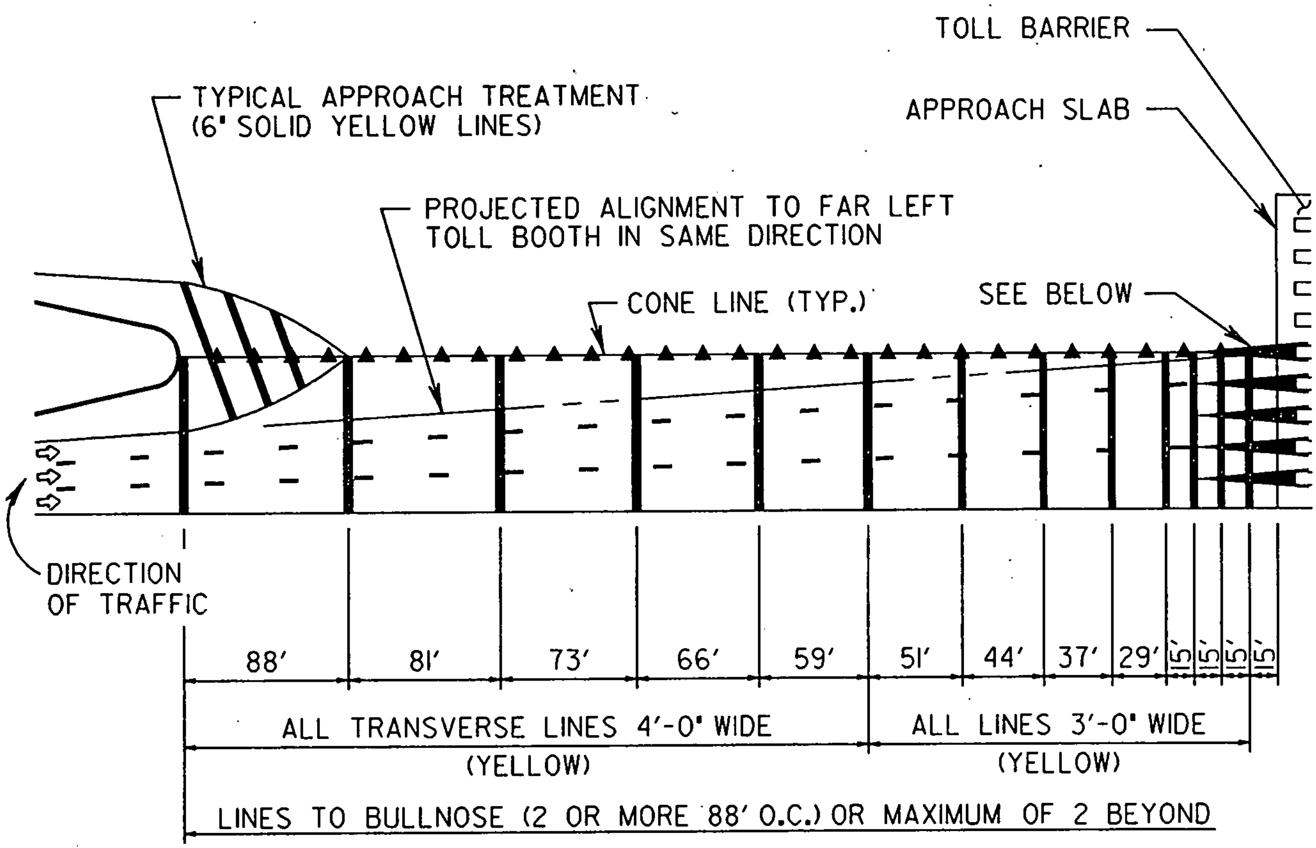
TABLE 7
TYPICAL TOLL LANE CAPACITIES BY METHOD OF COLLECTION AND VEHICLE USE (IN VEHICLES PER HOUR PER LANE—VPHPL)

Types of Toll Payment/Lanes	No. of Responses	Actual Data Range (VPHPL)	Average Value (VPHPL)	Notes
Payment Methods				
Manual (Attended)				
Private passenger vehicles	22	240–500	416	
Commercial only	11	162–350	233	
Mixed (< 5% trucks/buses)	24	180–550	360	
ACM (Exact Change, Single Coin/Token)				
Private passenger vehicles	4	600–950	687	
Mixed (<5% trucks/buses)	2	550	550	
ACM (Multiple Coins/Tokens)				
Private passenger vehicles	22	450–925	627	
Mixed (< 5% trucks/buses)	2	550	550	665–745[a]
Electronic Toll Collection				
Private passenger vehicles	4	850–1300	1154	
Mixed (< 5% trucks/buses)	2	500–1600	1050	
Bar Code Reader with ACM (Single Coin/Token)				
Private passenger vehicles	1	550		
Commercial	1	550		
Mixed (< 5% trucks/buses)	1	500		
Manual (Exact Change)				
Private passenger vehicles	2	203–393	315	750–800[b]
Commercial	1	298		
Credit Card				
Commercial	1	425		
Ticket Entry				
Private passenger vehicles	5	327–750	587	
Commercial only	4	159–700	382	
Mixed (< 5% trucks/buses)	4	425–600	506	
Ticket (Manual Payment at Exit)				
Private passenger vehicles	2	325–350	338	
Mixed (< 5% trucks/buses)	2	275–465	370	
Special Lanes				
Feeder Lane with 2 or 3 Branch Lanes				
Private passenger vehicles	1	640–1975		
Tandem Lanes (Manual)				
Private passenger vehicles	2	500–540	520	
Mixed (< 5% trucks/buses)	1	520		
ETC Express/Lanes				
Private passenger vehicles	2	1200–1800	1500	

Source: Survey of U.S. Toll Operators—April 1994.

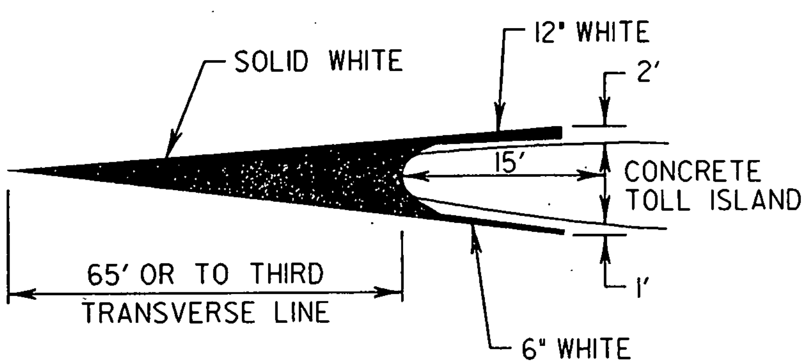
[a]Woo, T.H., and L.A. Hoel. Toll Plaza Capacity and Level of Service. *Proc., 70th Annual Meeting of the Transportation Research Board*, Washington, D.C., January 13–17, 1991, p. 11, Table 1 (former Richmond–Petersburg (VA) Turnpike).

[b]Gregory, A.E. Congestion Management Techniques. *Proc., International Bridge, Tunnel, and Turnpike Association*, New Orleans, LA, November 1992, pp. 121–125 (Tappan Zee Bridge).



TRANSVERSE STRIPING (TYPICAL)

N.T.S.



PAINTED BULLNOSE (ISLAND GORE) STRIPING (TYPICAL)

N.T.S.

(ADAPTED FROM NEW JERSEY HIGHWAY AUTHORITY (GARDEN STATE PARKWAY DESIGN MANUAL, TRAFFIC DIVISION - PAVEMENT MARKING GUIDE EXHIBIT 7-A,) (18)

FIGURE 26 Typical transverse pavement markings on a toll plaza approach (*18*). Markings give illusion of acceleration if drivers do not slow down (New Jersey Highway Authority).

use some form of overhead lane signal. Of these, 67 percent use red/green circular signal heads, 19 percent use standard lane-use signals (red Xs and green down arrows), and 14 percent use a combination of these signals. Overhead lane signals not only provide the status of a lane (i.e., whether it is open or closed), but also depict the method of toll collection if used in conjunction with advance and overhead canopy signing. For example, the New Jersey Highway Authority uses flashing green signals (described on advance information signing) to signify an automatic (exact change) lane and a double green signal to signify a "token only " lane.

Fixed Message (Advance) Signs

Advance signing uses symbols, colors, and legends to tell drivers which lane to use for specific methods of collection. Seventy-one percent of the toll facilities surveyed employ some form of advance signing.

Fixed Message Signs

As shown in Figures 27a, 27b, and 27c, fixed message signs consist of rotary drum, suspended vertical, and flip panel signs, respectively. These signs describe and reinforce the information depicted on advance signs pertaining to methods of collection available in a specific lane and lane restrictions such as commercial vehicles only and exact change. Forty percent of the facilities reported using fixed signs in their toll lanes to denote specific lane use. Rotary drum signs such as those used on the New York State Thruway (Figure 27a) and the Florida Turnpike have three changeable messages. By varying the messages, the toll lane configuration can be changed to meet different customer payment needs on weekdays and weekends. Fixed message signs can be mounted on top of the canopy or on the fascia or suspended over a particular toll lane.

FIGURE 27a Canopy-mounted changeable message signs designate collection methods available in lanes, New York State Thruway Spring Valley toll plaza (New York State Thruway Authority).

FIGURE 27b Suspended vertical sign, Betsy Ross Bridge, circa 1988 (Delaware River Port Authority).

FIGURE 27c Flip signs above and below canopy, Garden State Parkway (New Jersey Highway Authority).

Variable Message Signs

Programmable variable message signs are used by only 8 percent of the surveyed toll facilities. Messages are limited only by the number of characters and lines available and by highway authority policies. These signs are mounted in advance of the

FIGURE 28a Advance variable message sign (VMS) designating available ETC lanes (E-ZPass), Tappan Zee Bridge, Nyack, New York (New York State Thruway Authority).

FIGURE 28b Canopy-mounted VMSs used to designate lane status and method of toll collection, Newport Bridge toll plaza, Rhode Island (Fiberoptic Display Systems, Smithfield, Rhode Island).

plaza and on the canopy. They serve two purposes: to provide information on the method of collection available in the lane and to provide traveler information. A typical advance variable message sign at the Tappan Zee Bridge is shown in Figure 28a. Figure 28b shows a canopy installation at the Newport Bridge.

PLAZA ADMINISTRATION BUILDING

The plaza administration or utility building is similar to the toll (gate) house of the 17th century. The building serves as the support structure for the operation and maintenance of the toll plaza. It is from here that utilities are distributed and controlled, employee amenities are maintained, the toll collection process is overseen, and revenues are processed and audited. At some facilities, administration and financial management functions also are conducted in the building. Some operators sell tickets and tokens at a counter in the lobby.

SIGNING

One of the most important elements in toll plaza design is providing concise and adequate driver information with signing, both in advance of and at the toll plaza. The primary purpose of advance signing is to warn drivers of the presence of a toll plaza. Other purposes are to provide information on toll rates and methods of payment available and to provide regulatory information, tailored to the payment of tolls and use of the toll plaza and toll lanes.

The MUTCD states that toll facilities are required to comply with standards set forth for freeway guide signing but not for toll plaza signing (*13*, p. 2F-1). Some states, such as New York, address advance plaza warning signs in their state manual. The MUTCD also states that "where messages are required other than those herein provided for, the sign shall be of the same shape and color as standard signs of the same functional type"(*13*, p. 2A-4).

From a preliminary review of data on toll plaza signing compiled by the Institute of Transportation Engineers' Committee 4M-29, Driver Informational Needs at Toll Plazas (forthcoming), there appears to be a lack of consistency in the color and text used by toll facilities to convey similar information. In addition, the placement, mounting, and repetition of these signs and the consistency in the use of certain signs varies. Moreover, operators categorize the function of signs differently. For example, some consider service signs depicting collection methods as regulatory in nature. Others consider warning signs such as TOLL AHEAD (after which the distance is stated) also as regulatory and regulatory signs such as TRUCKS AND BUSES USE ATTENDED LANES as informational. Colors used for text and background also vary widely among facilities and, in some cases, are inconsistent with accepted conventions as stated in the MUTCD.

Consistency and uniformity of message, color, and placement of signs at toll plazas according to functionality is essential nationwide to enhance driver awareness, optimize the use of toll facilities, and promote safety in toll plazas.

Messages

There are three functional categories of signs: regulatory, warning, and informational or guide signs. At toll plazas, the general messages that fall under these categories are as follows:

- Regulatory—Facility regulations such as speed limits, enforcement measures, toll schedules, use of specific lanes by certain classes or groups of users, prohibitions, and directions (e.g., STOP–PAY TOLL).
- Warning—Signs advising motorists of a toll ahead or telling them to reduce speed or alerting them of an un-

usual condition such as a height or width restriction at the plaza.

- Information/Guide/Service—This series includes service messages such as the methods of toll collection available and how to identify them, as depicted in Figures 28b and 28c. These signs use logos (symbols), color, and text to convey information. Driver recognition, rather than understanding, is essential in such instances because of the amount of information and the number of decisions drivers face when approaching a toll plaza. This practice is similar to that used to indicate food and gas available at service areas and to indicate off-facility services on interstate highways and major toll roads, such as the Maryland and Delaware Turnpikes, and along segments of I-95.

Color

The colors associated with each of the three functional categories are defined in Section 2A-11 of the MUTCD. Examples of basic text, border, and background colors for each category are as follows:

- Black text and borders on a white reflective background denote a regulatory sign, whereas red on white is used to signify a prohibition and green on white permission.
- Warning signs typically use black lettering on a yellow reflective background.
- For the guide series, the MUTCD specifies reflective white text and borders on a green background.
- A recent adaptation of the guide or informational series, designated for service signing, uses white reflective characters and borders on a blue background with logos or name inserts depicting available services.

Placement

Because toll facilities vary in size and are found on different classifications of roads with various posted speed limits, placement of signs is not always the same. Placement of toll signs must be integrated with other standard highway signs, which have specific guidelines as to their placement, based on the category of sign, classification of roadway, and speed.

Based on information provided by the operators' survey, Figure 29 depicts the location and number of the major categories of signs used in advance of toll plazas. The location is represented by the distance measured by the centerline of the toll plaza and is further divided by the number of signs in a particular category. It is apparent from the number of signs deployed by the surveyed toll operators that an emphasis is placed on warning and speed restriction signs.

Approaches—Most advance signing is placed within 1/2 mi. (800 m) of the toll barrier with warning signs starting 1 to 2 mi. (800–1600 m) in advance. Speed restriction advisories typically start at 1/2 to 1 mi. (800–1600) m) out. Most agencies tend to use 2 to 3 advance panels. Again placement and number of panels is largely a function of the type of panel, posted speed, the facility's location, the driver's awareness, and the prominence of the upcoming toll plaza. For urban facilities, advance signing is placed closer to the toll plaza (usually less than 1 mi (1.6 km), depending on the proximity of interchanges. On heavily traveled turnpikes such as I-76 (Pa. Tpk.), I-95 (N.J. Tpk.), and I-80 (Ohio Tpk.), advance warning that is farther from the toll plaza may be warranted. For example, turnpikes with infrequent mainline toll plazas and interchanges typically use multiple signs starting 1 to 2 mi (1.6 to 3.2 km) in advance of a plaza or interchange. In some cases, warning/information signs are placed as far as 3 mi (4.8 km) before the plaza. Toll schedules, on the other hand, appear to be within 2,000 ft (610 m) of most toll plazas. It should be noted that a simple per-axle toll rate (e.g., TOLL/CARS $1.00/EACH ADDLE AXLE $1.00) greatly simplifies toll processing and facilitates the patron's comprehension, compared with rates that are not multiples of an axle count.

Toll Lanes—Within toll lanes, motorists usually are confronted by a multitude of signs, ranging from STOP–PAY TOLL to the toll rate schedule, speed limits, lane restrictions, toll payment methods designated for a lane, and regulatory messages. Some facilities post information on special events in the area, safety tips, and directions to popular attractions on the booth.

Based on information obtained for 40 facilities, Table 8 provides information on typical signs, their use, and their locations. Samples of regulatory signs and other messages displayed appear Appendix B.

LANE CONFIGURATION

As described in chapter 2, lane configuration implies the arrangement of toll lanes at a plaza according to methods of collection. Of the 45 facilities responding, 70 percent replied that they do not use a fixed arrangement. The majority alter the opening and closing of lanes depending on patron demands.

When asked to indicate an example of their typical configuration, most operators showed their automatic lanes on the left side of the plaza, with ETC lanes spread across the plaza in dedicated and some mixed-use lanes. Operators of the Massachusetts Turnpike and Lincoln Tunnel, for example, noted that they offer exclusive HOV and "bus only" bypass lanes at their plazas. Twenty-eight percent reported that they have a wide-load lane on the right side of the plaza that is between 14 ft (4.3 m) and 16 ft (4.9 m) wide, with some more than 34 ft (10.4 m) wide.

To increase toll barrier throughput, 5 of the 27 responding facilities, including the Garden State Parkway and Pennsylvania Turnpike, use tandem or branch toll lanes. Most operators, however, have not adopted such practices.

Operators were asked if their toll lanes are equipped for more than one method of toll collection. Seventy-one percent have only one method available. Most operators whose toll plazas do have more than one collection option available in a lane (e.g., manual and automatic modes) base their decision to equip a lane in this manner on the following:

SIGN CATEGORY	Percent Respondents (%) With Signs Located at:						
	0-1000 Ft.	1001-2000 Ft.	2001-3000 Ft.	3001-4000 Ft.	4001-5000 Ft.	5001-6000 Ft.	TOTAL**
TOLL SCHEDULE	38	18	4	0	0	22	82
WARNING/INFORMATION	18	16	11	2	2	27	76
SPEED RESTRICTION/ADVISORY	62	27	16	0	0	7	111
TOLL LANE USE INFORMATION	36	20	18	2	0	0	76

SIGN CATEGORY	Percent Respondents (%) With Signs Located at:				
	6001-7000 Ft.	7001-8000 Ft.	Over 10000 Ft.	No Information*	TOTAL**
TOLL SCHEDULE	0	0	2	36	38
WARNING/INFORMATION	11	2	33	42	89
SPEED RESTRICTION/ADVISORY	0	0	0	62	62
TOLL LANE USE INFORMATION	0	9	0	60	69

* Not enough information was provided by these respondents to determine the number and location of toll plaza signs.
** The total for both portions of this table exceeds 100 percent (%) due to the incident of multiple signs at individual plazas.

SIGN CATEGORY	NUMBER OF RESPONDENTS WITH SIGNS IN SERIES					
	2 signs	3 signs	4 signs	5 signs	6 signs	7 signs
TOLL SCHEDULE	4	2	0	0	0	0
WARNING/INFORMATION	7	3	0	0	0	0
SPEED RESTRICTION/ADVISORY	7	2	1	0	1	2
TOLL LANE USE INFORMATION	3	1	1	2	1	0
TOTAL	21	8	2	2	2	2

FIGURE 29 Typical locations of advance toll plaza signing deployed by surveyed toll facilities according to category and number of advance signs.

- Provisions for more than one collection method offers more flexibility to accommodate different patrons (i.e., weekend travelers, commuters, and off-peak travelers).
- Multiple collection systems provide a fallback in case of a failure in the primary collection method.
- More than one collection method is used in a lane simultaneously.

TABLE 8
TYPICAL TOLL LANE SIGNING (BASED ON RESPONSES FROM 40 FACILITIES)

Type of Message	Respondents Using Sign (%)	Location
STOP (PAY TOLL)	90	Toll Island
Speed Limit	55	Booth
Toll Schedule	22	Booth
Regulations	18	Canopy, Booth
Other (special events, driver information, etc.)	22	Canopy, Booth

REVERSIBLE LANES

Of the 47 percent of the responding facilities that use reversible lanes to accommodate directional traffic demands, 86 percent rely on a combination of canopy lane signals and cones or delineators to channel vehicles. Some facilities also use canopy-mounted signs in conjunction with these devices. Only three of the facilities use moveable barriers.

ENFORCEMENT

Over the centuries, toll violations have continued to be a problem at toll facilities. Gates were first used in the 11th century, whereas elaborate photographic-based enforcement systems, including digital imaging, are being used today. Responses from the 45 facilities indicate that 38 percent still use automatic gates, mostly in conjunction with automatic toll collection. Video enforcement is predominately used in ETC lanes, with about 10 percent of the facilities reporting that they use a VES in their automatic lanes as well. The majority, though, stated that they use some form of police presence, either full-time or at random times, as well as toll personnel to record the license plates of violators, as their primary method of toll enforcement.

ACCESSIBILITY

In chapter 2, employment of physically challenged individuals in a toll plaza environment was discussed. Safety, design accommodations, production with respect to toll lane processing, and ergonomics associated with various tasks are issues that have yet to be addressed. In addition, use of toll lanes by drivers who are classified as disabled should be considered when a toll plaza is designed.

Only representatives of the Pennsylvania Turnpike replied that they designate an attended lane at a toll plaza for these motorists. As for accommodation of the physically challenged, 5 percent of the responding facilities provide personnel with an extra-wide booth with ramped access to the toll island. Eleven percent of the responding facilities provide restrooms, ramped curbs, and elevators to accommodate physically challenged employees.

CHAPTER FOUR

ONGOING CHANGE: ETC PROBLEMS AND PROMISES

Since its introduction into toll revenue service in the late 1980s, automatic vehicle identification (AVI), now better known as electronic toll collection (ETC), has been postulated as being the best way of achieving "barrier-free" toll collection. However, in the past decade, toll operators have been somewhat reluctant to embrace this new toll collection technology. Only eight of the toll operators that responded to the survey indicated that they use some form of AVI/ETC device. Currently, both passive and active "read only" tags are being used at some facilities, including the following:

- Crescent City Connection,
- Lake Ponchartrain Causeway,
- Dallas North Tollway,
- E-470 in Denver,
- New York State Thruway (cash system),
- Oklahoma Turnpike,
- Hardy Toll Road and Sam Houston Tollway, and
- The Peace Bridge in Buffalo.

In addition, "read-write" tags and "smart cards," which are prevalent in Europe, are making inroads in the United States. Read-write tags are used on or by the following:

- The Illinois NS Toll Road;
- The Kansas Turnpike;
- The Orlando-Orange County Expressway Authority;
- The Georgia 400;
- The Coleman Bridge in Yorktown, Virginia;
- The Dulles Greenway Toll Road extension, in Northern Virginia;
- The three Orange County (California) Transportation Corridor Projects; and
- The New York Region Interagency Group (a consortium of eight major toll operators).

The reluctance in going forward with ETC is caused in part by the ever-changing technology and investment required to deploy equipment on more than 4,000 mi (6,436 km) of tollways. Other factors also play a significant role in toll operators' reluctance, primarily the difficulties in defining an ETC system that will operate satisfactorily within multi–toll agency jurisdictions, the cost per transaction attributed to a clearinghouse operation, and the initial tag/transponder cost. The administration of such a system also presents several obstacles:

- Handling revenue collection and distribution;
- Auditing transactions;
- Customer relations; and
- Timing, political agendas, and mandates of the 1990 Clean Air Act Amendments.

In addition, there are numerous technical and institutional issues dealing with enforcement legislation, agreements on protocol, banking, system standards, and data archiving—not to mention privacy. Among system standards or parameters, a number of issues must be dealt with at a policy level, including the following:

- System compatibility among adjacent toll facilities;
- Tag/transponder transferability;
- Use of express, dedicated, and mixed-use lanes;
- Payment and billing options;
- Ease of program registration, including sales and renewals;
- Surcharge/payment for the tag/transponder;
- Radio frequency/interference/licensing;
- System architecture; and
- Privacy.

These factors have the most direct impact on public acceptance of an ETC program. The public's acceptance and level of participation, in turn, affect the cost-effectiveness of introducing ETC.

Despite these drawbacks, which are viewed by the industry as temporary, ETC does offer a leap forward in toll collection with promises of

- Increased toll processing throughput;
- Reduced commuting time;
- Reduced emissions resulting from elimination of idling vehicles;
- Minimized right-of-way requirements for new plazas, thereby reducing the cost of toll plaza widening and associated environmental impacts;
- Reduced cost of toll collection;
- Decreased fuel consumption; and
- Minimized driver inconvenience in toll payment (e.g., looking for change and waiting in line).

Another potential use for ETC focuses on the original reason transponder system research was first undertaken in the 1970s and early 1980s—road pricing (*19*). Under the congestion management system function of ISTEA, congestion pricing, which is an adaptation of road pricing, has been identified as a means of reducing the volume of peak period traffic in our urban centers. Tolls, particularly ETC, offer the means to implement a congestion pricing program if the system is tied to other revenue-based traveler functions such as parking and transit usage. This concept is not new. For example, in the 1920s, Arthur Pigou, in his work, *Economics of Welfare,* wrote "proposed directly charging motorists for each piece of road that they used" (*20*). ETC could provide such an opportunity.

Tags/transponders also can be used as probes in an electronic toll and traffic management system. The tags, in conjunction with roadside readers and antennas strategically placed along a roadway, provide an electronic signature that, when read, can indicate traffic flow or vehicle location. A vehicle probe demonstration project initiated by TRANSCOM, called TRANSMIT, is currently under way in the New York area.

TOLL PLAZA DESIGN RETROFIT AND NEW DESIGN

Retrofit

An existing toll plaza may be retrofitted to incorporate ETC, either by using mixed-use toll lanes (traditional toll lanes equipped for ETC and manual or automatic collection) or dedicated toll lanes (traditional toll lanes equipped to serve only ETC customers). The decision is based on ETC market penetration and patron acceptance of an ETC program, demand at various times of the day, the location of entry and exit ramps adjacent to a mainline toll plaza, and the operational impact on plaza throughput.

In addition, a number of policy and safety issues need to be considered. For example, at the Dallas North Tollway, where customers were charged a $2/month service fee and a $0.05/ transaction premium, the customers made it clear that they expected service in the form of dedicated lanes instead of mixed-use lanes, which would minimize travel time. In addition, concerns were raised that, in such an environment, the possibility increased for a slow cash-paying vehicle being struck in the rear by a faster ETC-paying vehicle (*21*). This sentiment was also expressed by the New York Region Interagency Group.

Where commercial vehicles are processed, ETC must be available in mixed-use attended lanes. However, dedicated ETC lanes for commercial vehicles similar to those used by the express bus lane at the Lincoln Tunnel toll plaza may be used where the level of participation warrants such use. Separate facilities or mixed-use lanes for commercial vehicles are needed to solve the problems encountered with using video surveillance for toll enforcement. These problems result from the differences in the location of commercial vehicle license plates and the lack of audit controls to differentiate and verify vehicle class.

Dedicated lanes pose other safety and operational concerns, such as differential speeds on departure, placement of lanes within the plaza, pedestrian (employee) access across the toll lanes, non-ETC customers inadvertently wandering into a dedicated ETC lane, and toll evasion. Each of these concerns needs to be addressed during retrofit. Some examples of action taken by operators of the Dallas North Tollway (DNT) and the New York State Thruway (NYST) follow:

- Providing physical channeling of vehicles by using rubber stanchions in both the approach and departure lanes to separate adjacent traffic, thereby placing the point at which a motorist decides to connect to the dedicated lane further upstream in the plaza (DNT);
- Placing dedicated ETC lanes toward the center of a mainline plaza to maximize accessibility from approaching traffic lanes (NYST);
- Physically restricting pedestrian access to dedicated lanes by installing barriers and enforcing use of grade-separated access to toll lanes, except for coin vault changes on an island (DNT);
- Posting signs in advance and over the lanes to inform motorists of their use and improve recognition (NYST);
- Instituting a speed limit (5 mph (8 km/hr)) with speed detection and video enforcement to warn speeders and toll evaders (NYST); and
- Installing speed bumps and speed limit signs (10 mph (16 km/hr)) to reduce approach speeds (DNT).

New Plaza Design

In 1988 the *Urban Transportation Monitor* conducted a survey of public attitude toward toll roads. A surprising 66 percent of the respondents approved of their use. The survey also indicated that 85 percent were in favor of tolls if ETC were adopted (*22*).

ETC technology offers the opportunity to reduce the rising costs of toll collection, reduce congestion and delays, and improve air quality within a toll environment. To maximize the potential of ETC technology, new toll facilities will need to undergo a transformation in both their operation and design.

To optimize the benefits of ETC and allow for future options while minimizing right-of-way requirements, new plaza designs incorporate express lanes and off-line toll (service) plazas. These new designs consist of toll plazas in each direction of travel to provide conventional toll collection methods as well as ETC for commercial traffic and to accommodate patrons using adjacent interchanges and ETC patrons experiencing tag/ transponder problems.

The toll plazas usually are located on the outside of mainline travel lanes, as on E-470 and the Oklahoma Turnpike. The express toll lanes are merely continuations of the mainline travel way. These lanes are equipped with ETC antennas, which usually are mounted on overhead gantries over the lanes. Designs such as the one shown in Figure 30 for the Orange County Transportation Corridor Projects also provide for an optional HOV or transit corridor in the median.

New toll plaza designs have a smaller plaza footprint in terms of right-of-way width than a conventional mainline plaza, but with similar or improved capacity. In addition, because of the split design and fewer conventional toll lanes, visual impact is lessened. The new designs provide an advantage to ETC program participants, while providing conventional toll services for others. The project director responsible for design of the Orange County Transportation Corridor Projects stated, "the true potential of [ETC] technology will be realized in applications on roads designed specifically for AVI (ETC) collection" (*23*).

CHAPTER FIVE

CONCLUSIONS

For centuries, tolls have provided an alternative source of revenue to help build, reconstruct/rehabilitate, and maintain our highway/bridge/tunnel infrastructure. Now with the support of ISTEA, incentives for public-private partnerships and partial federal funding are being fostered for construction of new toll roads. In addition, operators of older roads and bridges can revert to toll collection to finance reconstruction and rehabilitation. These efforts have signaled a rebirth and renewed interest in toll facilities. However, as we have seen in our review of current toll plaza design practices, practices vary widely among facilities and their operators.

Most toll facility design standards are proprietary in nature. These standards, which have been developed by individual agencies and their design consultants, are based on the facilities' experience in accommodating their maintenance and operation needs, the needs of their customers, and the constraints of their facilities. This is particularly true in the design of approach and departure zone transitions and taper geometry; the toll plaza, including the lanes, islands, booths, and canopy; and the plaza administration or utility buildings.

Even toll collection methods and equipment deployed for in-lane toll auditing vary among facilities and operators. In addition, there is no apparent measure of toll lane capacity that can be used as a benchmark to judge productivity, customer satisfaction, and efficiency. However, some design elements, such as profile and cross slope, used to facilitate drainage appear to follow standards prescribed by AASHTO geometric guidelines even though toll plazas are not directly addressed in these guidelines. Some areas in which practices vary among facilities are described in the following summaries.

LIGHTING

Although the toll plaza lighting levels reported are typically above those of the approach roadway, no uniform level or range was evident from the responding facilities. Such lighting levels have been adopted for tunnels; freeways in commercial, residential, industrial, and rural settings; and overhead signing.

ENVIRONMENTAL ISSUES

Environmental conditions such as air quality within a toll booth and noise in the toll plaza's surroundings are of concern to toll operators. However, there are no uniform standards or practices with respect to decibel levels and CO levels, including the length of time a collector may be exposed. Positive pressure airflow systems have been installed in some newer toll facilities to protect toll collectors.

Also associated with the design and operation of toll plazas is the need to meet federal, state, and local environmental requirements for ambient air quality, waterborne runoff, noise, and other pollutants. During the design phase of some toll plazas there may be a need to analyze the effects of the toll plaza operation on localized CO "hotspots." It may also be necessary to analyze the future air quality effects on persons in the immediate area of the toll plaza, as well as on the region as a whole.

ETC LANE CONTROL

With the emergence of ETC and its use in dedicated lanes within a toll plaza, traffic control and safety measures need to be assessed in terms of ETC lane location, signage, channeling of vehicles, and pavement markings with respect to personnel safety and awareness.

TOLL BOOTHS

Although manual toll collection has remained somewhat unchanged during the past 5 decades, booth size, amenities, and layout do not appear to be conducive to the most efficient operation or environment. For example, some booths are 2.8 ft (85.3 cm) wide, whereas others reach nearly 8 ft (2.4 m) in width. Some have only one means of access/egress, but most offer two means of egress for collector safety. Defining spatial requirements and amenities using ergonomic principles and safety criteria would facilitate the development of a more efficient and comfortable work environment.

IN-LANE EQUIPMENT

Over the years, manufacturers and toll operators have located myriad in-lane devices for toll audit and detection, as depicted in Appendix F and Figure 24. As with traffic detectors and surveillance/control devices, toll equipment use and placement need to be assessed to develop parameters and guidelines that will provide the utmost audit integrity and control and establish industry standards with respect to function, reliability, and maintainability.

TRAFFIC CONTROL DEVICES

Traffic control devices, particularly signs, are unique to each facility. Text, placement, color, and uniformity in type of regulatory, warning, and guide signs vary among facilities. This lack of consistency can be confusing to new patrons as well as to older drivers, leading to slower toll processing and causing drivers to make abrupt maneuvers in a plaza. Even for the commuter, changes in the configuration of payment methods during off-peak hours can be a problem without proper information and guidance.

Differing applications of traffic signal heads and lane-use signals to denote lane status among facilities and jurisdictions were noted in the survey. In addition, variation in the use and placement of pavement markings is apparent to anyone who has traveled through different toll jurisdictions. Lane-use signals and pavement markings afford one of the most positive forms of guidance to help motorists access desired toll lanes. Similar to other traveled ways, toll plazas should have consistent signing, pavement markings, and signal displays to promote driver recognition and to encourage consistent motorist behavior.

ELECTRONIC TOLL COLLECTION

Toll collection equipment has changed little in the past 25 years, except for its improved efficiency, speed of processing, and toll auditing capability. However, the advent of ETC may change the complexion of both the toll collection process and the plaza. ETC offers almost barrier-free design, seamless use and processing between facilities, more convenience for the customer, increased processing rates, nearly 100 percent accountability, enhanced classification and toll enforcement systems, and congestion-pricing opportunities. However, a number of problems must be resolved, including the following:

- Differences in systems and protocols between adjacent toll facilities;
- Allocation of payments, including administrative costs, between adjacent operators to afford a seamless ETC program;
- Legal issues regarding use of photographic enforcement;
- Reliability and accuracy of photographic enforcement in mixed-use, dedicated, and express lane applications and with commercial vehicles;
- Operating frequency interference and cross-reads;
- Cost of enforcement;
- Cost of centralized banking;
- Cost of the tag/transponder; and
- Incentives to encourage ETC program participation.

Although this synthesis encapsulates present toll plaza design practices, it appears that there is a need for additional research. Research opportunities exist on plaza geometries, lighting, signing, toll barriers, toll equipment performance and layout, pavement markings, VES, and ETC. Such research could enhance safety and operations, provide better efficiency and economy of design, and improve patron recognition and acceptance of toll facilities through consistency. Suggested areas for research include the following:

- Horizontal alignment—Examine minimum and desired transition lengths and criteria for setting tapers to provide adequate stopping sight distance and improve merge and diverge maneuvers, with emphasis on retrofitting existing facilities for ETC dedicated and express lanes.
- Vertical alignment—Consider defining vertical geometry, including desirable cross slopes and profiles for toll facilities, in the design of toll lanes and toll plaza transition areas.
- Pavement markings—Explore the use of plaza pavement markings, including transverse striping, lane lines, and gore markings with respect to various driver needs to reduce speed, discourage weaving and lane changes, reduce driver confusion on entering and exiting a toll plaza, and improve channeling between approach roadway lanes and toll lanes.
- Signing—Develop categories for plaza signing according to functionality (i.e., warning, regulatory, and informational) while providing consistency in color and placement of advance and toll lane signs, according to the provisions of the MUTCD. Also consider standard text and symbols for certain applications (e.g., advance toll informational signs).
- Lighting—Research lighting levels in plaza transition and toll lane areas to help the driver's eye make the transition from ambient roadway lighting levels to the more intense levels required for recognition and safety in a toll plaza. Such research should take into account surrounding land use.
- Lighting for poor visibility—Explore the use of approach and hazard lighting on toll islands and lighting for periods of poor visibility using devices such as strobe lights, in-pavement "runway" lights, and flashers.
- Booth design—Evaluate the use of ergonomic design to enhance the efficiency of manual toll collection and improve the comfort of the booth environment for toll collectors. Also consider size, lighting, heating, ventilation, and safety criteria in toll booth design.
- Environmental measures—Research levels and duration of exposure to noise, carbon monoxide, and electromagnetic emissions encountered by toll collectors and the effects on ambient air quality in the region.
- Americans With Disabilities Act (ADA) compliance—To comply with federal mandates, providing accessibility for people who are physically challenged is becoming more prevalent in toll plaza design. Before such mandates are arbitrarily implemented, the toll industry and government need to explore the opportunities for employment of the physically challenged in the toll industry. Safety issues and performance criteria, which are established by a toll operator to meet the expectations of its customers, need to be considered. Job requirements and minimum acceptable proficiencies, as well as a means for requesting and granting exemptions on a case-by-case basis, could be considered.
- Toll Islands—Assess toll island design, including configuration, size, and placement of various protective de-

vices, and attenuation, including tunnel access to afford protection for both collector and customer.

- Electronic toll collection—Study the feasibility of a national ETC protocol and standards, addressing the ETC system, deployment, transponder/tag placement, classification criteria, data security (encryption and distribution of account numbers), operating frequency, data requirements, data storage, data dissemination, and audit controls. Such standardization should enhance opportunities to maximize ETC market penetration, reduce unnecessary data transfer and storage, provide seamless travel, reduce capital and operating costs, and address privacy concerns.
- ETC lane traffic controls, signing, and pavement markings—Consider ways to reduce motorist speed; enhance motorist safety, particularly in mixed-use lanes; and alert personnel of the presence of ETC operations in dedicated and mixed-use lanes.
- Video enforcement systems—Although a VES offers one of the most efficient and full-time methods of toll enforcement, particularly for ETC, a number of unresolved or questionable issues remain. Assess current policies and design for the application of VES standards, practices, and placement for toll plaza retrofit and new express lane designs. These issues entail legislation, commercial vehicle applications, cost versus benefit (particularly the cost per violation), and VES reliability at high-speed express lane collection points.

Although common design standards do not exist and practices vary by facility, toll collection has come a long way since the single-lane toll plazas of the 17th century. New toll facility designs have incorporated lessons learned by operators through years of experience and have begun to take on a new look with the advent of ETC express lanes. The findings in this synthesis can be helpful in improving the consistency of critical design elements, such as lane width, signing, lighting, and ETC procedures, which will result in a more user-friendly toll collection process.

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GLOSSARY

Access/Service Tunnel—A secure tunnel beneath a toll plaza that provides access to the toll lanes for utilities and toll personnel. Tunnels not only provide access for personnel but also for utilities and data and communication lines. Tunnels also can serve as an alternate location for ACM lane vaults and lane controller cabinets.

Approach Closure Gate—A wood, metal, or fiberglass swing gate (usually manually operated) with reflective diagonal striping used to close a lane when not in use.

Approach Speed—The average operating speed of vehicles on the main roadway before they enter the approach transition zone to a toll plaza.

Approach Taper—The ratio of the tangent distance between the main approach roadway and the leading edge of the Q area and the offset of the right roadway's right pavement edge measured to the edge of the rightmost toll lane.

Approach Transition Zone—The area in advance of a toll plaza where the pavement widens from the normal travel roadway to the width of the available toll lanes.

Audit Contact Treadle—An axle counting device set in the toll lane in a metal frame, with a pad or cover containing two to four electrical contacts, each covered by high-impact rubber strips.

Automatic Exit Gate—An automatic gate with a breakaway wood or frangible fiberglass arm at the departure end of a toll lane, usually in an automatic lane.

Automatic Coin Dispenser (ACD)—An electronic coin processor that collects, counts, evaluates, and stores various denominations of coins and tokens.

Automatic Ticket Dispenser (ATD)—A device used in a ticket toll system that dispatches a ticket coded with a time and date stamp plus point of entry.

Beam Scale—A balance beam set in a structural frame in a commercial vehicle toll lane used to weigh vehicles in a static manner.

Bill Changer (BC)—An adaptation of a change-making device commonly found on vending machines and in transit facilities. A bill changer can handle bill denominations from $1 to $10, depending on the toll rate, and provides change in either coins or tokens by means of a return hopper.

Bond Indenture—A legal document defining the terms and conditions for the sale and redemption of revenue bonds.

Branch Toll Lanes—Toll lanes constructed either in advance of or after a toll plaza to increase plaza throughput. Access to or egress from a branch lane usually is through an inoperable toll lane in the main plaza—a feeder lane or a "mother lane." Branch lanes provide the same methods of toll collection as the main plaza.

Bypass Lanes—A lane usually constructed to either side of a toll plaza that allows vehicles to avoid the toll lanes. A bypass typically is used for nonpaying high occupancy vehicles and oversized loads or as a feeder lane for branch toll lanes.

Canopy—A roof over a toll booth or toll lane.

Capacity—The maximum number of vehicles that can pass through a toll lane in 1 hour.

Centralized ETC System—A collection system, similar to a credit card system, that maintains the patron's account for electronic toll collection (ETC).

Clearinghouse—A bank-type database or form of record storage used by a toll agency or multiple agencies to store toll transactions. The purpose of this database is to disseminate payment from a patron's account to the individual toll facilities used by the patron during a predetermined period.

Closed Toll System—A system predicated on all patrons paying an equitable share of the cost for use of a facility, based on miles of travel and type of vehicle.

Closed (Cash) Toll System—A system in which patrons are charged a toll, payable in cash or by token, at a series of strategically placed mainline and ramp toll plazas to ensure that all travelers pay a toll.

Closed (Ticket) Toll System—A system in which the patron receives a ticket upon entering the facility for the class of vehicle being driven. The ticket is surrendered with the prescribed payment upon exiting the facility.

Coin Vault—A steel box with an integral locking cover mounted at the bottom of an ACM or drop tube mechanism that serves as the depository for coins and tokens used for toll payments. Each vault can store up to several thousand coins and tokens.

Collector's Counter—A raised table or desk on which the collector's terminal, receipt printers, and magnetic card reader sits. The counter usually contains two locked cash drawers and a switch panel to control booth lighting. The counter typically is made of stainless steel and is placed at the end of the booth facing traffic.

Collector's Door Bubble—An awning over the toll collector's door to provide added protection from precipitation.

Color Rendition—The quality of a color.

Contrast—The ability of a person to detect objects as a result of differences in brightness.

Crash Block—A reinforced concrete block on the approach to a toll booth to protect the toll attendant from being struck by a vehicle.

Cross-Read—A term used to describe a situation in which an ETC antenna in one toll lane picks up a signal from an adjacent toll lane.

Debt Service—The amount specified by a bond indenture needed to pay principle and interest on outstanding bonds. Usually a debt coverage factor based on the rating of the authority is applied.

Decentralized ETC System—A self-contained system in which the toll operator credits a patron's account electronically by using the patron's toll tag, transponder, or card. The system automatically debits the patron's account upon each transaction

Departure Taper—The ratio of the tangent distance between the recovery area on the departure side of a toll plaza and the transition to the normal roadway to the offset between the edge line of rightmost toll lane and the projection of the right edge of the normal travel way.

Departure Transition Zone—The area encountered by a driver after leaving a toll plaza, at which the pavement narrows or merges from the width of the available toll lanes to the width of the normal travelway.

Design Speed—The maximum safe speed that can be maintained over a specified section of highway when conditions are so favorable that the design feature of the highway governs.

Diagonal Ramp—A one-way ramp that usually provides both left and right turns at its terminals with a minor road or a direct right turn connection with a major roadway. A diagonal ramp may be tangent or wishbone in shape with a reverse curve or on a continuous curve. (See Slip Ramp.)

Double-Ended Booth—A toll booth that contains collector counters and toll equipment at both ends for reversible lane operation.

Driver Feedback Sign—A fiber-optic sign or signal display used to indicate the status of transactions in an ETC-equipped lane. The messages typically indicate valid transactions, low account balances, account replenishments required, and violations.

Dutch Door—A half-height door in the collector's door opening that typically protrudes beyond the door of the booth, allowing the attendant to move closer to the patron to facilitate payment.

Entry/Arrival Loop—A vehicle detector loop, embedded at the beginning of the toll lane approach, used to activate or alert the collection system.

ETC Antenna—A radio frequency or acoustic wave antenna in the toll lane used to focus a signal emitted by a transceiver and receive and transmit transponder or tag information between the vehicle and a lane reader or controller.

Electronic Toll Collection (ETC)—A system that automatically identifies a vehicle equipped with an encoded data tag or transponder. The system debits the cost of the toll from or charges the toll to a patron's account without the patron having to stop to pay the toll.

ETC Driver Feedback Indicator (DFI)—A microprocessor-actuated disc matrix, flip disc, or blank-out sign with a fixed message (ETC program name) used to display a series of messages to the motorist regarding his or her ETC account status.

Evasion—The act of avoiding payment of a toll.

Exit Loop—A vehicle detector loop, generally positioned at least a vehicle length from the transaction loop, with its back edge slightly ahead or even with an automatic gate arm or an island traffic signal, used to close the gate and change the signal to red.

Express Lanes—A mainline travel lane equipped with ETC that provides non-stop, barrier-free toll collection.

Headway Time—A measure of time from when a motorist has completed his or her transaction and begins to pull away from the toll collector's door to the arrival of the next waiting vehicle.

Height Clearance Restrictor—A horizontal bar placed above a toll lane at a prescribed height to deter commercial vehicles from using designated passenger car lanes or to detect overheight vehicles.

Height Sensor—An optical or infrared sensor mounted at a predetermined height to monitor overheight vehicles or to classify a vehicle typically found on a facility.

Horizontal Height Bar—See Height Clearance Restrictor.

Horizontal Luminance (Foot Candles)—The measure of pavement surface illuminance or lumen distributed over a horizontal surface 1 ft^2 in area.

Host Lane—An inoperable toll lane in the main toll plaza that feeds traffic to branch toll lanes or through which traffic passes from branch toll lanes.

HOV Bypass—A bypass lane or designated toll lane for high occupancy vehicles used to expedite their processing around normal toll lane queues.

Impact Attenuator—A frangible or other energy-absorbing device designed to decrease the momentum of a vehicle traveling at a prescribed speed, thereby reducing the impact of an errant vehicle and damage to the vehicle and its occupant, while affording added protection for the toll collector.

In-Lane Equipment—Vehicle detection and classification devices, such as treadles, vehicle loops, profile identifiers, vehicle separators, scales, overheight sensors, and ETC antennas and transceivers installed in a toll lane. This equipment also includes surveillance, toll enforcement systems, traffic control devices, and toll payment indicators.

Intensity of Illumination—A measure of illumination, stated in foot-candles, defined as the unit of illumination when the unit length is 1 ft.

Island Traffic Signal (ITS)—A standard traffic signal head mounted on a post at the departure end of the toll island in an automatic or ETC toll lane, which signals a patron to stop and pay the toll. After satisfactory payment, the lane controller makes the signal turn green.

Lane Configuration—The operational policy established in arranging toll lanes at a toll plaza according to the methods of toll collection available. The configuration may vary by time of day and day of week.

Lane-Use Signal (LUS)—A rectangular-shaped fiber-optic, disc matrix, or LED signal that displays a red X, denoting that a lane is closed, or a green down arrow, denoting that a lane is open. An LUS is mounted either in a single section or in separate sections.

Laser Scanner —A scanner similar to a bar code reader used in a retail store that reads a bar code affixed to the side of a vehicle. This device is one of the simplest forms of automatic vehicle identification used for toll payment.

Lateral Distribution Coefficient —A coefficient based on the efficiency of extreme toll lane throughput, compared with the throughput of similar, more directly accessible lanes within a toll plaza. The lateral distribution coefficient is used by the Illinois Tollway to compute plaza throughput.

Level of Service (LOS) —A measure of traffic flow defined by Special Report 209: *Highway Capacity Manual* (published by TRB) in terms of traffic volume, density, speed, or average vehicle delay. Service is defined by six gradations from LOS A (free flow) to LOS F (forced flow).

Light Curtain (LC)—An optical or infrared stanchion, usually 4 to 7 ft high, mounted in a toll lane either before or after the toll booth. The LC, which consists of a number beams of light to provide a profile of a vehicle for classification purposes, is generally used in combination with a treadle. The profile is matched by computer to prescribed vehicle silhouettes, which in turn depict the vehicles within each class according to the facility's toll rate schedule.

Loop Ramp—A ramp pattern that provides left turn movement through a 270-degree movement by using a grade separation to cross through traffic; however, travel is more indirect. Loops can have either single (left or right) or double (left and right) movements at either or both ends.

Lumens—A measurement of light intensity equivalent to 1 foot-candle or the unit of illumination when the unit is 1 ft in length.

Magnetic Card Reader—A swipe or motorized (insertion) type of magnetic (credit) card reader.

Mainline Plaza—A toll plaza located on the main roadway, which creates a barrier to traffic flow.

Manual Toll Collection—The method of toll collection that employs attendants to collect tolls, make change, sell script and tokens, and provide change.

Market Penetration—The level of participation by customers in ETC and token programs.

Mixed-Use Lane—A multipurpose toll lane in which more than one toll collection method is available, such as ETC and manual toll collection.

Mobility 2000—A study undertaken by a coalition of public, private, and academic interests in 1990 that indicated the need for improved utilization of our transportation infrastructure by decreasing congestion and delay through optimization of capacity, enhanced incident response, improved surveillance and control, and intermodalism to enhance the movement of people and goods.

Moveable Barrier—A series of linked concrete or sand-filled barriers used to separate opposing flows of traffic and capable of being moved by mechanical means to change traffic patterns.

Off-Driver Side Toll Collection—Toll collection initiated from the passenger side of a vehicle.

One-Way Toll—A toll plaza configuration in which tolls are collected in one direction of travel only.

Open Toll System—A system in which not all patrons are charged a toll. Typically a system in which local traffic is not charged, whereas long distance through traffic is charged.

Optical Treadle—An audit treadle with an optical strip through which light passes. Upon interruption of the light, an axle count is registered.

Overhead Classification Indicator (OCI)—An illuminated display typically mounted on the upper part of the booth or the canopy fascia in the line of sight of the toll plaza supervisor. OCIs automatically display the vehicle classification entered by the toll collector. The OCI is used by the supervisor to observe toll transactions and monitor attendants.

Overhead Lane Signals—Another term used to describe a lane-use signal, including red/green or combinations of standard 8- or 12-in. circular traffic signals or lane-use signals, with red Xs and green down arrows displayed singularly or in a single section over the center of a toll lane to indicate the status of the lane.

Parkway—A paved travelway, usually with access control, constructed through parklands for the sole use of private passenger cars.

Patron Fare Indicator (PFI)—A disc matrix or flip disc micro-processor-actuated display with an illuminated message such as TOLL PAID and used to display the toll charged.

Piezoelectric Tube—A sensor consisting of a copper core and copper outer sheeting separated by a piezoelectric insulator that, when subjected to a wheel pressure, produces a voltage between the core and sheeting that is proportional to the applied force.

Plaza Administration Building—The support structure for the operation and maintenance of the toll plaza. (See Utility Building.)

Plaza Configuration—The arrangement of a toll plaza (i.e., a two-way plaza, a split plaza (separate plaza for each direction of travel), or a split plaza with service plazas and express lanes).

Positive Ventilation System—A system that draws fresh air from a source away from the plaza and diffuses it into the toll booths, creating an outward pressure that keeps contaminated air from entering the booth. Some facilities condition the air before discharging it.

Postbilling—A method of charging for services whereby an invoice is sent to a customer (usually monthly).

Prepaid Account—An account in which funds are replenished automatically by direct credit card or bank account withdrawal or by cash payment.

Preclassification—A form of vehicle classification in which a vehicle is classified by axle count or by profiling devices prior to the toll transaction. The classification can be displayed automatically on the toll collector's terminal.

Postclassification—A form of vehicle classification in which a vehicle is classified by axle count or by profiling devices after the toll transaction. This form of classification generally is used for audit verification.

Processing Time—The time measured from when a vehicle arrives at a toll booth to when the next vehicle in queue takes its place.

Queue (Q)—A series of vehicles waiting to be processed in a toll lane. The length of the queue and delay frequently is used to identify the level of service being provided.

Ramp Plaza—A toll plaza located on an entry or exit ramp to a toll facility.

Rampart—A sloped concrete structure, located on the approach end of a toll island prior to a toll booth, used to redirect an errant vehicle in the toll lane and protect the toll collector.

Reader/Controller—A microprocessor used in an ETC system that processes information and formats it for printing or that passes it along to a central computer. The controller also signals the transceiver to reset the island traffic signal when a vehicle enters the read zone.

Receipt Printer—Typically a high-speed printing device capable of producing 150 to 220 lines per minute using standard roll receipt paper and a dot matrix or other printing mechanism to imprint the receipt with a date and time stamp, toll amount, lane and toll plaza ID, and facility name.

Recovery Zone—The distance perpendicular to the toll plaza measured from the departing end of the toll island to the area before the departure transition or merge begins. Usually equal to the length of the longest vehicle permitted on the facility.

Reversible Lane Operation—A toll lane in which the direction of traffic flow is changed to accommodate peak traffic demands, thereby increasing the capacity of the toll plaza in the peak direction.

Running Speed—The speed attained by a vehicle along a segment of roadway, discounting any delays encountered.

Secure Areas—Areas within a toll plaza where toll receipts and toll audit equipment are present.

Semidirect Connection—A ramp connection, sometimes referred to as a "jug-handle," in which the driver makes a left turn over a grade-separated structure (over or under through traffic) by first making a right turn, swinging away from the intended direction, then gradually reversing movement to the left, following directly around and crossing the roadway just vacated.

Slip Ramp—See Diagonal Ramp.

Split Toll Plaza—A plaza off the main travel roadway that accommodates conventional toll collection methods as well as ETC for commercial traffic and adjacent interchange traffic. Used in conjunction with express lanes.

Single-Ended Booth—A conventional toll booth equipped to handle tolls in one direction of travel only.

Tandem Toll Booths—A toll booth arrangement in which two manual booths are placed in line in the same toll lane, thereby permitting the simultaneous processing of two vehicles.

Tell Tales—An arrangement of chains or pipes suspended from a horizontal bar at a preset height above the pavement to detect an overheight vehicle.

Toll Barrier—A toll lane and booth or series of lanes and booths placed perpendicular to the flow of traffic for the purpose of collecting tolls. The plaza generally comprises a toll island, a toll booth, and a canopy.

Toll Booth—A shelter for toll attendants as they collect tolls or dispense tickets. A toll booth can be freestanding or can provide structural support for a canopy.

Toll Collection—A way to impose a tax or fee on a traveler for the use of a road facility. Tolls sometimes are referred to as tariffs or fees or, in medieval times, as visage, pillage, or alms.

Toll Collection Equipment—Devices used to collect, process, and record a toll transaction, including the lane control dedicated microprocessor that monitors and operates the toll equipment and records toll transactions.

Toll Collector Terminal (TCT)—A button box or collector classification unit, which has designated classification or function buttons, a touch key pad, or a numeric keypad that permits the toll attendant to enter the classification of a vehicle that enters the toll lane and to handle other toll lane functions, including the issuance of receipts.

Toll Facility—A road, bridge, or tunnel at which travelers pay a toll to use.

Toll Island—A raised platform, usually made of concrete, consisting of some form of crash protection or attenuation device on the traffic approach side where a toll booth or freestanding ACM is located.

Toll Lane—An individual lane in which toll payment is rendered either by manual or automatic collection or through electronic means.

Toll Lane (Recorder) Cabinet—A secure cabinet in the toll booth or tunnel that houses the low-voltage supply distribution blocks and relays for the toll equipment. The cabinet provides the data linkage between the lane controller and the toll lane.

Toll Lane Envelope—The combined width of the toll lane and toll island.

Toll Plaza—A place at which tolls are collected. A toll plaza typically includes a toll booth or barrier, approach and departure transition lanes, a queue area, a recovery zone, advance toll signing, a plaza administration or utility building, and a parking area for personnel.

Transaction Time—The time measured from when a vehicle arrives at a toll collection point to when it leaves (e.g., in an ACM lane, this time is measured from when the motorist stops adjacent to the ACM until the island traffic signal turns green and the vehicle accelerates).

Transceiver—A radio frequency modulator that generates signal waves emitted by an ETC antenna to energize a passive tag or transponder.

Transponder or **Tag**—A device mounted in or on a vehicle that stores encoded data used to identify the patron, class of vehicle, toll agency, and account balance in a read-write system as well as a limited number of previous transactions.

Treadle—A device embedded in a toll lane used to record the number of vehicle axles that pass over it.

Trumpet Interchange—This type of interchange, also referred to as a T interchange, provides connections between three intersecting legs, where two legs using one or more grade separations are in direct alignment. The design usually consists of a loop ramp, two diagonal or slip ramps, and a semidirect connection.

Utility Building—See Plaza Administration Building.

Weigh-in-Motion (WIM)—A piezoelectric hydraulic load switch or bending plate scale in a toll lane or on the open roadway used to measure axle loads.

Variable Message Sign (VMS)—A fiber-optic, disc/light matrix, or LED illuminated sign used in advance of toll plazas and in toll lanes to provide information on lane status and payment method. On open roadways, a VMS also provides information on traffic and roadway conditions as well as motorist alerts.

Vehicle Separator/Profile Identifier—An ultrasonic, radar, or microwave scanner or light bar mounted overhead or on a pole to differentiate a vehicle by classification according to a prescribed length or silhouette and axle configuration.

Video Surveillance Camera (VSC)—A video camera, similar to a bank surveillance camera, used by a plaza supervisor and toll security and audit personnel to monitor the transactions in a toll lane banking or counting room.

Video Enforcement System (VES)—A low-lux camera or a camera with a strobe, infrared, or incandescent spotlight that records the rear license plate of a toll violator in an automatic or ETC lane. The camera, which operates on a continuous basis or by still frame, typically is triggered by the exit loop when a toll transaction is incomplete and the vehicle leaves the toll lane. The license plate is read directly by or through computer photo imaging (enhancement) using a toll violation computer. The system usually is linked to state motor vehicle department records and in-house ETC customer files. A warning or summons is issued to a violator.

Windscreen—A vertical shutter, usually made of Plexiglas, mounted on adjustable hinges to deflect wind and keep precipitation from entering a toll collector's door.

APPENDIX A

TOLL FACILITY OPERATOR QUESTIONNAIRE

NCHRP PROJECT 20-5

TOPIC 25-11

TOLL PLAZA DESIGN

TOLL FACILITY OPERATOR QUESTIONNAIRE

I. FACILITY BACKGROUND

Please complete one questionnaire for each facility operated. (Make extra copies as required.)

A. Name of Toll Facility______________________ B. Name of Contact Person (Position)______________

C. Agency/Authority/Operator__________________ D. Phone No. _____________ Fax ______________

E. Facility/Location___________________________ F. Person Filling Out Questionnaire _______________
(If not the same as contact)

G. Type of Facility: Toll Road ____ Tunnel ____ Bridge ____

H. Year opened _____ Year of last renovation to plaza(s) ___ (Describe:_____________________________)

I. Size of Facility

1. Length in Miles (km) ____( ) or Feet (m) ____( )
2. Lane Miles (km) ____( )
3. Number of Mainline Toll Plazas ____ Ramp Plazas ____
4. Total Number of Toll Lanes ____

J. Types of Toll System Closed _____ Open _____ (Ticket _____ or Cash _____)

K. Methods of Toll Collection

1. Manual ____ (Cash _____, Script _____, Exact Cash ____ Ticket (Entry) ____)
2. Charge (Credit Card _____)
3. ACM* (Exact Change_____, Token _____)
4. ETC** (Dedicated _____, Bypass _____, Mixed _____)

II. DESIGN STANDARDS

A. What Published Standards or Guidelines were used to design your toll plaza facility?

1. AASHTO ____ 5. BOCA ____
2. MUTCD ____ 6. NFTA ____
3. State Design Manual ____ 7. NEC ____

* ACM = Automatic Coin Machine

** ETC = Electronic Toll Collection

April 13, 1994

TOLL FACILITY OPERATOR QUESTIONNAIRE (Con't)

4. Agency/Authority Standards ____ 8. ADA ____
9. Other (Please Describe) ______________________

B. Are these standards/guidelines currently used for new toll plaza facility/designs improvements? Yes ____ No ____

C. If no, what standards/guidelines have been adopted?

1. AASHTO ____
2. MUTCD ____
3. State Design Manual ____
4. Agency/Authority ____
5. Other (Describe:____)

III. PLAZA DESIGN CRITERIA

A. GEOMETRICS

1 Using the attached generic toll plaza schematics (Toll Plaza Layout and Elevations) please indicate geometric/measurement information in feet-inches (mm) to the best of your knowledge for those elements which best describe your plaza. Separate forms should be used for Mainline and Ramp Plazas.

B. PAVEMENT

1. What type of pavement is used in a toll lane?
   Asphalt _____ Concrete _____
2. What type of pavement is used in approach and departure (taper) transition areas?
   Asphalt _____ Concrete _____
3. What percent pavement cross slope and/or profile (maximum grade) is used in the following areas?

Cross Slope/Profile(Gr.)

a. Approach ___________/___________
b. Departure ___________/___________
c. Toll Lanes ___________/___________

C. LIGHTING

Roadway

1. What is the level of illumination in foot candles in each of the following areas?
   a. Mainline Roadway ____ b. Departure Transition ____
   c. Approach Transition ____ c. Ramp Plaza ____

2. What type and intensity (Wattage) of lighting do you use in the following areas?

	1) High Pressure Sodium	2) Mercury Vapor	3) Incandescent	4) Halogen	5) Other (Specify)
a. Approach Transition	____	____	____	____	____
b. Departure Transition	____	____	____	____	____

3. What form of lighting structures are used for each of the above areas?

	1) High Mast (Tower) >50'	2) Standard Mast Arm	3) Cobra Heads on 20-35' Poles
a. Approach Transition	____	____	____
b. Departure Transition	____	____	____
c. Ramp Plaza	____	____	____

Toll Lanes -

4. Is toll lane lighting provided? Yes ____ No ____
5. If Yes, where is lighting located?
   - a. Canopy Ceiling ____
   - b. Booth Mounted ____
   - c. Other (Describe) ____________
6. What is the lighting level within this area? ________ foot candles
7. What type and wattage of lighting is used?
   - a. HP Sodium ____, b. Fluorescent ____, c. Incandescent ____ c. Halogen ____
8. Are special devices used under conditions of poor visibility such as fog? Yes ____ No ____
9. If yes, what type of devices are used and where?

	On Canopy	In Advance of Plaza
a. Fog Lights	____	____
b. Strobe Lights	____	____
c. Variable Message Sign(s) (VMS)	____	____

   d. Other (Briefly Describe:)____________________________

D. DRAINAGE

1. What type of drainage system is used on the plaza transition roadways?
   - a. Closed (Piped) ____ b. Open Swales ____
2. If closed , what type of collection system is generally used along/on the transaction roadways?
   - a. Longitudinal ____ b. Transverse ____ c. Combined ____

3. Within the toll lanes which of the following drainage structures are used?
   - a. Curb Inlet ____ b. Treadle Drain(s) ____ c. Transverse Drains ____ d. None ____

E. ENVIRONMENTAL ISSUES

1. Which of the following environmental issues have you had to address?
   - a. Air Quality ____ b. Noise Levels ____ c. Water Quality ____
   - d. Other (Describe:____________________________)
2. What types of remedial measures have been applied to obtain acceptable levels?
   - a. **Noise:** 1) Walls ____, 2) Landscaped Berm ____, 3) Planting Trees ____, 4) Other (Describe:____________________)
   - b. **Air Quality:** 1) Decreased Vehicle Delays ____ (Describe e.g. additional toll lane, such as Branch Lanes were constructed ____________________)
     2) Positive Booth Ventilation system ____________
   - c. **Water Quality:** 1) Installed settlement ponds/swales ____ 2) Oil/Water separators ____
     3) Created Wetlands Buffer Area ____ 4) Closed Drainage w/ settlement chambers ____
     5) Other (Describe: ____________________)
3. Are there air quality monitoring devices located on or near the toll Plaza? Yes ____ No ____
4. If yes, please indicate pollutants monitored and location of device.

Pollutants:	**Location:**	
CO ____	Booth ____	Plaza ____
HC ____	In Lane ____	Other (describe)
NOX ____	Admin Bldg. ____	

Other (Describe: ____________________________)

F. SAFETY DEVICES

1. What form of crash device (s) is used on the approach ends to your toll island? (Check all that apply)
   - a. Rampart with single Crash Block ____
   - b. Rampart with a double Crash Block ____
   - c. Impact Attenuator ____ (Type:____________________)
   - d. Other (Describe)____________________
2. Are devices placed on both ends of a typical toll island? Yes ____ No ____ Only reversible lanes ____
3. What is the purpose of these Safety Devices (check all that apply)?
   - a. Minimize damage to the vehicle and toll lane ____
   - b. Deflect the vehicle into the toll lane ____
   - c. Afford Protection for the toll attendant ____
   - c. Other (Describe: ____________________)

TOLL FACILITY OPERATOR QUESTIONNAIRE (Con't)

G. CANOPY

1. Are your toll lanes covered by a canopy? Yes ____ No ____
2. If yes, what is the purpose of the canopy? (Check all that apply)
   a. Better define the location of the toll barrier for motorists ____
   b. Serve as a mounting frame for signs, lighting and lane signals ____
   c. Provide a chase for toll lane data, communications and power lines ____
   d. Shield toll attendants from the elements and precipitation ____
   e. Other (Describe:____________________________________)

   (On the attached schematics describe the primary design characteristics of your canopy, e.g., clearance(s) and length.)
3. In determining the shape and size of the canopy, what were the primary design considerations?
   a. The angle of wind-driven precipitation ____
   b. The sun's path ____
   c. Local Aesthetic Requirements ____
   d. Architectural Statement ____
   e. Other (Describe:____________________________________)

H. TOLL BOOTHS

Construction

1. What are the exterior dimensions of a single ended booth (Length/Width) ____/____
   double ended booth ____/____
2. Are your booths used as structural supports for your canopy? Yes ____ No ____ Both ____
3. What is the primary booth construction material?
   a. Frame: Steel ____, Rolled Steel ____ Extruded Alum ____ Wood ____, Other ____
   b. Exterior Skin: Wood ____, Masonry ____, Brick ____, Plate Steel ____ (thickness ______), Stainless Steel ____, Aluminum ____, (Gauge ____)
   c. Interior Skin: Galvanized Steel ____, Sheet Rock ____, Aluminum (Gauge ____)
4. Are the booths insulated? Yes ____ No ____

HVAC

5. What type of heating is used? Electric ____, Stove ____, Hot Air ____, Radiant ____, Hot Water ____, Other (Describe) ____________
6. What type of A/C units are used? Wall Mounted ____ Central ____
7. Is positive ventilation (pressurization) provided? Yes ____ No ____
8. If yes, where is air supplier located
   a. Booth ____
   b. on Canopy ____
   c. at a remote location ____

TOLL FACILITY OPERATOR QUESTIONNAIRE (Con't)

Flooring -

9. What is the type of booth flooring?
   a. Concrete with Rubber Mat ____ b. Concrete with Vinyl ____
   c. Concrete with built-up Wood Floor ____ c. Other (Describe) ____________

Doors

10. How many means of ingress/egress does your booth have? 1 ____ or 2 ____ Doors, Escape Hatch ____
11. What type(s) of doors are used? a. Slide ____ b. Dutch Door ____ c. Hinged ____
12. Are collector doors equipped with any of the following:
    a. Vertical Windscreens ____ b. Plastic Bubble ____ c. None ____
    d. Other (Describe:____________________________________)

Glazing

13. Are booths constructed with the following?
    a. Plexiglas ____
    b. Insulated Glass ____
    c. Tinted Glass ____
    d. Bullet Proof Glass ____
    e. Black Out Glass ____
    f. PolarizedGlass ____
    g. Venetian Blinds ____
    h. Filament (Heat Sensitive) Glass ____
    I. Other (Describe) ____________

Booth Fixtures/Equipment

14. Which of the following equipment is contained in your standard booth or toll house?
    a.____ Chair
    b.____ Front Counter
    c.____ Cash Drawer (No. ____ per counter)
    d.____ Fan (Ceiling ____ Counter ____)
    e.____ Switch Panel (Booth Lights ____ Canopy ____)
    f.____ Thermostat (Heat/Air)
    g.____ Change/Token Holder
    h.____ Portable TV
    i.____ Toll Recorder Cabinet
    j.____ Toilet
    k.____ Sink
    l.____ Security Door Locks
    m____ Drawer Locks
    n.____ Rear Counter
    o.____ Telephone (Direct ____, PABX ____)
    p.____ Intercom
    q.____ Duplex Outlet
    r.____ Radio AM/FM
    s.____ Counter Lighting
    t.____ Silent Alarm
    u.____ Refrigerator
    v.____ Bulletin Board
    w.____ 2-Way Radio
    x.____ Stool
    y.____ Lounge Chair
    z.____ Bill Alarm

I. LANE EQUIPMENT

1. Which of the following toll collection equipment is used in a manual, automatic and/or ETC equipped toll lane? (Please show the approximate location on the attached **toll lane equipment - configuration** for each lane type.)

	Manual	Auto	ETC	Not Used
a. Approach Closure Gate	___	___	___	___
b. Entry/Arming Loop	___	___	___	___
c. Audit Treadle				
1) 2 contact	___	___	___	___
2) 4 contact	___	___	___	___
3) Piezo Tube	___	___	___	___
4) Optical	___	___	___	___
d. Scale Beam (Size ___ (tons)/ Feet))	___	___	___	___
e. Weigh in Motion (WIM)	___	___	___	___
f. Vehicle Separator	___	___	___	___
g. Overhead Indicator	___	___	___	___
h. Infrared or Optical Height Sensors	___	___	___	___
i. Infrared or Optical Length Sensors	___	___	___	___
j. Canopy Mounted VMS	___	___	___	___
k. Overhead Lane Signals	___	___	___	___
l. ETC Antennae	___	___	___	___
m. Transaction Loops	___	___	___	___
n. Exiting Loop	___	___	___	___
o. Patron Fare Indicator	___	___	___	___
p. ETC Patron Status Display	___	___	___	___
q. Island Traffic Signal	___	___	___	___
r. Audible/Visual Alarm	___	___	___	___
s. Automatic Exit Gate	___	___	___	___
t. Automatic Surveillance Camera	___	___	___	___
u. Video Enforcement Camera()s	___	___	___	___

J. COLLECTION EQUIPMENT

1. Which of the following toll collection devices are installed in a manual, automatic and/or ETC equipped toll lanes?

	Manual	Auto	ETC	Not Used
a. Automatic Coin Machine (ACM)	___	___	___	___
b. Collector's Terminal (Button) Box	___	___	___	___
c. Collector Badge/ID Reader	___	___	___	___
d. Receipt Printer	___	___	___	___
e. Magnetic Card Reader	___	___	___	___
f. Bar Code Reader	___	___	___	___
g. Change Machine	___	___	___	___
h. Receipt Printer	___	___	___	___
i. Intercom	___	___	___	___
j. Bill Feeder	___	___	___	___

2. Where are your ACM's located?
   - a. Before booth (approach) ____
   - b. Free Standing (no booth) ____
   - c. After booth (departure) ____
   - d. Mounted in booth ____

(Please note the physical height of the ACM basket from the pavement on the attached toll lane approach elevation plan and its location on the lane equipment plan)

3. What typical collection equipment configurations are used?
   - a. Manual Only ____
   - b. Automatic Only ____
   - c. Dedicated ETC ____
   - d. Express (Bypass) ETC ____
   - e. Manual/Automatic ____
   - f. Manual/ETC ____
   - g. Automatic/ETC ____

TOLL FACILITY OPERATOR QUESTIONNAIRE (Con't)

K. LANE CAPACITY

1. What is the capacity of each toll lane type? (Provide a range of value if appropriate.)

	Private Passenger Vehicles Only	Commercial Only	Mixed (Commercial ___%)
a. Manual Lane	___	___	___
b. ACM Exact Cash Single (Coin or Token)	___	___	___
c. ACM (Multiple Coin or Token)	___	___	___
d. ETC	___	___	___
e. Ticket (Entry)	___	___	___
f. Credit Card (Mag Card)	___	___	___
g. Feeder Lane (w/3 Branch Lanes)	___	___	___
h. Tandem Lane (Manual-Auto)	___	___	___
i. Express/Bypass Lane (No Barrier)	___	___	___
j. Combined Lanes * (Describe: ___________)	___	___	___

* (Where collection methods are mixed and used simultaneously in the same lane estimate combined thru-put here)

L. TOLL PLAZA ACCESS

1. Is on-site parking provided for collectors? ___ Yes ___ No.
2. If Yes -- how is parking accessed? from mainline ___ From local roadway ___
3. If No -- how do personnel arrive at plaza? a. By Van (from remote lot) ___ b. Walk from off-site lot ___
   c. other (Describe: ___________________________
4. Which of the following means are used by collectors to access and/or service toll lanes?
   a. Walk across plaza ___
   b. Use tunnel with intermittent stairwells to islands ___
   c. Use aerial walkway with stairs down ___
   d. Elevator from elevated walkway or overhead offices ___
   e. Other (Describe: ___________________________
5. How are ACM coin vaults serviced?
   a. From toll island or inside/booth ___
   b. Vaults located in tunnel ___
   c. Vacuum (Pneumatic) Tube to Admin Building ___
   d. Other (Describe: ___________________________

TOLL FACILITY OPERATOR QUESTIONNAIRE (Con't)

M. TRAFFIC CONTROL DEVICES

1. Are pavement markings used to channelize vehicles in the toll plaza approach and departure zones?
   Yes ___ No ___
2. If Yes, on the attached **plaza layout** schematic, please sketch the typical approach and departure lane lines (skip and solid), channelizing lines to toll island approach end and (transverse) lane markings used. Indicate typical width and color, e.g., 4 Y (four-inch yellow), 6 W (six-inch white markings). A typical lane or lane group is sufficient.
3. How are toll lane and collection method status conveyed to the motorist?
   a. Overhead Red/Green Signal ___
   b. Overhead Green Arrow and Red "X's" ___
   c. Variable Message Signs (Canopy Mounted ___ In Advance of Plaza ___)
   d. Fixed Message (Flip or Swing Signs) On canopy ___
   e. Fixed Signs along Roadway in advance of plaza ___

N. PLAZA UTILITY/ADMINISTRATION BUILDING FUNCTIONS

1. Which of the following functions are typically provided? (Indicate functions/locations if requested)

	Mainline Barrier Plaza	Ramp	Not Provided
a. Public Foyer (w/restroom yes ___ No ___)	___	___	___
b. Computer (Toll Recorder)Room	___	___	___
c. Collector Count (Audit Observation) Room (w/drop safe for deposit Yes ___ No ___)	___	___	___
d. Banking Room (For wrapping and counting of collector deposits and/or coin/token vaults)	___	___	___
e. ACM Vault Storage (Empty)	___	___	___
f. Money Vault (Walk-in)	___	___	___
g. Token Storage Room	___	___	___
h. Electronics (Toll Equipment) Maintenance	___	___	___
i. Collector Lunch Room	___	___	___
j. Collector Lounge/Day Room	___	___	___
k. Employee Locker Room (w/showers Yes ___ No ___)	___	___	___
l. ETC Sales Office (sold at booth ___ or off-site Store ___)	___	___	___
m. ETC Installation Facility	___	___	___
n. Token Sales Office (sold at booth ___ or off-site store ___			
o. Armored Car/Loading Dock	___	___	___
p. Mechanical Room	___	___	___
q. Generator Room (Generator located outside ___)	___	___	___
r. Communications Office ___ or Console ___	___	___	___
s. Police Desk ___ or Console ___	___	___	___
t. Electrical Room ___ or closet ___ (w/UPS Yes ___ No ___)	___	___	___

u. Plaza Supervisor's Office ____ (with Control Console ____) ____ ____ ____
v. Other Rooms/Office (Describe:____________________) ____ ____ ____
w. Toll Island Collector or Utility Tunnel ____ ____ ____

Please note any exceptions next to description of function e.g. Mechanical Room - contains Electrical Panels.)

O. SIGNING

1. What type of Advance Signing is deployed and approximately how far in advance of the Plaza are they placed(If more than one sign for a service is displayed, please note number of signs.) Reference distances to centerline of toll barrier for the furthest sign.

	Distance (in feet (mm)	Number of Signs
a. Toll Schedule	____( )	____
b. Warning/Informational Message e.g., TOLL PLAZA AHEAD	____( )	____
c. Speed Restriction (Advisory)	____( )	____
d. Toll Lane Use Information, e.g. TRUCKS/BUSES USE RIGHT LANE, EXACT CHANGE/TOKENS ONLY or Symbols	____( )	____

2. Which signs are typically displayed within a toll lane and where are they located?

Indicate location on the toll plaza layout schematic. Use the circled number(s) to show sign designation

a. STOP (Pay Toll) ① ____
b. Toll Schedule ② ____
c. Speed Limit ③ ____
d. Regulatory Message ⑦ - ⑨ (Describe: ____________________
e. Other ④ - ⑥ (Describe: ____________________

P. LANE CONFIGURATION

1. Does your facility have a fixed lane configuration for toll collection, e.g., all automatics on the left?

Yes ____ No ____

2. If yes, show an example configuration (Use M for Manual, A for Automatic, E for ETC (T for Automatic Ticket) and combinations e.g., M/A to designate manual and automatic lane functions available)

Mainline Plaza

(Left) ↑ ↑ ↑ ↑ ↑ ↑ (Right)

__ __ __ __ __ __

Ramp Plaza Entry

(Left) ↑ ↑ ↑ ↑ ↑ ↑ (Right)

__ __ __ __ __ __

Ramp Plaza Exit (leaving facility)

(Left) ↑ ↑ ↑ ↑ ↑ ↑ (Right)

__ __ __ __ __ __

(Arrows indicate typical toll lanes - Add or delete lanes to show typical plaza.)

3. Does your facility use any of the following bypass toll lanes? (Check as many as apply for a Mainline and/or Ramp exit/entry Plaza)?

	Mainline Plaza	Ramp Plaza
a. Express ETC Mainline Lane(s)	____	
b. HOV Bypass Lane. ____	____	
c. Bus ONLY Bypass Lane.	____	____
d. None	____	____
e. Oversize vehicles	____	____

4. Does your facility use any of the following lane configurations to increase thru put?
   a. Tandem Lanes ____, b Branch Lanes ____, c. Neither ____

5. Are all lanes equipped to provide more than one toll collection method? Yes ____ No ____

6. If yes, why are lanes so equipped?
   a. A fall back in case of a failure in the primary collection method. ____
   b. More than one collection method is used in a lane simultaneously. ____
   c. Flexibility to accommodate different users i.e. weekend travelers, commuters and off peak travel. ____

Q. REVERSIBILITY

1. Does your facility use reversible toll lanes to accommodate peak directional traffic demands?
   Yes ____ No ____

2. If yes - What method(s) is used to channelize motorists into the reversed lane? (Check all that apply)
   a. Canopy Signing ____
   b. Canopy Lane Signals ____
   c. Advanced Variable Message Signs ____
   d. Movable Barrier ____
   e. Cones/Delineators ____
   f. Other (Describe: ________________)

R. ENFORCEMENT

1. What method(s) of toll violation enforcement is used?
   a. None ____
   b. Collectors are deputized police officers ____
   c. Personnel record violator's plate ____
   d. Random police presence ____
   e. Police at the plaza ____
   f. Violation (Video) Enforcement camera (in ACM lanes ____
   g. ETC lanes ____ All lanes ____)
   h. Automatic Exit Gates ____

TOLL FACILITY OPERATOR QUESTIONNAIRE (Con't)

4. Is special equipment, devices and/or designs incorporated in the toll booths, lanes or building for physically challenged personnel aside from ramps, restrooms and door openings? Yes ____ No ____

   If yes, please briefly describe these modifications.

   ____

   ____

5. If the modifications for physically challenged personnel are for booth access and use, are these limited to a particular lane? Yes ____ No ____

   (If yes, please define which lane(s) ____)

Please return the completed questionnaire in the stamped self-enclosed envelope to:

Albert E. Schaufler, P.E., P.P.
9 Harbourton Woodsville Road
Pennington, New Jersey 08534-3709

Thank you for your participation

APPENDIX B

TOLL FACILITY OPERATOR QUESTIONNAIRE—SUMMARY

APPENDIX B
TOLL PLAZA DESIGN
TOLL FACILITY OPERATOR QUESTIONAIRE - SUMMARY

NCHRP PROJECT 20-5
TOPIC 25-11

I		FACILITY BACKGROUND	1	2	3	4	5	6	7	8	9 *	10	11	12	13	14 *
A		Facility Identification	Gross Ile Br.	Ind. Toll Rd.	Mackinac Br.	Pontchatrain Causeway	Chesapeake Bay Br & Tunn	W. VA. Tpk	Garden State Pkwy	NY Thruway	Florida Tpk System	Oklahoma Tpk	Mass. Pike	Penn Tpk.	Tobin Br.	Harding Toll Rd (S. Houston Tlwy)
E		Location	MICH.	NORTH IND.	MICH.	LA.	VA	W.V	NJ	NY	FLA	OKLA	MASS.	PA	MASS.	TEX.
G		Type	Br.	Toll Road	Br.	Br.	Br/Tunn	Toll Road	Toll Road	Toll Road	Toll Roads	Toll Road	Toll Road	Toll Road	Br.	Toll Rd/Br.
H		Year Opened	1913	1956	1957	1956	1964	1954	1954	1954	1958-86	1953	1957	1940	1950	1982 (88,90)
		Year Last Renovated	--	1993	--	1994	--		1994 (Recon/Renov)		1994, Plaza Renov.	1992 (Barrier Sys)	1994 (Expan Rehb)	1994, (Reconstr)	1993 Repl Toll Plaza	--
I		Facility Size														
	1	Length Mi. (km)	1	156.9	4	23.82	19.5	90	173	641	373	557	135	506	2.25	21 (27,2)
	2	Lane Mi. (km)	2	642	16	95.28	39	450	1260	--	1714	2228	1100	2046	13.5	92 (62)
	3	No. of Toll Plazas M/R	1/-	3/17	1/-	2/-	2/-	3/1	12/31	13/48	13/56	26/-	3/17	7/51	1/-	6/25
	4	No. of Toll Lanes (Reversible)	2	120	8	7	6	38	329	354	404 (6)	43	235	335	7	145 (exist)
J		Type of Toll System	C	C	c	0	C	O (c)	C/O (c)	C(t) O (c)	C (c)	c/o (T,c)	c/o (T,c)	C (T)	C	O (c)
K*		Method of Collection	M (CS)	M(T/C)	M (CS)	M (C),E (d,m)	M (C,S),C	M, (C, Ex,)	M(C), A (EX/T)	M (c,cc) ACM (E) ETC	M (c) ACM (Ex) E (D, M)	M(C/T),A(Ex) CC E (D,M)	M (C/T) CC, A(E)	M (T/ Cc) A (E)	M(C/S/E) ACM	M(C,S,E),C,C * 6ml+3 25 ramp +18 ACM(E,T) E (D,M)
II		DESIGN STANDARDS														
A		Standard/Guidelines	--	3.4	1,4	3	1	3	1-7	1-4 (varies)	1-4,6-9	1-3	1,4,7	1-5, 7,8	1,3	1-4,7,8
B		New Plaza	N/A	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
C		Adopted	N/A	N/A	3,4	4	1,2,3	3	1-7+ADA	--	Stand. Toll Fac. Plans	--	--	--	--	--

Numbers/Letters in cells for Section II and III refer to response to Questions presented in Operator's Survey Questionnaire unless a specific value, e.g., % volume, or length was requested.

N - No
Y - Yes
NA - Not Available

* Notes:
9H2: 1994-1999 5 New expwy/pkwys under const TOTAL 106.8 miles (434.4 La Mi.)
9I1: New 106.8 Mi
9I2: 434.4 mi
9I3: 10 M Plazas, 49 R Plaza
9K: ATIM used on central
14I 3/4: 3 new mailine Plaza with 12 toll lanes and 18 Ramp Plazas.
9I4: New 208 Toll Lanes (6 Reversible) -- 2 systems to use bypass ETC. Lanes.
K: (T) Tickey, (C) Cash, (Cc) Charge Card
(Ex) Exact Change, (D) Dedicated (M) Mixed

APPENDIX B **NCHRP PROJECT 20-5**
TOLL PLAZA DESIGN **TOPIC 25-11**
TOLL FACILITY OPERATOR QUESTIONAIRE - SUMMARY

			1	2	3	4	5	6	7*	8*	9*	10	11	12	13	14
III		**PLAZA GEOMETRICS**														
A		**Geometrics**	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
B		**Pavement**														
	1	**Toll Lane**	C	C	C	C	C	C	C	C	C	C	C	C	Epoxy Conc	C
	2	**Transitions**	A	A	C	C(Ap), A(Dp)	A	C	A	A/C	A	C	C/A	C	Epoxy Conc	C
	3	X Slope/Profile (%)														
		a. Approach	0/1.5	1.0/0	1-2.5/-	0.7/-	-/2	--	1.5/1.0	--	0-2.0/0.5-1	1.7/3	2.0/-	2.0/.6	1.0/0.8	1.6/0.3
		b. Departure	0/1.5	1.0/.5	1-2.5/-	0.5/-	-/2	--	1.5/1.0	--	0-2.0/0.5-1	1.7/3	2.0/-	2.0/.6	1.0/0.8	1.6/0.3
		c. Toll Lane	0/0	1.0/0	1-2.5/-	1.0/-	-/2	--	1.0/0.5	1.5/-	0/0	1.7/0.4	0/-	2.0/.5	1.0/0.8	1.6/0.3
C*		**Lighting**														
	1	Level (ft candle)														
		a. Mainline	--	1.5	--	1.6	--	--	0.6-0.8	--	1.5	--	<0.6	0.6	1.0	--
		b. Departure	--	2.0	--	1.6	--	--	2-1	0.5	2	--	<0.6	0.6	1.0	--
		c. Approach	--	2.0	--	1.5	--	--	1-2	0.5	2	--	<0.6	0.6	1.0	--
		d. Ramp	--	2.5	--	N/A	--	--	2	.5 (min)	2	--	0.6	0.6	N/A	--
	2	Type/Intensity	--													
		a. Approach	S/250	S/1000	M/400	S/75-100	S/250	S/250	S/150-400	S/1000	S/400	--	LPS/90	S/250-400	S/100	S/--
		b. Departure	S/250	S/1000	M/400	S/100,M/400	S/250	--	3/150-400	S/1000	S/400	--	LPS/90	S/250-400	A/100	S/--
	3	Lighting Structure														
		a. Aproach	2	1,3	3		3	2	1/400,2/250	1,3/250	1,3 (50')	3	2	1,2,3	3	1
		b. Departure	2	1,3	3	3	3	2	1/400,2/250	1	1,3 (50')	3	2	1,2,3	3	1
		c. Ramp	--	1,3	--	N/A	--	2	1/400,2/250 3/150	1	1,3 (30-35')	3	2	3(40')	N/A	2
	4	Toll Lane Lighting	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	5	Location	a.	a.	a	a	a	a	a,b	a,b c (Mast)	a,b	a	a,b	a	a	a
	6	Level	--	40	--	--	--	--	- >2	2.5	20	--		1.5	5	--
	7	Type/Intensity	S/400	S/100	I/150	H/250	I/150	MV/70	F/200,H/200	H/1000	S/250	S/250	All/-	S/150,F/40	S/--	S/--
	8	Visibility Devices	N	N	Y	Y	Y	N	Y	Y	N	N	N	N	N	N
	9	Type/Location	--	--	b(1,2),C(2)	c v, C (Br1/-Mi)	d (canopy)	--	a(i), c(1),(2),d	c/Adv,d	--	--	--	--	--	--
D		**Drainage**				d (cones,signs)										
	1	Transition Roadway	c	c	b	a	b	a	a,b	a	b	a,b	a	a,b	N/A	a
	2	Closed-Type	a	a	--	a,b	--	c	c	c	--	c	a	c	N/A	a
	3	In Toll Lane	N	N	b	b,c	a,b,c	b	a,b	a-c	a,b	a	b	a,b,c	b	a

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*Notes:
7C 1 b, ,c - 500' - 500'-200'-500'
7C 2a, b - 150 W (40' Pole), 400 (High Tower)
7C5, 7 - booth mounted (sevent @ ramps) H200 W
7C9 - d-Fiber Optic Fixed Message over Host Lane
9 B3C - Flat 20' ADJto Booth
8 C9 - C HI Fiberoptic
- d LS (fiberoptic) 2 levels

N - No
Y - Yes
NA - Not Available

APPENDIX B
TOLL PLAZA DESIGN
TOLL FACILITY OPERATOR QUESTIONAIRE - SUMMARY

NCHRP PROJECT 20-5
TOPIC 25-11

			1	2	3	4	5	6	7	8*	9*	10	11	12	13*	14
E		Environmental														
	1	Issues	N	a,b,c	a	c	N	a,b,c	a,b,c	a-d	a-d	a,b,c	a,c	a,b,c	a,b	a,b,c
	2	Remedial Measures														
		a. Noise	--	1	--	N/A	--	--	1,3	1,3	1,3	1,3	--	1,2	--	1
		b. A/Q	--	1 (Widen), 2	2	N/A	--	2	1	1,2 tandem	1 (ETC),2	2	LA, Tandem	2	2	1 (ETC)
		c. Water Quality	--	5 (Filter)	--	5 (Treant/Sep)	--	2	2,3,4	5	1-4	1,3	\ 2	1,3	--	2
	3	Air Monitoring Devices	--	N	N	N	N	N	N	N	N	N	N	N	N	N
	4	Pollutants/Loc.	--	--	--	--	--	--	--	--	--	--	--	--	--	CO,HC,NOX CHK OCCAS. @ BOOTH/LA
F		Safty Devices														
	1	Crash Device	d (Steel Δ 1 2 x 12 wood)	a, b, c	d (conc. attenuator)	b,c	a	c (8 Bay Hydro)	a,b,c (Great Near Side Branch)	a,c GREAT	c GREAT	a,c HEXFOAM (40-70 mph)	a	c	a	b
	2	Both Ends	Y	N	Y	Y	N	Y	Reversible	Reversible	Reversible	Reversible	Y	Reversible	N	Y
	3	Purpose	b, c	a, b, c	b,c	a-d (Toll Eq.)	a,b,c	a,c	a-c	a-d	a-c	a,c	b,c	a-c	α,β,χ	a,b,c
G		Canopy														
	1	Over Lanes	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	2	Purpose	d	a,b,d	b,d	b,d	a,b,c,d	a,b,d	b,d,e	a,b,d	b,d	b,d	a,b,d	a,b,d	b,c,d,e	a,b,d
	3	Design Considerations	a	a	--	a,b	a,b	d	a,e	a,b,d	a,c,d,e	b	a	a	e	a,d
H		Toll Booths														
	1	a. Single End Dimension	--	10' x 5	11' x 4'	8' x 4'	9' x 3.5'	6' x 4'	12' x 3.5'	12' x 4	--	9'7"x3'9"	11' x 4	14' x 6'8"	--	10'x3'.6" ML
		b. Double End Dimension	8' x 2'-6"	15' x 5	11' x 4'	--	--	10' x 4'	12' x 3.5'	12' x 4	11x4/14x4	--	--	19x17	--	16'x3'6" Ramp
	2	Structural Support Func.	N	N	Y	N	N	N	Both	N	Both	N	Both	N	N	N
	3	a. Frame Material	St	St	St	Ex. Al	St	ST	ST, RSt	RSt	ST,SS	St	St., RS	ST	--	ST
		b. Ext. Skin	PS	PS (9)	SS	Al (16)	PS (1/4")	SS	Br, PS (1/4")	St (10), A(20)	SS	--	PS (1/4)	Br	SS Al(16)	Al
		c. Int. Skin	--	A (12)	--	Al (16)	ST (16)	--	SS	SS (20)	SS	--	St	GS	GS	Sh.Rk
	4	Insulated	N	Y	Y	Y	Y	N	Y	Y	Y	Y	N	Y	Y	Y
	5	Type Heating	E	HW	HW	E	E/HW	HA	E	E, HW, Fan	E	E,S, Propane	HW	E,HA,Steam	E	E
	6	A/C	--	--	--	W	W	C	W	--	Roof	W/C	--	W/C	OH	W

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*Notes:
13G2e - carry utilities
8 E 1 - High mast lighting
8 EZC - Wash water collection/disposal
9 H2 - Support on SM ramp plazas
8F 1C, 3d - Mainline & Interstate ramps
d - Protect Attendants
9 E1 d - Bald Eagle, Soil contamin, asbestos
9 G 3e - Cost, maint., durability, Island length

N - No
Y - Yes
NA - Not Available

APPENDIX B
TOLL PLAZA DESIGN
TOLL FACILITY OPERATOR QUESTIONAIRE - SUMMARY

NCHRP PROJECT 20-5
TOPIC 25-11

			1	2	3	4	5*	6	7*	8	9*	10	11	12	13	14
	7	Positive vent.	N	Y	Y	N	N	Y	Y (Partial)	Y	Y	Y	N	Y	Y	N
	8	Air Supply Loc	--	c	c	--	--	c	a	c	c	c	--	a,c	b	--
	9	Booth Flooring	d St w/Mat	d St w/Mat	a	a	a	c A/1 on St w/Mat	a SS w.Mat	c St w/MaT	d-concw/ Computer Fl	a,c	a,d St, w/Mat	d wood w/Mat	a	b
	10	No. of Doors	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	11	Type of Doors	a	a,b	a,b	a,b	a (2) w/b	a	a,b	a,(old),b,c	ab or bc	a	a,b	a-c	a,b,c	a
	12	Door Equip.	d (sliding window)	a	b	b	a	d (Splash)	a,b,d	a,b	a	c	c	b,d (Extend. Dr)	a	c
	13	Booth Glass	1 (Auto)	b,c	g	a,c,d	/4" Solex Duplate	a,b,c	Tinted Lexan	g,1 (laminated)	a,c,l	c,g	c,l (temper)	a,c,g	a,c	c
	14	Fixtures/Equipment														
		a. Chair	✓		✓	✓						✓				
		b. Front Counter	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		c. Cash Drawer (1 or 2 drawer)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		d. Fan (counter, ceiling)				✓	✓				✓	✓	✓			
		e. Switch Panel, Booth, Canopy	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		f. Thermostat	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
		g. Change/Token Holder	✓									✓	✓			
		h. Portable TV	✓									✓				
		i. Toll Recorder (Lane Control Cabinet)	✓	✓				✓	✓		✓			✓		
		j. Toilet	✓	✓							✓					✓
		k. Sink	✓	✓							✓					✓
		l. Security Dr. Locks	✓	✓				✓	✓	✓	✓	✓		✓	✓	✓
		m. Drawer Locks	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		n. Rear Counter	✓	✓		✓	✓	✓'	✓	✓			✓	✓	✓	
		o. Telephone	✓	✓		✓			✓	✓	✓	✓	✓	✓		
		p. Intercom	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		q. Duplex Outlet	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		r. Radio Am/Fm			✓							✓				
		s. Counter Lite	✓	✓			✓	✓			✓		✓	✓	✓	✓
		t. Silent Alarm		✓		✓	✓	✓	✓		✓	✓			✓	

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N - No
Y - Yes
NA - Not Available

*Notes:
9H 13 - 1 Pull Downs
5H 14 - d (ceiling)
e (booth lights)
7E 2b - Optimize toll collection method
Add branch lanes
7G2 - Shield patrons from elements
7G3 - Veh. clear + cover toll personnel workway
7H 12 - Triple track weather shield
7 H 14 - j, k, u some ramps w/o Admin. Bldg

APPENDIX B
TOLL PLAZA DESIGN
TOLL FACILITY OPERATOR QUESTIONAIRE - SUMMARY

			1	2	3	4	5	6	7	8	9	10	11	12	13	14
		u. Refrigerator										✓				
		v. Bulletin Board			✓							✓		✓		
		w. 2-way Radio	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓		✓
		x. Stool		✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		y. Lounge Chair														
		z. Bill Alarm							✓							
II		**Lane Equipment**														
	1	a. Appr. Closure Gate		M, A	M	M,E				A			M (some)		M/A	
		b. Entry/Arming Loop								ETC	M,A	M,A	A		M,A	E
		c. Audit Treadle	3M	2M, 2A	2M	(1-2,4 M&E)	IM	2 M/A	2 M	2 (M,A,E)	2M	I M/A	4 M/A	1-2 M/A	2 M	M,A,E
		d. Scale (Beam)				12' (50T)										
		e. WIM				M,E								M/A		
		f. Veh Separator			M	M,E					M,E		A	M/A		
		g. OHI			M			M,A				M,A,E		M/A		
		h. Height Sensors				M,E	M		A	(bar)				M/A		
		i. Length Sensors														
		j. VMS (canopy)				M,E				M,A,E	M,A		M (two)		M,A	
		k. OH Lane Signal		M, A	M	M,E	M	M,A	M,A	M,A,E	M,A	M,A	M,A	M/A	M,A	M,A,E
		l. ETC Antennae				M,E				E	E	M,A,E				E
		m. Transcation Loop		M, A			M	A				M,A	A	M/A	M,A	
		n. Exit Loop			A	M,E	M	A	A	A,E	A	M,A	M	M/A	M,A	M,A,E
		o. PFI		M, A	A	M,E	M	M,A		M	M,A,E	M	M	M/A	M,A	M
		p. ETC - PSD				M,E				E	E				M,A	E
		q. Island TS	M	A	M	M,E	M	A	A	A,E	A,E	M,A	A	M/A	A	M,A,E
		r. Alarm		M, A		M,E	M	A	A	A,E	A		A		A	M,A,E
		s. Auto Exit Gate		A		E					A,E		A	M/A	A	A
		t. Surveillance Cameras				E,E	M		in lanes		M,A	M,A,E			A	
		u. VEC								E	E					E
III		**Collection Equipment**														
	1	Devices														
		a. ACM		A	--				A	A	M,A,E	M,A	A	M/A	M.A	M.A
		b. Button Box	M		M		M	M	M	M	M,E	M,A	M		M.A	
		c. ID Reader		M, A	--		M		M,A	M,A,E	M,E	M	M	M	M.A	M
		d. RP	M	M	--	M,E	M	M	M	M	M,A,E	M	M	M	M.A	M
		e. MCR		M, A	--			M,A			M,A,E		M	M	M.A	M
		f. BCR					M			M,A,E						
		g. CM														
		h. RP (in lane)			M											A

Numbers/Letters in cells for Section II and III refer
to responses to Questions presented in Operator's Survey
Questionnaire unless a specific value, e.g., %
volume, or length was requested.

N - No
Y - Yes
NA - Not Available

APPENDIX B
TOLL PLAZA DESIGN
TOLL FACILITY OPERATOR QUESTIONAIRE - SUMMARY

NCHRP PROJECT 20-5
TOPIC 25-11

			1	2	3	4	5	6	7	8	9 (10-15)*	10	11*	12	13*	14
		i. Intercom	M	M, A	M	M,E	M	M	M,A	M,A,E	M,A,E	M	M,A	M,A	M,A	M
		j. Bill Feeder														
	2	ACM Loc.		b	--	N/A	a	d (MCR)	d	d	b,d	a	b,d	c,d	c	b,d
	3	Toll Configuration	a	e	a	a,e	a	a,b,e	a,b,e	a,b,c,e,f	d-g	--	a,b,e	a,b,e	e	a,b,e
K		**Lane Capacity (VPH) (% Comm.)**														
		a. Manual Lane	1-500	1-240,2,3-180	N/A	N/A	N/A	See Note 1.	1-450/500	3-400	1-450,2-280 3-400	N/A --	3-300/ 350 (5-10)	1-360,2-240 3-300 (12)	N/A --.	1/300/350 3-250/300
		b. ACM (Single)			--	N/A	N/A		1-900/1000	--	1-600	N/A	1-600		N/A	1-500/600
		c. ACM (Multi)		1-480	--	N/A	N/A		1-800/900	1-400/600+	1-535	N/A		1-900,2-450	N/A	1-500/600
		d. ETC			1-1200,3(12)/500	N/A	N/A			1-850+	1-900	N/A				1800
		e. Ticket (entry)		3-600	--	N/A	N/A			1-750+,3-550	1-700,2-700'	N/A	3-400/450 (5-10)	1-540,2-360 3-450 (12)		
		f. Mag Card			--			See Note 1.			--	N/A	3-400/450/(5-10)			
		g. Branch Feed Lane			--	N/A	N/A		MAT 1975		1-640					
		h. Tandem Lane			--	N/A	N/A			1(30),3(10-20)	1-500 (M)		3-480/560/(5-10)	1-540		
		i. Bypass Lane			--	N/A	N/A			--	1-800					
		j. Combined		3-180	--	N/A	N/A				1-640					
		k. Ticket (Exit)]									1-350				K=12%,C=465/La See Note 2	1-300/350 3-250/300 (M/E)

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N - No
Y - Yes
NA - Not Available

*Notes:
1 5 kaf 29M (auto) + 8M (comm) ADT = 300 veh.hr
2 13KK = 26300ADT,T_9%
9 K h - used for special event, (M/A) peak hour
restore tolls after natural disaster
manual - autmatic or human -automatic
11. kh - Manual only
K - 1 - Priv. Pass. Veh
2 - Commercial Only
3 - Mixed (% Comm.)

APPENDIX B **NCHRP PROJECT 20-5**
TOLL PLAZA DESIGN **TOPIC 25-11**
TOLL FACILITY OPERATOR QUESTIONAIRE - SUMMARY

L		Toll Plaza Access	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	1	On-site Parking	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	2	Parking Access Mainline (M), Local Road (LR)	LR	M, LR	LR	M	LR	M	M	M, R	M	M,R	M,R	M,R	R	M
	3	Arrival (Alt.)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	4	Toll Lane Access	a	a, b	a	a	a	a,b	a,b	a,b	a,b	a	a, b (some)	a	a	a
	5	ACM Vault Serv	--	a,b	--	--	--	a	a,b	a	a,b	a	a	b	a	a
M		Traffic Control Devices														
	1	Pavement Markings	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y
	2	(Plaza Layout)	N	N	Y (part)	Y (+ Plan)	Y (plan)	N	Y	Y	N	N	N	N	N	N
	3	Motorist Info	N	b,d	a,e	a,c,e	a	b	a,d,e	a-e	a,c,e	a,e	a,d	a,b,e	b,c	b,d,e
N		Administration Building														
		Functions - Mainline (M) Ramp (R)														
		a. Public Foyer (Rest Room Y/N)			M	M	M				M		M,R	M,R	M (y)	M
		b. Computer (Toll) Room				M	M	M	M,R	M,R	M,R		M,R	M,R	M	M
		c. Count Room (Safe)	M	M,R		M	M	M	M	M,R	M	M,R	M,R (s)	M,R (s)	M	M,R (s)
		d. Banking Room		M,R	M		M	M			M	M,R	M,R	M,R		
		e. Vault Storage (Empty)		M,R					M		M	M,R	M	M,R	M	M
		f. Money Vault			M		M	M	M		M	M,R	M,R	M,R		M
		g. Token Storage							M					M,R		
		h. Electronic Maint.		M,R	M	M	M	M	M	M,R	M		M,R	M,R	M,R	
		i. Lunch Room	M	M,R	M	M	M	M	M,R	M,R	M	M,R	M,R	M,R	M,R	
		j. Lounge/Day Room	M		M									M,R	M,R	
		k. Locker Room (w/wo Showers)		MR (w/o)	M		M	M	M	MR	M		M,R	M,R (w)	M,R	
		l. ETC Sales Office				M									R	
		m. ETC Install. Facility				M									R	M,R
		n. Token Sales (on/off site)													R	M
		o. Armored Car/Loading Dock		M,R					M,R			M,R	M	M	R	M
		p. Mechanical Room		M,R	M	M	M	M	M,R	M,R	M	M,R	M,R	M	R	M
		q. Generator		M,R	M	M	M	M	M	M,R	M,R	M,R	M,R	M	M,R	M
		r. Communications				M	M	M	M	M,R			M,R		M,R	M
		s. Police Desk/Console				M	M					M	M,R		M,R	M
		t. Electrical Room (w/UPS)		M,R (UPS)	M	M	M	M (UPS)	M,R	M ,R (UPS)	M	M	M,R (UPS)	M,R (UPS)	M,R	M
		u. Supervisor's (Office/Console)		M,R	M	M	M	M	M	M,R	M	M	M,R	M	MC	MC
		v. Other Room/Office				M				M,R	M		M,R	M		M
		w. Collector/Utility Tunn.		M,R				M	M	M,R	M	M	M,R	M		
O		Signing DIST. (FT.) # of SIGNS									(See Quest.)					
	1	Type														
		a. Toll Schedule	1200/2	0	1500/2	10/1	1500/1	5280/11320	5280/2	5280(cars)	900/1	--	--	500/1	2411,1215/2	400/1
		b. Warning/Info	1200/2	500	1000/2	1300/1	3775/1	10560/2640	5280/2	5280(varies)/	2,1&1/2 mi/3	--	2,1&1/2 mi/3	5280/3	2, 1/2 mi /2	2000/1

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*Notes:
6 N1p - Mech. Room W/elect + heating
601a - Cars only
6L5 - ACM
7/8L4,5 - b @ 1 Plaza
7N1 - w @ 1 Plaza
9N1 - NO UPS
10 N - Off Site Storeg, C Safe, S desk

N - No
Y - Yes
NA - Not Available

APPENDIX B
TOLL PLAZA DESIGN
TOLL FACILITY OPERATOR QUESTIONAIRE - SUMMARY

NCHRP PROJECT 20-5
TOPIC 25-11

			1	2	3*	4*	5*	6*	7*	8*	9	10	11	12	13	14
		c. Speed Restriction	1000/2	1000/1	850/2	10/4	1925/2	2640/1320	--	--	Ded. ETC	--	--	5280/3	1997,571/3	500/1
		d. Lane Use	--	1200/1	--	800+canopy	--	Varied/2 Partial	4000/2	2640/1	1500/1 or 2	--	--	2600/1	1529,571/2 2 Mi TRk/Bus 1/4 Mi Exact Chg	
	2	In Lane	--	d (on Booth)	a,b, (Booth)	a-d	Plan	a,e	a,b,e	a,b,e	a,b,c,e	--	--	a,b	a,b,c	--
P		**Lane Configuration**														
	1	Fixed	Y	Y	N	Y	N	N	N	N	N	Y	N	N	N	Y
	2	Example	N	Y	N	4 La/AE	--	Y	--	(See Sketches)		M,M/A,M,E	(See Sketches)	--	--	See Question
	3	a. Exp. ETC						N/A			Under Design		--		--	ML
		b. HOV										--	M		--	--
		c. Bus Only										--			--	--
		d. None														
		e. Oversized						M,R		Outside LA	M	--	M/R	M/R	--	Outside LA
	4	Branch/Tandem Lane														
	5	>1 Method/Lane	N	N	N	Y	N	R	n	n	const. only	--	N	Y	Some	Some
	6	WHM >1	--	--	--	b,c	--	--	--	--	--	--	--	a	C	b,c
Q		**Reversibility**										--				
	1	Dir. Peak	N	Y	Y	N	N	Y	N	N	Y	N	Y	N	N	Y (3 of 6 Plazas)
	2	Method to Inform.	--	b,,e	b,d,e	--	--	b,e	b,e	b,e	b,e	--	b,e	b,e	--	a,b,e
R		**Enforcement Method**	c	c,d,	d	c	e	c,d	c,d,h (some)	c,d,f,(ETC)	c,f,h	--	c,h	c,d,h	e	c,d,f (ETC)
S		**Handicap Access**														
	1	Avail to Motorists	N	N	N	N	N	N	N	N	N	N	N	Y	N	N
	2	Type of Serv/Equip	--	--	--	--	--	--	--	--	--	--	--	a	--	--
	3	For Collectors	N	N	--	N	N	N	--	--	N	--	--	N	N	--
	4	Eq., Devices, Design	N	N	Y	--	N	N	N	N	N	Curb Ramps	Ramp/R Rm	N	N	N
	5	Limit (Lane)	--	--	--	--	N	--	--	--	--	N	N	--	N	--

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*Notes:
4 R - Call ahead to Police
3 S4 - Curb Ramps
5 N 1 - V Extra office
602 - 'OPEN' Sign in booth
PFI on side
702 - Tokens/Exact Change
802- Receipts/Trks Keep Right
Exact Changes - Cars Only

N - No
Y - Yes
NA - Not Available

TOLL FACILITY OPERATOR QUESTIONAIRE - SUMMARY

I		FACILITY BACKGROUND	15	16a	16b	16c	16d	16e	17a	17b	17c	17d	17e	17f	18a	18b
A		Facility Identification	International Br.	Rip Van Winkle	Kingston-Rhinecliff	Mid Hudson Br.	Newburg-Beacon Br.	Bear Mt. Br.	GW Br.	Holland Tunnel	Lincoln Tunnel	Bayonne Br.	Goethals Br.	Outerbridge Crossing	Ben Franklin Br.	Betsy Ross Br.
E		Location	MICH	NY	NY	NY	NY	NY	NJ-NY	NJ-NY	NJ-NY	NJ-NY	NJ-NY	NJ-NY	NJ-PA	NJ-PA
G		Type	BR.	BR.	BR.	BR.	BR.	BR.	BR.	Tunnel	Tunnel	BR.	BR.	BR.	BR.	BR.
H		Year Opened	1962	1935	1957	1930	1963	1924	1931	1927	1937	1928	1928	1928	1926	1976
		Year Last Renovated	--	1969 Toll Plaza	1980 New Booths	1967 New Plaza/Bths	1980 New Plaza	1993 New Plaza	1981 Main Plaza	1991 New Plaza	1995 New Plaza	1964 New Bth/Plaza	1964 New Bth/Plaza	1964 New Bth/Plaza	1992 One-Way Toll	1994 One-Way Toll
I		Facility Size														
	1	Length Mi. (km)	2.5	1 (BR)	1.5 (BR)	0.6 (BR)	1.5 (Br)	0.5 (Br)	1	1.5	--	1.09	1.35	1.66	1.8	3.38
	2	Lane Mi. (km)	10.2	3.5	7	10	26	4	72	6	26	4.36	5.4	6.64	10	41
	3	No. of Toll Plazas (M/R)	1/-	1/-	1/-	1/-	1/-	1/-	3/-	1/-	1/-	1/-	1/-	1/-	1/-	1/-
	4	No. of Toll Lanes (Reversible)	6	2	2	4	8	2	31	9	13	4	8	8	13	13
J		Type of Toll System	C	o (c) 1 way	o (c) 1 way	o (c) 1 way	o (c) 1 way	o (c) 1 way	o (c) 1 way	o (c) 1 way	o (c) 1 way	o (c) 1 way	o (c) 1 way	o (c) 1 way	o (c) 1 way	o (c) 1 way
K		Method of Collection	M (C)	M (C/S)	M (C/S)	M (C/S)	M (C/S/Ex)	M (C/S)	M (C,S,Ex)	M (C,S,Ex)	M (C,S,Ex)	M (C,S,Ex)	M (C,S,Ex)	M (C,S,Ex)	M (C,S,Ex) ACM,AVI	M (C,S,Ex) ACM,AVI
II		DESIGN STANDARDS														
A		Standard/Guidelines	--	1-3,5-7	1-3,5-7	1-3,5-7	1-3,5-7	1-3,5-7	4	4,8	--	1,4,7	1,4,7	1,4,7	9 (USBS STAND)	1 (1965)
B		New Plaza	--	Y	Y	Y	Y	Y	Y	Y	--	Y	Y	Y	N	N
C		Adopted	--	--	--	--	--	--	--	--	--	--	--	--	1,4,5 NJ-PA DOT SPEC	1,3,4

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N - No
Y - Yes
NA - Not Available

APPENDIX B
TOLL PLAZA DESIGN
TOLL FACILITY OPERATOR QUESTIONAIRE - SUMMARY

NCHRP PROJECT 20-5
TOPIC 25-11

			15	16a	16b	16c	16d	16e	17a	17b	17c	17d	17e	17f	18a	18b
III		PLAZA GEOMETRICS														
A		Geometrics	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
B		Pavement														
	1	Toll Lane	C	C	C	C	C	C	A/C	C	C	C	C	C	C	C
	2	Transitions	C	A	A	A	C	A	A/C	C	A/C	C	C	C		
	3	X Slope/Profile (%)														
		a. Approach	--	0.02/1.0	0.02/1.0	0.02/1.0	0.02/1.0	0.02/1.0	--	--	-/3.5	--	--	--	-/0-3.5	-/2.0
		b. Departure	--	0.02/1.0	0.02/1.0	0.02/1.0	0.02/1.0	0.02/1.0	--	--	-/3.5	--	--	--	-/0-3.5	-/2.0
		c. Toll Lane	--	0.02/1.0	0.02/1.0	0.02/1.0	0.02/1.0	0.02/1.0	--	--	--	--	--	--	-/0	-/1.39
C		Lighting														
	1	Level (ft candle)														
		a. Mainline	25-30	5	7	7	--	5	--	--	--	--	--	--	5	5
		b. Departure	35-50	5	7	7	--	5	--	--	--	--	--	--	5	5
		c. Approach	30-35	5	7	7	--	5	--	--	--	--	--	--	5	5
		d. Ramp	50	7 (PLAZA)	12(PLAZA)	10(PLAZA)	--	10 (PLAZA)	--	--	--	--	--	--	--	--
	2	Type/Intensity														
		a. Approach	S/250, HALIDE 1000	S/250	S/250	S/250	S/250	S/250	S/-	Metal Haude/500	S/-	S/-	S/-	S/-	S/1000	S/1000
		b. Departure	--	S/250	MV/1000	S/250	S/-	S/250	S/-	Metal Haude/500	S/-	S/-	S/-	S/-	S/1000	S/1000
	3	Lighting Structure														
		a. Aproach	1,3	3	3	3	3	Decrorative	1	1	3	1	1	1	1	1
		b. Departure	3	3	1	3	3	Decrorative	1	1	3	1	1	1	1	1
		c. Ramp	1,3	--					1	2	1	1 (PLAZA)	1 (PLAZA)	1 (PLAZA)	--	--
	4	Toll Lane Lighting	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	5	Location	a	a	a	a	a	a	a	a,b	a	a	a	a	a	a
	6	Level	75-90	7	--	10	10-12	10	--	--	--	--	--	--	7.5-10	7-10
	7	Type/Intensity	HALIDE/250	F/40	S/150	S/150	S/150	S/150	F	--	S/--	S/--	S/--	S/--	S/175	S/175
	8	Visibility Devices	Y	N	N	N	N	N	N	N	N	N	N	N	N	N
	9	Type/Location	C (Before Br.)	--	--	--	--	--	--	--	--	--	--	--	--	--
D		Drainage														
	1	Transition Roadway	--	a	a,b	a	a	a	a	a	a	a	a	a	a	a
	2	Closed-Type	--	c	c	c	c	c	c	c	c	a	a	a	a	a
	3	In Toll Lane	--	a	a	a	a	a	a,b	b	d	a,b	a,b	a,b	a	a,b

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N - No
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NA - Not Available

APPENDIX B
TOLL PLAZA DESIGN
TOLL FACILITY OPERATOR QUESTIONAIRE - SUMMARY

NCHRP PROJECT 20-5
TOPIC 25-11

			15	16a	16b	16c	16d	16e	17a	17b	17c	17d	17e	17f	18a	18b
E		**Environmental**														
	1	Issues	b	a,b	a,b	a,b	a,b	a,b	a,b	a-c	--	a-c+ asbestos	a-c+ asbestos	a-c+ asbestos	N/A	--
	2	Remedial Measures														
		a. Noise	3	3	--	3	1-3	3	--	3	--	--	--		--	4 (Sound Barrier)
		b. A/Q	--	--	2	--	2	2	2	2	--	2	2	2	--	
		c. Water Quality	--	--	--	--	--	4	2	2	--	2,3	2,3	2,3	--	
	3	Air Monitoring Devices	N	N	N	N	N	N	Y	N	--	N	N	N	N	N
	4	Pollutants/Loc.	--	--	--	--	--	Monitored Annually	Plaza	--	--	--	--	--	--	--
F		**Safty Devices**														
	1	Crash Device	a	a,c	a	a	a	b	a,c	c (compressed ST& Rubber)	a,c	c (hexfoam)	c (hexfoam)	c (hexfoam)	d 2-8' ϕ Conc-Pipe	a,c (great)
	2	Both Ends	Y	Y	Y	Y	Y	Y	N	N	N	N	N	N	N	N
	3	Purpose	b,c	a,c	c	c	c	c	a,c	a-c	c	a,c	a,c	a,c	a,c	a,c
G		**Canopy**														
	1	Over Lanes	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	2	Purpose	b,d	a-d	a,b,d	a,b,d	a-d+Mt.HVAC	a-d	a-d	a-d	b,d	a-d	a-d	a-d	b,d	b,d
	3	Design Considerations	--	a,b	a,b	a,b	a,b	a-c	--	Loc&Real Estate	--	c,d	c,d	c,d	a,b	a,b
H		**Toll Booths**														
	1	a. Single End Dimension	--	16' x 6'	17' x 6'	14' x 6'	12' x 6'	16' x 5'8"	19'-6' x 4"	8' x 4'	8' x 2'-8"	8'-10' x 3'	9' x 3'	10' X 4	8'-81/'x3'-61/2'	8'-6'x3'-8"
		b. Double End Dimension	11' x 3'-6'		--			--	--	--		--	--		14x3'-61/2"	12'-8"x3'8"
	2	Structural Support Func.	Y	N	N	N	N	N	N	Y	Y	N	--	N	Y	N
	3	a. Frame Material	ST	ST	ST	Conc. Blk.	ST	ST	ST	ST	ST	ST	ST	ST	ST	--
		b. Ext. Skin	PS	Br.	Br.	Masonry	Masonry	Masonry (4")	St, Al.	Masonry	PS	Al	Al	Al	PS 1/4"	PS
		c. Int. Skin	--	A1 (9)	--	--	Sh. Rock	Sh. Rock	GS, Sh. Rock	SS	GS	Al	Al	Al	SS	SS
	4	Insulated	--	--	--	N	Y	Y	Y	Y	Y	--	--	--	Y	Y
	5	Type Heating	HW	El	HA	El	HW	El	El	El,HW	Radiant/HW	HW	HW	HW	El	El
	6	A/C	--	W	W	W	C	C	C	C	C	C	C	C	W	W

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APPENDIX B
TOLL PLAZA DESIGN
TOLL FACILITY OPERATOR QUESTIONAIRE - SUMMARY

NCHRP PROJECT 20-5
TOPIC 25-11

			15	16a	16b	16c	16d	16e	17a	17b	17c	17d	17e	17f	18a	18b
	7	Positive vent.	N	N	Y	b	N	Y	Y	Y	N	Y	Y	Y	N	N
	8	Air Supply Loc	--	--	b	--	b	b	b	c	--	b	b	b	--	--
	9	Booth Flooring	a	a	a	a	a	conc w/cork mat	St Frame/Al	a	b w/Mat	a	a	a	a	a
	10	No. of Doors	2	2	2	2	2	2	1,+Esc.Hatch	2	2	2	2	2	1	1
	11	Type of Doors	a,b	a	a	a	a	a	a,c	b,c	a	a,c	a,c	a,c	a,b	a,b
	12	Door Equip.	b,d(1/2door)	c	c	c	c	c	a	a	a	a	a	a	a	a
	13	Booth Glass	a	a,c,g (Safety)	c (safety)	c (safety)	c	c (safety)	a,c	C (sunshades)	c	a,b,g	a,b,g	a,b,g	i (Safety Glass)	i (Safety Glass)
	14	Fixtures/Equipment														
		a. Chair		✓	✓	✓		✓		✓					✓	✓
		b. Front Counter	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		c. Cash Drawer (1 or 2 drawer)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		d. Fan (counter, ceiling)	✓	✓	✓	✓		✓		✓						
		e. Switch Panel, Booth, Canopy	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
		f. Thermostat	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓		
		g. Change/Token Holder		✓	✓	✓	✓	✓	✓							
		h. Portable TV														
		i. Toll Recorder (Lane Control Cabinet)							✓						✓	✓
		j. Toilet														
		k. Sink									✓	✓	✓	✓		
		l. Security Dr. Locks		✓	✓	✓	✓	✓	✓	✓					✓	✓
		m. Drawer Locks	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		n. Rear Counter	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓		
		o. Telephone		✓	✓	✓	✓	✓		✓						
		p. Intercom	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		q. Duplex Outlet	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		r. Radio Am/Fm		✓	✓	✓	✓	✓								
		s. Counter Lite		✓			✓		✓	✓		✓	✓	✓		
		t. Silent Alarm			✓			✓	✓	✓	✓	✓	✓	✓		

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APPENDIX B
TOLL PLAZA DESIGN
TOLL FACILITY OPERATOR QUESTIONAIRE - SUMMARY

NCHRP PROJECT 20-5
TOPIC 25-11

			15	16a	16b	16c	16d	16e	17a	17b	17c	17d	17e	17f	18a	18b
		u. Refrigerator														
		v. Bulletin Board		✓	✓	✓	✓	✓		✓						
		w. 2-way Radio		✓	✓	✓	✓	✓		✓						
		x. Stool	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		y. Lounge Chair														
		z. Bill Alarm														
I		**Lane Equipment**		N	N	N	N	N	N	Y	N	N	N	N	Y	N
	1	a. Appr. Closure Gate			M	M	--	M							M,A	M,A
		b. Entry/Arming Loop			--		--	--			E (bus)				M,A	M
		c. Audit Treadle	2M (Rt. Lane Only)	2M	2M	2M	2M	2M	2M,4M	2M	1/2M	2M	2M	2M	2M	2M
		d. Scale (Beam)					--	--								
		e. WIM					--	--								
		f. Veh Separator					--	--								
		g. OHI		M	M	M	M	M	M	M	M	M	M	M		
		h. Height Sensors					--	--		M						
		i. Length Sensors					--	--								
		j. VMS (canopy)					M	--		M						
		k. OH Lane Signal	M	M	M		M	M	M	M	M	M	M	M	M,A	M,A
		l. ETC Antennae					--	--			E					
		m. Transcation Loop					--	--		M					M,A	M,A
		n. Exit Loop	M				--	--							M,A	M,A
		o. PFI	M	M	M	M	M	M	M	M	M	M	M	M	M,A	M,A
		p. ETC - PSD					--	--								
		q. Island TS		M	M	M	--	M							A	A
		r. Alarm					--	--		M	M	M	M	M	A	A
		s. Auto Exit Gate					--	--							A	A
		t. Surveillance Cameras					--	--	M			M	M	M	M,A	M,A
		u. VEC					M	--			E	M	M	M		
J		**Collection Equipment**														
	1	Devices														
		a. ACM		--	--	--	--	--	--	--	--	--	--	--	A	A
		b. Button Box	M	M	M	M	M	M	M	M	M	M	M	M	M	M
		c. ID Reader		M	M	M	M	M	M	M	M	M	M	M	M	M
		d. RP	M	M	M	M	M	M	M	M	M	M	M	M	M	M
		e. MCR		--	--	--	--	--	M	M	--	M	M	M	M	M
		f. BCR		--	--	--	--	--	--	--	--	--	--	--	M,A	M,A
		g. CM		--	--	--	--	--	--	--	--	--	--	--	--	--
		h. RP (in lane)													--	--

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APPENDIX B
TOLL PLAZA DESIGN
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NCHRP PROJECT 20-5
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			15	16a	16b	16c	16d	16e	17a	17b	17c	17d	17e	17f	18a	18b
		i. Intercom	M	M	M	M	M	M	M	M	M	M	M	M	M,A	M,A
		j. Bill Feeder		--	--	--	--	--	--	--	--	--	--	--	--	--
	2	ACM Loc.	--	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	d	d
	3	Toll Configuration	a	e	e	e	a	e	a	b	a,d (bus)	a	a	a	e (w/BCR)	e (w/BCR)
K		Lane Capacity (VPH) (% Comm.)														
		a. Manual Lane	--	1-400, 2-200 3-300 (50)	1-400, 2-200 3-300 (50)	1-400, 2-200 3-300 (50)	1-420/500+ 2-200,3-300	1-400, 2-200 3-300 (50)	--	1-360,3 3-300(20)	3-300 (10)	1-342,2-162 Ex. Cash - 1-465, 2-203		1-214, 2-131 Ex. Cash - 1-315,2-393	1-450 2-350 (9)	1-450 2-350 (9)
		b. ACM (Single)													1-550 (W/BCR)	1-550 (W/BCR)
		c. ACM (Multi)														
		d. ETC														
		e. Ticket (entry)										1-619,2-310		1-327,2-159		
		f. Mag Card														
		g. Branch Feed Lane														
		h. Tandem Lane														
		i. Bypass Lane														
		j. Combined											Cash/Ticket 1-360, 3-339 (28)			
		k. Ticket (Exit)]														

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TOPIC 25-11

L		Toll Plaza Access	15	16a	16b	16c	16d	16e	17a	17b	17c	17d	17e	17f	18a	18b
	1	On-site Parking	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y
	2	Parking Access Mainline (M), Local Road (LR)	LR	M	M	M	M, LR	M	M, LR	LR	--	LR	LR	LR	LR	LR
	3	Arrival (Alt.)	--	--,	--	--	--	--	a,b	--	b	--	--	--	'--	--
	4	Toll Lane Access	a	a	a	a	a	a	a-c	d	a, b (not used)	a,b	a,b	a,b	a,b	a,b
	5	ACM Vault Serv	--	N/A	N/A	N/A	N/A	N/A	--	--	--	N/A	N/A	N/A	b	b
M		Traffic Control Devices														
	1	Pavement Markings	N ·	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	N	N
	2	(Plaza Layout)	N	N	N	N	N	N	--	N	N	N	N	N	--	--
	3	Motorist Info	a	a	a	a	a	a	a,d,e	b-e	a,d,e	a,e	a,e	a,e	a,d,e	a,d,e
N		Administration Building														
		Functions - Mainline (M) Ramp (R)														
		a. Public Foyer		M	M				M	M		M	M	M	M	M
		b. Computer (Toll) Room	M	M	M	M	M	M	M	M	M	M	M	M	M	M
		c. Count Room		M		M	M	M	M	M	M	M	M	M	M	M
		d. Banking Room	M	M		M	M	M		M	M	M	M	M	M	M
		e. Vault Storage (Empty)													M	M
		f. Money Vault	M	M	M	M	M	M	M	M	M	M	M	M	M	M
		g. Token Storage										M	M	M		
		h. Electronic Maint.	M						M	M	M	M	M	M	M	M
		i. Lunch Room	M	M	M	M	M	M	M	M	M	M	M	M	M	M
		j. Lounge/Day Room							M	M	M	M	M	M	M	M
		k. Locker Room		M	M	M	M	M	M	M	M	M		M	M	M
		l. ETC Sales Office														
		m. ETC Install. Fac.														
		n. Token Sales									M (script)					
		o. Armored Car/Loading Dock										M	M	M	M	M
		p. Mechanical Room		M	M	M	M	M	M	M	M	M	M	M	M	M
		q. Generator	M	M	M	M	M	M	M		M	M	M	M	M	M
		r. Comm.	M						M	M	M	M	M	M	M	M
		s. Police Desk						M	M		M		M		M	M
		t. Electrical Room	M	M	M (UPS)	M (UPS)	M	M	M	M	M	M	M		M	M
		u. Supervisor's Office	M	M	M	M	M	M		M	M	M	M	M	M	M
		v. Other Room/Office													M	M
		w. Collector/Utility Tunn.			M	M	M		M		M	M	M	M	M	M
O		Signing DIST. (FT.)/# OF SIGNS														
	1	Type														
		a. Toll Schedule		200/1	300/1	1000/1	250/1	200/1	8/-	8/1	2600/15	1000/1	1000/1	1000/1		5000/3
		b. Warning/Info	3MI,1MI/2	--	--	--	8000/1	--	10/-	--	1500/1	500/1	500/1	500/1	6000/2	6500/1

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			15	16a	16b	16c	16d	16e	17a	17b	17c	17d	17e	17f	18a	18b
		c. Speed Restriction	Rumble Strip/2	--	--	--	--	--	2/-	2500/6	--/11	500/2	500/2	500/2	800/7 Non-Toll Dir.	350/1
		d. Lane use		--	--	--	--	--	--	2500/6	--	1000/1	1000/1	1000/1	8000/4	1000/5
	2	In Lane	a,b	a	a	a	a	a,b		a-d (Haz Mat/OH)	a,b	a,b	a,b	a,b	a,b,e Non Toll	a
P		**Lane Configuration**														
	1	Fixed	N	N	N	N	N	N	N	N	N	N/A	N/A	N/A	N	N
	2	Example	Center Reversible	--	--	--	--	--	--	--	--	--	--	--	--	--
	3	a. Exp. ETC	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		b. HOV	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		c. Bus Only	--	c	--	--	--	--	--	--	ML	--	--	--	--	--
		d. None	--	--	--	--	✓	--	--	--	--	--	--	--	✓	✓
		e. Oversized	--	--	--	--	--	--	✓	--	--	✓	✓	✓	--	--
	4	Branch/Tandem Lane	--	c	c	c	c	--	c	c	c	c	c	c	c	c
	5	>1 Method/Lane	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	6	WHM >1	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Q		**Reversibility**														
	1	Dir. Peak	Y	one-way	N	N	N	N	N	N	N	N	N	N	N	N
	2	Method to Inform.	b,e	--	--	--	--	--	--	--	--	--	--	--	--	--
R		**Enforcement Method**	c,d	b,d	b,d	b,e	b,d	b,d	c,e	c-e	c,e,f (ETC)	e	e	e	c,d,e	c,d,e,g
S		**Handicap Access**														
	1	Avail to Motorists	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	2	Type of Serv/Equip	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	3	For Collectors	--	--	--	--	--	--	N	--	--	N	N	N	N	N
	4	Eq., Devices, Design	N	N	N	N	N	N	N	Y (Elevator)	N	N	Y (Elevator)	N	N	N
	5	Limit (Lane)	--	--	--	--	--	--	--	N	--	--	--	N/A	--	--

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I-		FACILITY BACKGROUND	18c	18d	19	20a	20b	21	22	23a	23b	23c	23d	23e	23f	23g
A		Facility Identification	Walt Whitman Br.	Commodore Barry Br.	Peace Br.	Dallas N. Toll NKY	Mt. Creek Lake Br.	E-470 -	IL Toll Road	BBT	QMT	Cross Bay Br.	Tribrough Br.	Marine Pkwy Br.	Henry Hudson Br.	Throgs Neck Br.
E		Location	NJ-PA	NJ-PA	NY-Canada	Texas	Texas	Colorado	Illinois	N.Y.	N.Y.	N.Y.	N.Y.	N.Y.	N.Y.	N.Y.
G		Type	Br.	Br.	Br.	Toll Rd.	Br.	Toll Rd.	Toll Road	TUNN.	TUNN	Br.	Br.	Br.	Br.	Br.
H		Year Opened	1957	1974	1927	1968	1970	1991	1959	1950	1940	1939	1936	1937	1936	1961
		Year Last Renovated	1992 one-way tolls	1993 one-way tolls	1956 Enlarge Toll Plaza	--	--	--	1993 Plaza Reconst	1988 New Toll Plaza	-	1970 New Br.	1969 Plaza Exp.	-	-	1976 Add Toll Lanes
I		Facility Size														
	1	Length Mi. (km)	2.2	2.5	0.8	21	2.6	5	276	1.73	1.21	3000	-	3840	2209	2.05
	2	Lane Mi. (km)	49	23	3	126		30	--	7	4.86	-	-	-	2.5	-
	3	No. of Toll Plazas (M/R)	1/-	1/-	1/-	3 / 20	1/-	1/4	20/34	1/-	1/-	1/-	2/-	1/-	2/-	-
	4	No. of Toll Lanes (Reversible)	10	9	11	--	5	14	418	17	14	12	38	10	15	21
J		Type of Toll System	O (C) 1-way	O (C) 1-way	C/C	O/C	C (C)	C (C)	O(C)	O (T,C)	O (T,C)	O (T,C)	O (T,C)	O (T,C)	O (T,C)	O (T,C)
K		Method of Collection	M(C,S Ex) ACM,AVI	M(C,S Ex) ACM,AVI	M (C),CC,ACM (Ex,T),ETC (D)	M (C), ACM,ETC (D,M)	M (C), ACM (EX)	M (C), ACM,E (BYPASS)	M (C), CC ACM (Ex) E (M)	M (C,T) ACM (Ex,T)	M (C,T) ACM (Ex,T)	M (C,T) ACM (Ex,T)	M (C,T) ACM (Ex,T)	M (C,T) ACM (Ex,T)	M (C,T) ACM (Ex,T)	M (C,T) ACM (Ex,T)
II		DESIGN STANDARDS														
A		Standard/Guidelines	1 (1949)	1,3,4	4	2,3,4,8	1-4	1-4,7,8	1,4	-	-	-	-	-	-	-
B		New Plaza	N	Y	Y	Y	Y	Y	Y	Y	Y	-	-	Y	-	-
C		Adopted	1,3,4	--	--	--	--	4	--	-	-	-	-	-	-	-

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			18c	18d	19	20a	20b	21	22	23a	23b	23c	23d	23e	23f	23g
III		**PLAZA GEOMETRICS**														
A		**Geometrics**	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
B		**Pavement**														
	1	Toll Lane	C	C	A,C	C	C	C	C	A/C	C	A/C	C	A/C	C	C
	2	Transitions	A	A	C	C	C	C	A,C	A/C	A	C	-	C	A	-
	3	X Slope/Profile (%)														
		a. Approach	--	-/2.0	0/0	2.5/-	2.5/-	2.0/.5	1.5/0.5	-	1.2 / 4.0	-	-	-	0/0	-
		b. Departure	--	-/2.0	0/0	2.5/-	2.5/-	2.0/.5	1.5/0.5	-	1.2 / 5.4	-	-	-	0/0	-
		c. Toll Lane	-/1.4	-/2.0	0/0	1.0/-	1.0/-	2.0/.5 ETC (3.3/.5)	0/0	-	1.6 / 0.6	-	-	-	0/0	-
C		**Lighting**														
	1	Level (ft candle)														
		a. Mainline	3	5	5	2	2	N/A	1	8-10	8-10	3-5	3-5	3-5	3-5	2-3
		b. Departure	3	5	10	2	2	N/A	1.5	15-20	-	-	-	-	-	-
		c. Approach	3	5	10	2	2	N/A	1.5	15-20	3-5	-	-	-	-	-
		d. Ramp/Plaza	--	--	10 (PLAZA)	1.5	1.5	N/A	1.5	15-20 (Plaza)	10-12 (Plaza)	12-15 (Plaza)	12-15 (Plaza)	-	12-15 (Plaza)	12-15 (Plaza)
	2	Type/Intensity														
		a. Approach	S/1000+250	S/1000	S/1000	S/400	S/400	S/-	S/400	5/-	5/-	-	S (Plaza)	-	MH	S
		b. Departure	S/1000+250	S/1000	S/1000	S/400	S/400	S/-		5/-	5/-	-	-	-	MH	S
	3	Lighting Structure														
		a. Aproach	1	1	1	3 (30')	3 (30')	1	2(50)	3	-		3	-	3	3
		b. Departure	1	1	1	3 (30')	3 (30')	1	(15'ARM)	3	-		3	-	3	3
		c. Ramp	--	--	--	3 (30')	3 (30')	1	--	3 (Plaza)	1 (Plaza)	1 (Plaza)	1 (Plaza)	1 (Plaza)	1 (Plaza)	1 (Plaza)
	4	Toll Lane Lighting	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	5	Location	a	a	a	a	a,b	C (Reflective)	a	a	a	a	-	a	a	a
	6	Level	7-10	7-10	15	2.5	1.5	N/A	5	-	-	-	-	-	-	-
	7	Type/Intensity	S/175	S/175	S/250	S/250	F/90	I/-	S/-	-	-	-	-	-	-	-
	8	Visibility Devices	N	N	N	N	Y	Y	Y	-	Y	N	Y	Y	Y	Y
	9	Type/Location (Canopy/ Plaza)	--	--	--	--	b (PL)	c (PL) Flashers	b(C,Pi)	-	C(C)	-	C(C)	d(Fog Horn)	c(C,P)	c(C,P)
D		**Drainage**														
	1	Transition Roadway	a	a	a	a	a	a,b	a	a	a	a	a	a	a	a
	2	Closed-Type	a	a		c	c	b	a,c	a	c	c	c	c	a	a
	3	In Toll Lane	a	a,b	b,c	b,c	b,c	a,b	b	d	d	d	d	d	d	d

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			18c	18d	19	20a	20b	21	22*	23a	23b	23c	23d	23e	23f	23g
E		**Environmental**														
	1	Issues	b	c	--	b,c	b	a,b,d (Light)	a,b	-	b	-	-	-	-	-
	2	Remedial Measures														
		a. Noise	4 (sound barrier)	--	--	1-4 (Shrubs)	2	2,3	1,2	-	-	-	-	-	-	-
		b. A/Q	--	--	--			Exp. Lane, 2	2	2	-	-	-	-	-	-
		c. Water Quality	--	--	--	5 (NP)		3 ditches	--	-	-	-	-	-	-	-
	3	Air Monitoring Devices	N	N	--	N	N	Y	N	N	N	N	N	N	N	-
	4	Pollutants/Loc.	--	--	--	--	--	CO/Booth Tunnel	--	-	-	-	-	-	-	-
F		**Safty Devices**														
	1	Crash Device	e, (conc) c (GREAT)	a,c,(GREAT)	d (Conc Abut)	a,c (Hex-Foam)	a	c (Great)	b,c	a	a	a	a	a	a	a
	2	Both Ends	N	N	Y	Reversible	Y	N	Reversible	Y	Y	Y	-	Y	Y	Y
	3	Purpose	a,c	a,c	a,c	a-c	a-c	a,c	b,c	b,c	b,c	b,c	b,c	b,c	b,c	b,c
G		**Canopy**														
	1	Over Lanes	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	2	Purpose	b,d	b,d	a,b,d	a-d	a-d	b-d	a,b,d,e	a-d	a-d	a-d	a-d	a-d	a-d	a-d
	3	Design Considerations	a,b	a,b	c,d	a-d .	a-d	a,c,d	c,d							
H		**Toll Booths**														
	1	a. Single End Dimension	8'81/2"x4'	8'81/2"x4'	10'x3'	10'6"x4'	10'6"x4'	--	9'x4'							
		b. Double End Dimension	16'-11"x4'	14'8"x4'	--	10'6"x4'	10'6"x4'	16x4	--							
	2	Structural Support Func.	Y	N	N	Both	Y	N	N							
	3	a. Frame Material	--	ST	ST	ST	ST	ST	ST							
		b. Ext. Skin	PS	PS	PS (3/8)	W,M,Br	Mason	PS	SS							
		c. Int. Skin	SS	SS	SS	Sh. Rock	Sh. Rock	Ga. St.	--							
	4	Insulated	Y	Y	Y	Y	Y	Y	Y							
	5	Type Heating	El	El	El	El	El	El	HA,Rad.							
	6	A/C	W	W	--	Roof,Cent.	Roof	W	W							

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*Note: 22 G2e-M+for ETC devices

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		18c	18d	19	20a	20b	21	22	23a	23b	23c	23d	23e	23f	23g
7	Positive vent.	N	N	N	Y	Y	Y	Y							
8	Air Supply Loc	--	--	--	a,c	a	c	c							
9	Booth Flooring	a	a	a	a,b	a	a	a							
10	No. of Doors	1	1	2	2	2	2	1							
11	Type of Doors	a,b	a,b	a	a,b	a	a,b	c							
12	Door Equip.	a	a	a	c	c,d (Al Splash Dr)	a	a	a,b	a,b	a,b	a,b	a,b	a,b	a,b
13	Booth Glass	i (safety Gl)	i (safety Gl)	c	b,c	b,c	b,c,g	b	a,c,i	a,c,i	a,c,i	a,c,i	a,c,i	a,c,i	a,c,i
14	Fixtures/Equipment														
	a. Chair	✓	✓												
	b. Front Counter	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	c. Cash Drawer (1 or 2 drawer)	✓	✓	✓	✓ (2)	✓ (2)	✓ (2)	✓	✓ (2)	✓ (2)	✓ (2)	✓ (2)	✓ (2)	✓ (2)	✓ (2)
	d. Fan (counter, ceiling)			✓				✓	✓	✓ (ct)	✓ (ct)	✓ (ct)	✓ (ct)	✓ (ct)	✓ (ct)
	e. Switch Panel, (Booth, Canopy)	✓	✓	✓	✓ (B,C)	✓	✓ (B)	✓	✓	✓	✓	✓	✓	(CT)	✓
	f. Thermostat			✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓
	g. Change/Token Holder							✓							
	h. Portable TV														
	i. Toll Recorder (Lane Control Cabinet)	✓	✓		✓				✓	✓	✓	✓	✓	✓	✓
	j. Toilet				✓										
	k. Sink				✓										
	l. Security Dr. Locks	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	m. Drawer Locks	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	n. Rear Counter			✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓
	o. Telephone				✓	✓	✓								
	p. Intercom	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	q. Duplex Outlet	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	r. Radio Am/Fm						✓								
	s. Counter Lite			✓			✓								
	t. Silent Alarm				✓		✓	✓	✓	✓	✓	✓	✓	✓	✓

Numbers/Letters in cells for Section II and III refer to responses to Questions presented in Operator's Survey Questionnaire unless a specific value, e.g., % volume, or length was requested.

N - No
Y - Yes
NA - Not Available

APPENDIX B
TOLL PLAZA DESIGN
TOLL FACILITY OPERATOR QUESTIONAIRE - SUMMARY

NCHRP PROJECT 20-5
TOPIC 25-11

			18c	18d	19	20a	20b	21	22	23a	23b	23c	23d	23e	23f	23g
		u. Refrigerator				✓										
		v. Bulletin Board														
		w. 2-way Radio			✓	✓	✓		✓							
		x. Stool	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		y. Lounge Chair														
		z. Bill Alarm														
I		**Lane Equipment**	Y	Y	N	N	N	N	N	Y	Y	N	N	Y	N	Y
	1	a. Appr. Closure Gate	M,A		M			M,A	M,A	M,A	M,A	M,A	M,A	M,A	M,A	M,A
		b. Entry/Arming Loop	M,A	M,A	M	E		M,A,E		A	A	A	A	A	A	A
		c. Audit Treadle	2M	2M	4M/A M-10X80 (100T)	2M/A/E	2 M/A	2 M/A	2C,4A	1 M/A	1 M/A	1 M/A	1 M/A	1 M/A	1 M/A	1 M/A
		d. Scale (Beam)														
		e. WIM						M								
		f. Veh Separator				E	M									
		g. OHI				M,A,E	M,A									
		h. Height Sensors								M						
		i. Length Sensors														
		j. VMS (canopy)				M,A,E		M,A								
		k. OH Lane Signal	M,A	M,A	M,A	M,A,E	M		M,A,E	M,A	M,A	M,A	M,A	M,A	M,A	M,A
		l. ETC Antennae				M,A,E		M,A,E	M,A							
		m. Transcation Loop	M,A	M,A	M	M,A,E	A	M,A,E								
		n. Exit Loop	M,A	M,A	A	M,A,E	M,A	M,A,E		A	A	A	A	A	A	A
		o. PFI	M,A	M,A	A	M,A	M,A	M,A	M,A	M	M	M	M	M	M	M
		p. ETC - PSD							M,A,E							
		q. Island TS	A	A	A	M,A,E	M,A	M,A	A	A	A	A	A	A	A	A
		r. Alarm	A	A	A	M,A,E	M,A	M,A	M	A	A	A	A	A	A	A
		s. Auto Exit Gate	A	A	A		A		A,E	A	A	A	A	A	A	A
		t. Surveillance Cameras	M,A	M,A	A			M,A,E	A,E	M	M	M	M	M	M	M
		u. VEC				M,A,E		M,A,E	A,E							
J		**Collection Equipment**														
	1	Devices														
		a. ACM	A	A	A	M,A	M,A	A	A,E	A	A	A	A	A	A	A
		b. Button Box	M	M	M	M	M	M	M	M	M	M	M	M	M	M
		c. ID Reader	M	M	M,A	M	M,A	M,A	M,A	M	M	M	M	M	M	M
		d. RP	M	M	M,A	M	M	M	M	M	M	M	M	M	M	M
		e. MCR	M	M	A	M,A,E			M							
		f. BCR	M,A	M,A	--	M,A,E										
		g. CM	--	--	--	A										
		h. RP (in lane)	--	--	--					A	A	A	A	A	A	A

Numbers/Letters in cells for Section II and III refer to responses to Questions presented in Operator's Survey Questionnaire unless a specific value, e.g., % volume, or length was requested.

N - No
Y - Yes
NA - Not Available

APPENDIX B
TOLL PLAZA DESIGN
TOLL FACILITY OPERATOR QUESTIONAIRE - SUMMARY

NCHRP PROJECT 20-5
TOPIC 25-11

			18c	18d	19	20a	20b	21	22	23a	23b	23c	23d	23e	23f	23g
		i. Intercom	M,A	M,A	M,A	M	M	M	M,A	M,A	M,A	M,A	M,A	M,A	M,A	M,A
		j. Bill Feeder	--	--	--											
	2	ACM Loc.	d	d	b	b,d	d	d	b,d							
	3	Toll Configuration	e(W/BCR)	e(W/BCR)	e	c,e,f,g	e	d,f,g	a,b,e-g	a,b	a,b	a,b	a,b	a,b	a,b	a,b
K		Lane Capacity (VPH)	18c-	18d-	19-	20a-	20b-	21-	22-	a,b,e	a,b,e	a,b,e	a,b,e	a,b,e	a,b,e	a,b,e
		a. Manual Lane	1-450, 2-350 (9)	1-450, 2-350 (9)	3-	1/400/600	3-	1/400	3-350/450	3/450	3/450	3/450	3/450	3/450	1 (450)	3/450
		b. ACM (Single)			1-	1-500/700										
		c. ACM (Multi)	1-550(W/BCR)	1-550(W/BCR)	1-	1-500/700		1-850	1-600/925	1/600	1/600	1/600	1/600	1/600	1/600	1/600
		d. ETC				1-1200/1400										
		e. Ticket (entry)														
		f. Mag Card														
		g. Branch Feed Lane														
		h. Tandem Lane														
		i. Bypass Lane						1-1200								
		j. Combined				A/E M/Ex/E			M/E 350-450							
		k. Ticket (Exit)]														

Numbers/Letters in cells for Section II and III refer to responses to Questions presented in Operator's Survey Questionnaire unless a specific value, e.g., % volume, or length was requested.

N - No
Y - Yes
NA - Not Available

APPENDIX B | **NCHRP PROJECT 20-5**

TOLL PLAZA DESIGN | **TOPIC 25-11**

TOLL FACILITY OPERATOR QUESTIONAIRE - SUMMARY

L		**Toll Plaza Access**	18c	18d	19	20a	20b	21	22	23a	23b	23c	23d	23e	23f	23g
	1	On-site Parking	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	2	Parking Access Mainline (M), Local Road (LR)	LR	LR	M,LR	LR	M	M	M,LR	LR	M,LR	M,LR	M,LR	M,LR	M,LR	M,LR
	3	Arrival (Alt.)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	4	Toll Lane Access	a,b	a,b	a	a,b	a	b	a,e	a	a	a	a	a	a	a
	5	ACM Vault Serv	b	b	a	a,b	a	b	a,b	a	a	a	a	a	a	a
M		**Traffic Control Devices**														
	1	Pavement Markings	--	N	Y	N	N	Y	Y	N	N	N	N	N	N	N
	2	(Plaza Layout)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	3	Motorist Info	a,d,e	a,d,e	b,c,e	a,b,d	a,b,e	c	b,e	b,d,e	a,d,e	a,d,e	a,d,e	a,d,e	a,d,e	a,d,e
N		**Administration Building**														
		Functions - Mainline (M) Ramp (R)														
		a. Public Foyer (w/wo Rest Room)	M	M		M	M	M (W)	M (W)	M	M	M	M	M	M	M
		b. Computer (Toll) Room	M	M	M	M	M	M	M	M	M				M	M
		c. Count Room (safe)	M	M	M	M		M								
		d. Banking Room	M	M	M	M		M								
		e. Vault Storage (Empty)	M	M	M	M		M	M	M	M	M	M	M	M	M
		f. Money Vault	M	M	M	M	M	M	M	M	M	M	M	M	M	M
		g. Token Storage			M	M	M	M		M	M	M	M	M	M	M
		h. Electronic Maint.	M	M	M	M		M	M,R	M	M	M	M	M	M	M
		i. Lunch Room	M	M	M	M	M	M	M	M	M	M	M	M	M	M
		j. Lounge/Day Room	M	M		M		M								
		k. Locker Room (w/wo Showers)	M	M		M	M	M (W)	M,R (W)	M (w)	M (w)	M (w)	M (w)	M (w)	M (w)	M (w)
		l. ETC Sales Office						M	Off-Site							
		m. ETC Install. Fac.						M								
		n. Token Sales (Booth/Stores)			M (B)			M		M (B)	M (B)	M (B)	M (B)	M (B)	M (B)	M (B)
		o. Armored Car/Loading Dock	M	M		M		M	M							
		p. Mechanical Room	M	M	M	M	M	M	M,R	M	M	M	M	M	M	M
		q. Generator	M	M	M	M,R	M	M	M,R	M	M	M	M	M	M	M
		r. Comm. (Office/Console)	M	M	M	M		M		M (c)	M (c)	M (c)	M (c)	M (c)	M (c)	M (c)
		s. Police (Desk/Console)	M	M		M		M		M (d)	M (c)	M (c)	M (c)	M (c)	M (c)	M (c)
		t. Electrical Room (w/wo UPS)	M	M	M	M (W)	M	M (W)	M (W)	M (w)	M (w)	M (w)	M (w)	M (w)	M (w)	M (w)
		u. Supervisor's Office/Console	M	M	M	M	M	M	M (W)	M (o)	M	M	M	M	M	M
		v. Other Room/Office	M	M	M (Admin)	M (Store)		M (Mgr)	M Telecom							
		w. Collector/Utility Tunn.	M	M		M		M	M (U)		M	M	M	M	M	M
O		**Signing DIST.(FT.)/# SIGNS**														
	1	Type (Dist/#)														
		a. Toll Schedule	5170/3	1600/2	--	Pl, La	Pl, La	-/1	500/1	--	--	--	--	--		--
		b. Warning/Info	15000/10	2400/1	5280/1	2000/1	2000/1	-/2	5000/1	--	--	--	--	--		--

Numbers/Letters in cells for Section II and III refer to responses to Questions presented in Operator's Survey Questionnaire unless a specific value, e.g., % volume, or length was requested.

*Note: 22L4e Tunnel w/intermittent Stairs

N - No
Y - Yes
NA - Not Available

APPENDIX B | **NCHRP PROJECT 20-5**
TOLL PLAZA DESIGN | **TOPIC 25-11**
TOLL FACILITY OPERATOR QUESTIONAIRE - SUMMARY

			18c	18d	19	20a*	20b*	21	22*	23a	23b	23c	23d	23e	23f	23g
		c. Speed Restriction	1700/7	1300/1	--	1000/1	1000/1	-/1	--	--	--	--	--	--	--	--
		d. Lane Use	300/3	1500/5	800/1	Pl, La	Pl, La	--	2500/1	--	--	--	--	--	--	--
	2	In Lane	a,b,c	a,b	--	a,b,c,d	a,b,c,e	a,b,c	d	--	a	a	a	a	a	a,e video
P		**Lane Configuration**														
	1	Fixed	N	N	N	N	N	Y	Y	N	N	N	Y	N	Y (upper)	Y
	2	Example	--	--	--	Ramp M,A	A,5M	M-2E,2A/E 1M/E,R-A/E	M-3A/E,3M/E R-3A/E	--	--	--	A,M,E/A, A,2M/A, E,3M	--	M/A, A, M/A A, M, M/A, M	3M, 5M/A, 3M
	3	a. Exp. ETC	--	--	--			M								
		b. HOV	--	--	--											
		c. Bus Only	--	--	--											
		d. None	✓	✓	✓	✓	✓		✓	✓	✓		✓		✓	
		e. Oversized	--	--	--	--		M				✓	✓	✓		✓
	4	Branch/Tandem Lane	c	c	c	c	c	c	c	b	c	c	b	c	b	b
	5	>1 Method/Lane	N	N	N	N	N	Y	N	(some)	N	(some)	N	Y	N	N
	6	WHM >1	--	--	--	--	a,b,c	(ETC)	--	c	--	c	--	--	--	--
Q		**Reversibility**														
	1	Dir. Peak	N	N	N	Y	Y	N	Y	Y	Y	Y	Y	Y	N	Y
	2	Method to Inform.	--	--	--	a,b,d	a,b,d	--	a,e	a,b,e	a,b,e	a,b,e	a,b,e	a,b,e	--	a,b,e
R		**Enforcement Method**	c,d,e,g	c,d,e,g	a	c,d,f (all)	c,d,h	e,f (all)	d,f(ACM),g	c,g	g	g	g	g	g	b, f (A)
S		**Handicap Access**														
	1	Avail to Motorists	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	2	Type of Serv/Equip	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	3	For Collectors	--	--	--	a,b	--	--	--	--	--	--	--	--	--	N
	4	Eq., Devices, Design	N	N	N	Elev, RR	N	N	N	N	N	N	N	N	N	N
	5	Limit (Lane)	N	--	N/A	Ramp Booth	--	--	--	--	N	N	N	--	N	N

Numbers/Letters in cells for Section II and III refer to responses to Questions presented in Operator's Survey Questionnaire unless a specific value, e.g., % volume, or length was requested.

*Notes:
20a, 02b - Speed Limit, Reduce Speed
20b, 02c - Change Made, Cars Only, Stay in Vehicle
22-02, d Cars Exact Change Left Lanes, All Veh Manual Lanes / Right Lanes

N - No
Y - Yes
NA - Not Available

APPENDIX B
TOLL PLAZA DESIGN
TOLL FACILITY OPERATOR QUESTIONAIRE - SUMMARY

I		FACILITY BACKGROUND	23h	23I	24a*	24b*	25	
A		Facility Identification	Verrazano Narrows Br.	Bronx-Whitestone	Orlando Orange-Main	Orlando Orange-Ramp	Foothill Trans Corridor	
E		Location	NY	NY	FL	FL	Calif	
G		Type	Br.	Br.	Toll Road	Toll Road	Toll Road	
H		Year Opened	1964	19--	1972	1972	1993	
		Year Last Renovated	1970 Added Toll LA	--	1994 Safety & Func impr	1994 Safety & Func impr	-	
I		Facility Size						
	1	Length Mi. (km)	1.5	3770'	79	--	3.5	
	2	Lane Mi. (km)	15	4.28	340		25	
	3	No. of Toll Plazas (M/R)	1/-	1/-	10 / --	-- / 34	- / 4	
	4	No. of Toll Lanes (Reversible)	23	22	160		10	
J		Type of Toll System	O (t,c)	O (t,c)	0 (c)		C (c)	
K		Method of Collection	M (c,t) ACM (Ex,t)	M (c,s, Ex,c)	M (c, ex) ACM (Ex) ETC (Ded, Mix)	M (c, ex) ACM (Ex) ETC (Ded, Mix)	M (c,ex) ACM(ex) ETC(Ded, Byp, Mix)	
II		DESIGN STANDARDS						
A		Standard/Guidelines	C	--	1-4, 6-9*	1-4 * 6-9	1-4,7,8	
B		New Plaza	--	N	Y	Y	Y	
C		Adopted	--	1-4	--	-	-	

Numbers/Letters in cells for Section II and III refer to responses to Questions presented in Operator's Survey Questionnaire unless a specific value, e.g., % volume, or length was requested.

*Note: 24a, bIIA: Standard Building Code State of Florida

N - No
Y - Yes
NA - Not Available

APPENDIX B
TOLL PLAZA DESIGN
TOLL FACILITY OPERATOR QUESTIONAIRE - SUMMARY

			23h	23I	24a	24b	25
III		PLAZA GEOMETRICS					
A		Geometrics	Y	Y	Y	Y	N
B		Pavement					
	1	Toll Lane	C	A/C	C	C	C
	2	Transitions	C	A/C	A / C	A / C	A
	3	X Slope/Profile (%)					
		a. Approach	1/4 / 0	2.0/-	.72 / 1.5	.72 / 1.5	2 / 2
		b. Departure	1/4 / 0	2.0/-	.72 / 1.5	.72 / 1.5	2 / 2
		c. Toll Lane	1/4 / 0	1.0/-	0 / 1		2 / 2
C		Lighting					
	1	Level (ft candle)					
		a. Mainline	3-5	3-5	1.5		
		b. Departure	3-5	4-3	2		
		c. Approach	3-5	4-7	2		
		d. Ramp/Plaza	14 (Plaza)	12-15 (Plaza)	--	2	
	2	Type/Intensity					
		a. Approach	MV/	S/-	s / 400w		s / 310
		b. Departure	MV/	--	s / 400w		s / 310
	3	Lighting Structure					
		a. Aproach	0.3	20-35	3		3
		b. Departure	3	20-35	3		3
		c. Ramp	1 (Plaza) S	1 (Plaza)	--	3	3
	4	Toll Lane Lighting	Y	Y	Y	Y	Y
	5	Location	a	a	a,b	a,b	a
	6	Level ft-candle	--	--	20	20	5
	7	Type/Intensity	F/-	--	s / --	s / --	S / -
	8	Visibility Devices	N	Y	N	N	N
	9	Type/Location Canopy/ Plaza	--	c	d (OH - warning sign)	d (OH - warning sign)	-
D		Drainage					
	1	Transition Roadway	a	a	b	b	b
	2	Closed-Type	c	c	--	--	-
	3	In Toll Lane	d	d	a,b	a,b	a,b

Numbers/Letters in cells for Section II and III refer to responses to Questions presented in Operator's Survey Questionnaire unless a specific value, e.g., % volume, or length was requested.

N - No
Y - Yes
NA - Not Available

APPENDIX B
TOLL PLAZA DESIGN
TOLL FACILITY OPERATOR QUESTIONAIRE - SUMMARY

E		Environmental	23h	23i	24a*	24b*	25
	1	Issues	b	--	a,c,d (Lite Levels)	a,c,d (Lite Levels)	a,b,c,d ERR
	2	Remedial Measures					
		a. Noise	1	--	2,3	2,3	1
		b. A/Q	2	--	2	2	1(added lane)
		c. Water Quality	--	--	1,2,3	1,2,3	1,3
	3	Air Monitoring Devices	N	N	N	N	N
	4	Pollutants/Loc.	--	--	--	--	-
F		Safty Devices					
	1	Crash Device	a	a	b,c (Great)	b,c (Great)	c
	2	Both Ends	Y	Y	Rev,	N	N
	3	Purpose	b,c	b,c	a-c	a-c	a,c
G		Canopy					
	1	Over Lanes	Y	Y	Y	Y	Y
	2	Purpose	a-d	a-d	a,b,d	a,b,d	a,d
	3	Design Considerations			a-d	a-d	c,d
H		Toll Booths			*	*	
	1	a. Single End Dimension			11' * 4'	28'8" x 7'8"	12' x 6.0'
		b. Double End Dimension			11' * 4'	--	--
	2	Structural Support Func.			N	N	N
	3	a. Frame Material			s+	block	St
		b. Ext. Skin			ss	masonry	S.S
		c. Int. Skin			ss	--	Gal. S
	4	Insulated			Y	N	Y
	5	Type Heating			El	El	El
	6	A/C			c (roof)	c (roof)	Wall

Numbers/Letters in cells for Section II and III refer to responses to Questions presented in Operator's Survey Questionnaire unless a specific value, e.g., % volume, or length was requested.

*Notes: 24a, H1, 2: Pre-fabricated Booth
24b, H1: Built in Place

N - No
Y - Yes
NA - Not Available

APPENDIX B
TOLL PLAZA DESIGN
TOLL FACILITY OPERATOR QUESTIONAIRE - SUMMARY

			23h	23i	24a	24b	25
	7	Positive vent.			Y	N	N
	8	Air Supply Loc			c	--	--
	9	Booth Flooring			c - Al.w/ mat.	a	c 2
	10	No. of Doors			2	2	b,c
	11	Type of Doors			a,b	b,c	c
	12	Door Equip.	a-b	a-b	a	a	c,d
	13	Booth Glass	a,c,i		c,i(tint/shade)	a,i(tint/shade)	
	14	Fixtures/Equipment					
		a. Chair					
		b. Front Counter	✓	✓	✓	✓	✓
		c. Cash Drawer (1 or 2 drawer)	✓ (2)	✓	✓	✓	✓ (2)
		d. Fan (counter, ceiling)	✓ (c,ct)	✓	✓	✓	
		e. Switch Panel, (Booth, Canopy)	✓ (B,C)	✓	✓	✓	✓ (B,C)
		f. Thermostat	✓	✓	✓	✓	✓
		g. Change/Token Holder					
		h. Portable TV					
		i. Toll Recorder (Lane Control Cabinet)	✓	✓			
		j. Toilet				✓	
		k. Sink				✓	
		l. Security Dr. Locks	✓	✓	✓	✓	✓
		m. Drawer Locks	✓	✓	✓	✓	✓
		n. Rear Counter	✓	✓	✓		
		o. Telephone			✓	✓	✓
		p. Intercom	✓	✓	✓	✓	
		q. Duplex Outlet	✓	✓	✓	✓	✓
		r. Radio Am/Fm					
		s. Counter Lite					✓
		t. Silent Alarm	✓	✓	✓	✓	

Numbers/Letters in cells for Section II and III refer to responses to Questions presented in Operator's Survey Questionnaire unless a specific value, e.g., % volume, or length was requested.

N - No
Y - Yes
NA - Not Available

APPENDIX B
TOLL PLAZA DESIGN
TOLL FACILITY OPERATOR QUESTIONAIRE - SUMMARY

			23h	23i	24a	24b	25	
		u. Refrigerator						
		v. Bulletin Board						
		w. 2-way Radio						
		x. Stool	✓	✓	✓	✓	✓	
		y. Lounge Chair						
		z. Bill Alarm						
I		**Lane Equipment**						
	1	a. Appr. Closure Gate	M,A	M,A	--	--		
		b. Entry/Arming Loop	A	A	M,A,E	M,A,E	M,A,E	
		c. Audit Treadle	1M/A	1M/A	1,2 (MAE)	1 MAE	2M 3E	
		d. Scale (Beam)						
		e. WIM						
		f. Veh Separator			M,A,E	M,A,E	M,A,E	
		g. OHI						
		h. Height Sensors						
		i. Length Sensors						
		j. VMS (canopy)						
		k. OH Lane Signal	M,A	M,A	M,A,E	M,A,E		
		l. ETC Antennae			M,A,E	M,A,E	M,A,E	
		m. Transcation Loop			A	A	M,A,E	
		n. Exit Loop	A	A	M,A,E	M,A,E	M,A,E	
		o. PFI	M	M	M,A,E	M,A,E	M,A	
		p. ETC - PSD			M,A,E	M,A,E		
		q. Island TS	A	A	M,A,E	M,A,E	M,A	
		r. Alarm	A	A	M,A,E	M,A,E	M,A	
		s. Auto Exit Gate	A	A	A,E	A,E		
		t. Surveillance Cameras	M	M			M,A,E	
		u. VEC			M,A,E	M,A,E	M,A,E	
J		**Collection Equipment**						
	1	Devices						
		a. ACM	A	A	A	A	A	
		b. Button Box / Touch Screen	M	M	M		M	
		c. ID Reader	M	M			M,A	
		d. RP	M	M	M		M	
		e. MCR			M,A	M,A	M,A	
		f. BCR						
		g. CM						
		h. RP (in lane)	A	A				

Numbers/Letters in cells for Section II and III refer to responses to Questions presented in Operator's Survey Questionnaire unless a specific value, e.g., % volume, or length was requested.

N - No
Y - Yes
NA - Not Available

APPENDIX B
TOLL PLAZA DESIGN
TOLL FACILITY OPERATOR QUESTIONAIRE - SUMMARY

			23h	23i	24a	24b	25	
		i. Intercom	M,A	M,A	A	A		
		j. Bill Feeder						
	2	ACM Loc.	a,b	a,b	b	d		
	3	Toll Configuration	a,b,e	a,b,e	c-g	c-g	d,f,g	
K		**Lane Capacity (VPH)**						
		a. Manual Lane	3-450	3-450	1-650 (M-ETC)		3 - 550	
		b. ACM (Single)					3 - 550	
		c. ACM (Multi)	1-600	1-600	1-750(w/ETC)		3 - 550	
		d. ETC			1-900		3 - 1600	
		e. Ticket (entry)						
		f. Mag Card						
		g. Branch Feed Lane						
		h. Tandem Lane						
		i. Bypass Lane						
		j. Combined						
		k. Ticket (Exit)]						

Numbers/Letters in cells for Section II and III refer to responses to Questions presented in Operator's Survey Questionnaire unless a specific value, e.g., % volume, or length was requested.

N - No
Y - Yes
NA - Not Available

APPENDIX B
TOLL PLAZA DESIGN
TOLL FACILITY OPERATOR QUESTIONAIRE - SUMMARY

			23h	23l	24a	24b	25	
L		**Toll Plaza Access**						
	1	On-site Parking	Y	Y	Y	N	N	
	2	Parking Access Mainline (M), Local Road (LR)	LR	M,LR	M	--	--	
	3	Arrival (Alt.)	--	--	--	a	a	
	4	Toll Lane Access	b	b	b	a	a	
	5	ACM Vault Serv	b	b	a,b	a	a	
M		**Traffic Control Devices**						
	1	Pavement Markings	N	N	Y	Y	Y	
	2	(Plaza Layout)			N	N	N	
	3	Motorist Info	a,d,e	a,d,e	a,b,e	a,b,e	e	
N		**Administration Building**						
		Functions - Mainline (M) Ramp (R)						
		a. Public Foyer (w/wo Rest Room)	M	M	M(w/o)			
		b. Computer (Toll) Room	M	M	M	R	R	
		c. Count Room (safe)			M(s)			
		d. Banking Room			M			
		e. Vault Storage (Empty)	M	M	M			
		f. Money Vault	M	M	M			
		g. Token Storage	M	M				
		h. Electronic Maint.	M	M	M			
		i. Lunch Room	M	M	M			
		j. Lounge/Day Room			M	R		
		k. Locker Room (w/wo Showers)	M (w)	M (w)	M(w/o)			
		l. ETC Sales Office			offsite	offsite	offsite	
		m. ETC Install. Fac.			offsite	offsite		
		n. Token Sales (Booth/Stores)	M (B)	M (B)	store	store		
		o. Armored Car/Loading Dock			M			
		p. Mechanical Room	M	M	M		R	
		q. Generator	M	M	M	R(outside)	R(outside)	
		r. Comm. (Office/Console)	M (c)	M (c)	M(c)			
		s. Police (Desk/Console)	M (c)	M (c)	--	--		
		t. Electrical Room (w/wo UPS)	M (w)	M (w)	M(w)	R (closet/w)	R(closet/w)	
		u. Supervisor's Office/Console	M	M	M(c)			
		v. Other Room/Office			Manager		Rest Room	
		w. Collector/Utility Tunn.	M	M	M			
O		**Signing DIST.(FT.)/NOT.SIGNS**						
	1	Type (Dist/#)						
		a. Toll Schedule	--	--	700 / 1		--	
		b. Warning/Info	--	--	700 / 1		--	

Numbers/Letters in cells for Section II and III refer to responses to Questions presented in Operator's Survey Questionnaire unless a specific value, e.g., % volume, or length was requested.

N - No
Y - Yes
NA - Not Available

APPENDIX B
TOLL PLAZA DESIGN
TOLL FACILITY OPERATOR QUESTIONAIRE - SUMMARY

			23h	23l	24a*	24b*	25	
		c. Speed Restriction	--	--	--	--	-- --	
		d. Lane Use	--	1000/S	2000/	--	--	
	2	In Lane	a	a	a,b,d,e •	a,b,d,e •	--	
P		**Lane Configuration**						
	1	Fixed	N	N	varies*	Y	Y	
	2	Example	--	--	E,M/E, A/E M/E	M/E, A/E	En E, A/E, M/E Ex E, A/E, A/E	
	3	a. Exp. ETC			Future		M,R	
		b. HOV						
		c. Bus Only						
		d. None	✓	✓				
		e. Oversized			✓	✓		
	4	Branch/Tandem Lane	b	. b	c	c	c	
	5	>1 Method/Lane	N	(some)	Y	Y	some	
	6	WHM >1	--	a,c	b,c	b,c	a,b	
Q		**Reversibility**						
	1	Dir. Peak	N	Y	Y	--	N	
	2	Method to Inform.	--	a,b,e	a,b,e	--	--	
R		**Enforcement Method**	b;h	f (ACM),g	e,d,f (All)g	c,d,f(all)g	f (all)	
S		**Handicap Access**						
	1	Avail to Motorists	N	N	N	N	N	
	2	Type of Serv/Equip	--	--	--	--		
	3	For Collectors	N	N	N/A	N/A	a,b	
	4	Eq., Devices, Design	N	N	N	N	N	
	5	Limit (Lane)	--	N	I	I	N	

Numbers/Letters in cells for Section II and III refer to responses to Questions presented in Operator's Survey Questionnaire unless a specific value, e.g., % volume, or length was requested.

*Notes:
24a,b-02: Wait for green
24a,b-02e: Watch for Ped, OH Canopy Lane- use Signal
24a-P1: ETC Left Most Non-Reversible
Manned / ETC Right Most
ACM to Left

N - No
Y - Yes
NA - Not Available

APPENDIX C

TOLL FACILITY OPERATOR QUESTIONNAIRE—PLAZA LAYOUT

APPENDIX C
TOLL PLAZA DESIGN
TOLL FACILITY OPERATOR QUESTIONAIRE - PLAZA LAYOUT

NCHRP PROJECT 20-5
TOPIC 25-11

		FACILITY	**2**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9 (Main)**	**9 (Midsize)**	**9 (Small)**	**10**	**11**	**12**
		Facility Identification	Indiana East-West Toll Road	Indiana East-West Toll Road	Mackinac Bridge	Ponchatrain Causeway	Chesapeeke Bay Bridge	W. Virginia Parkway	Garden State Parkway	N.Y. State Thruway	Southern Turnpike	Southern Turnpike	Southern Turnpike	Oklahoma Turnpike	Mass. Turnpike	PA Turnpike
1		Plaza Configuration														
	a	Barrier	√	√	√	√		√	√	√	√	√	√	√	√	√
	b	Split													√	
	c	Serv. Platit / Bypass													√	
2		Roadway Segment														
		(Tangent / Curve)	√	√		√	√	√	√	√	√	√	√	√	√	√
		MIN> Curve Radius							2,000							
3		Plaza Location														
	a	Mainline		√	√	√	√	√	√	√						
	b	Ramp (Engry / Exit)	√								√	√				
	c	Both													√	√
4		Geometric Criteria														
		Va -- Hwy Approach Speed	55	55	45	35	55	55	55	55	65	40--45	35		55	
		Vp -- Plaza Speed	25	25	--	5	slow	35	--	N/A		40--45	35		25	
		N1 -- Approach Travel Lane	2	2	3	4	2	2	2 to 7	1--3	2	1	3	4	2	
		N2 -- Typical No. Toll Lanes	3-5	10, 12, 14	3	4	3	5	6 to 20	4 -- 16	3 -- 9	2 or 3	3	4 -- 15	3 to 15	
		N3 -- Departure Travel Lanes	2	2	3	2	3	2	2 to 7	1 --3	2	1	3	2 -- 8	2	
		Wm -- Width Hwy Med.	4'	42'	2	83'	35	62'	N/A	varies	32' -- 64'	N/A	12'		4' 60'	
		Wt-- Total Width N2	(5) 94'	(12) 224'	62.75'	75.5'	--	84'	100' to 300'						81'	
		Ta -- Approach Taper	40:1	60: 1	5: 1	4: 1	--	14: 1	15: 1			15: 1	15: 1			
		Td -- Departure Taper	40:1	60: 1	7: 1	4: 1	--	13: 1	15: 1			15: 1	15: 1			
		La -- Length Approach Zone	400'	600'	400	500'	200'	942'	1000'	varies	900' to 1200'	200'	240'		varies	
		Lq -- Length Quenching 'Area'	100'	100'	0	75'	75'	21'	400'	140'	300'	100'	30.5		109'	
		Lts -- Length Concrete Toll Island Slab	75'	120'	50	129'	75'	57'	120'	82'	157'	82' 6'	67'	80'	130'	
		Lr -- Length Recovery Zone	100'	60'	0	40'	100	21'	400'	140'	60' to 90'	0	165.5'	60'		
		Ld -- Length Departure Zone	400'	600'	350	600'	1500	640'	1000'	varies	900' to 1200'	250' -- 300'	240'		varies	

APPENDIX C
TOLL PLAZA DESIGN
TOLL FACILITY OPERATOR QUESTIONAIRE - PLAZA LAYOUT

NCHRP PROJECT 20-5
TOPIC 25-11

		FACILITY	13	14	15	16a	16b	16c	16d	16e	17a	17b	17c	17d	17e
		Facility Identification	Tobin Memorial Bridge	Hardy & Sam Houston	International Bridge	Rip Van Winkl Br.	Kingston Bridge	Mid-Hudson Bridge	Newburgh Bridge	Bear Mountain Bridge	George Washington	Holland Tunnel	Lincoln Tunnel	Bayonne Bridge	Goethals Bridge
1		Plaza Configuration													
	a	Barrier	√	√	√	√	√	√	√	√	√	√	√	√	√
	b	Split													
	c	Serv. Platit / Bypass													
2		Roadway Segment													
		(Tangent / Curve)	√	√	√	√	√	√	√	√	√	√	√		
		MIN> Curve Radius													
3		Plaza Location													
	a	Mainline	√	√	√	√	√	√	√	√	√	√	√	√	√
	b	Ramp (Engry / Exit)													
	c	Both													
4		Geometric Criteria									E/B	E/B	E/B*	E/B	E/B
		Va -- Hwy Approach Speed	45	55	65	25	40	40	40	25	55	35		45	45
		Vp -- Plaza Speed	15	35	35	25	40	25	40	25	45	15		45	45
		N1 -- Approach Travel Lane	3	3	2	2	2	4	4	2	10	8		2	2
		N2 -- Typical No. Toll Lanes	7	18	5	2	--	4	6	2	12	13		4	8
		N3 -- Departure Travel Lanes	3	3	2	2	2	4	4	2	3	2-4		2	4
		Wm -- Width Hwy Med.	N/A	CTB	16'	8'	2	0	47	0	4'	24'		--	36' +/1
		Wt-- Total Width N2	16	132.5'	48'	41'	42	82'	184'	41'	--	225'		62'	
		Ta -- Approach Taper	--	10: 1	17: 1	14: 1	0: 1	10: 1	2: 1	14: 1	N/A			0	11: 1
		Td -- Departure Taper	--	10: 1	17: 1	3.5' 1	50: 1	6: 1	2.5: 1	6:1	N/A			0	'5'1
		La -- Length Approach Zone	440'	600'	120'	300'	INF	600'	300'	115'	150'	600'		525' +/-	525'
		Lq -- Length Quenching 'Area'	440'	150'	264'	175'	4 MI	150'	350'	30	N/A	600'		0	80'
		Lts -- Length Concrete Toll Island Slab	84'	90'	64'	60'	70'	44'	59'	35	N/A	20'		86	100'
		Lr -- Length Recovery Zone	471'	150'	162'	75'	--	100'	175'	8	N/A	120'		60	50' +/-
		Ld -- Length Departure Zone	471'	600'	609'	60'	500'	350'	500'	50	N/A	1500'		500' +/-	

* Date Not Provided

APPENDIX C
TOLL PLAZA DESIGN
TOLL FACILITY OPERATOR QUESTIONAIRE - PLAZA LAYOUT

		FACILITY	17f	18a	18b	18c	18d	19	20a	20b	21	22	23a	23b *	23c
		Facility Identification	Outerbridge Crossing	Ben Franklin Bridge	Betsy Ross Bridge	Walt Whitman Bridge	Commadore Bridge	Buffalo, Fort Erie Bridge	Dallas North Tollway	Mountain Creek Lake Br	E-470	Ilinois State Toll	Brooklyn Battery Tunnel	Queens-Mid Town Tunnel	Cross Bay Bridge
1		Plaza Configuration													
	a	Barrier	√	√	√	√	√	√	√	√	√	√		√	√
	b	Split													
	c	Serv. Platit / Bypass											√		
2		Roadway Segment													
		(Tangent / Curve)		√	√	√	√	√	√	√		√	√	√	
		MIN> Curve Radius									√	√			
											5729.58	5730'			
3		Plaza Location													
		Mainline	√	√	√	√	√	√	√	√	√	√	√	√	√
		Ramp (Engry / Exit)													
		Both													
4		Geometric Criteria													
		Va -- Hwy Approach Speed	45	55	50	45	50	30	45	35	65	55	50	none	40
		Vp -- Plaza Speed	45	20.	45	N/A	40	30	10	stop	35	none	35	none	10
		N1 -- Approach Travel Lane	2	10	5	3	2	3	3	3	3	4-6	5	4 - 6	3
		N2 -- Typical No. Toll Lanes	8	13	6	16	6	5	6	5	2 AVI, 3 Manual	14 to 18	5	7	6
		N3 -- Departure Travel Lanes	4	3	2 -- 4	5	1-3	2	3	3	4	4 to 5	2	3	6
		Wm -- Width Hwy Med.		N/A		N/A	32'		6'	N/A	112'	30'	N/A	21 *	
		Wt -- Total Width N2		205	234	311'	140'	84'	95'	82.5	118'	234--292	81'	110	6'
		Ta -- Approach Taper		N/A	3.5: 1	1.92: 1	2.4: 1	N/A	10: 1	10.8: 1	20.7: 1	3.4 - 6.2: 1	6.5' 1	6.5: 1	30: 1
		Td -- Departure Taper		3:1	2.6: 1	1.98: 1	2:1	N/A	10: 1	3: 1	34.8:1	3.4 - 6.2: 1	N/A	.5: 1	30: 1
		La -- Length Approach Zone		N/A	300	500'	210'		500'	820'	1200'	1000' to 1300'	360'	340	360'
		Lq -- Length Quenching 'Area'	70'	N/A	200	0	410'	400'	100'	55'	200'	300'	N/A	40	112'
		Lts -- Length Concrete Toll Island Slab	100'	32'	60'	100'	46'	20'	94'	92'	100'	78'	100'	100	68'
		Lr -- Length Recovery Zone	125'	N/A	100	0	320	10'	100'	55'	100'	50'-100'	50'	40	112'
		Ld -- Length Departure Zone		420'	250	500'	300	N/A	500'	250'	1600'	1000--1500'	300'	200	360'

Note: 23b, 4 Wm - Tunnel Roadway width at North and South Portals.
NA - Not Applicble

APPENDIX C
TOLL PLAZA DESIGN
TOLL FACILITY OPERATOR QUESTIONAIRE - PLAZA LAYOUT

NCHRP PROJECT 20-5
TOPIC 25-11

		FACILITY	23d	23e	23f	23g	23h *	23i	24a	24b	25	25			
		Facility Identification	Triborough Bridge	Marine Parkway Br.	Henry Hudson Br.	Throgs Neck Bridge	Verrazano Bridge	Bronx-Whitestone	Orlando Orange (Main)	Orlando Orange (ramp)	Foothill Trans Corridor	Foothill Trans Corridor			
1		Plaza Configuration													
	a	Barrier	√	√		√	√		√	√		√			
	b	Split			√ Upper/Lower										
	c	Serv. Platit / Bypass									√ (FUTURE)				
2		Roadway Segment													
		(Tangent / Curve)	√	√		√	√	√	√	√	√	√			
		MIN> Curve Radius													
3		Plaza Location													
		Mainline	√	√	√	√	√	√	√		√				
		Ramp (Engry / Exit)								√		√			
		Both													
4		Geometric Criteria			ND		EB/WB								
		Va -- Hwy Approach Speed	ND	40	--	ND	40/55	50	55	45	55	ND			
		Vp -- Plaza Speed	ND	10	--	ND	25	15	none	none	ND	ND			
		N1 -- Approach Travel Lane	3	3	--	6	3/6	3	2-3	1	3	2			
		N2 -- Typical No. Toll Lanes	8	6	--	18	8-Free 23-Toll	22	4-9	1-2	5	2			
		N3 -- Departure Travel Lanes	3	6	--	3	6/3	4	2-3	--	2	2			
		Wm -- Width Hwy Med.	32'		--	12	5'	4	64'	18' - 39'	--	--			
		Wtl -- Total Width N2	149' 3"	59' 6"	--	--	150'/350'	364'	75' - 165'	18' - 39'	80'	36'			
		Ta -- Approach Taper	N/A	40: 1	--	--	--	2: 1	25:1*	--	--	20: 1			
		Td -- Departure Taper	N/A	40: 1	--	--	--	2: 1	25:1*	25' 1	--	--			
		La -- Length Approach Zone	800'	440'	--	3000'	500/900	200'	100'	350'	1100'	93.3'			
		Lq -- Length Quenching 'Area'	200'	103'	--		80'	200'	75'	--	285'	100'			
		Lts -- Length Concrete Toll Island Slab	68'	68'	--	90'	40'	100'	160'	120'	165'	118.6'			
		Lr -- Length Recovery Zone	200'	103'	--	N/A	80'	22'	75'	--	200' min	--			
		Ld -- Length Departure Zone	700'	440'	--	2000'	80'	100'	100'	475'	1120'	--			

* Note: 23 h, 1a WB (One-Way Toll)
ND - No Data

APPENDIX D

TOLL FACILITY OPERATOR QUESTIONNAIRE—TOLL LANE APPROACH ELEVATION

APPENDIX D
TOLL PLAZA DESIGN
TOLL FACILITY OPERATOR QUESTIONAIRE - TOLL LANE APPROACH ELEVATION

NCHRP PROJECT 20-5
TOPIC 25-11

		FACILITY	2	3	4	5	6	7	8	9 (Main)	9 (Midsize)	10	11	12
		Facility Identification	Indiana East-West Toll Road	Mackinac Bridge	Ponchatrain Causeway	Chesapeeke Bay Bridge	West Virginia Parkway	Garden State Parkway	N.Y. State Thruway	Southern Turnpike	Southern Turnpike	Oklahoma Turnpike	Mass. Turnpike	PA Turnpike
		Ca -- Vertical Clearance	16' 6"	15' 9"	15' 6"	16"	17' 0"	18'	15' 9"	17' 6"	17' 6"	15'	15' 6"	17'
		Cs -- Clearance to Overhead Sign	14' 6"	N/A	N/A	--	N/A	16' 6"	14' 6"		N/A	15'	13' 8"	15' 6"
		Cb -- Lateral Clearance	18"	11"	18"	14'	1' 2"	8'	1' 6"	1'	9"	12'	1' 3"	2' 2"
		Hb -- Booth Height	8"	9' 6"	8'	--	7' 9"	12' 6"	8' 9"	10'	10' 6"	7' 10 3/16"	7' 6"	10' 9"
		Hc -- Curb Height (Min./ Desired)	6" / 9"	7"	8" /12"	8" / -	9" /	3" / 6"	4" / 6"	6" / 6"	6" / 6"	6" /	7" / --	6" / --
		Ha -- Height of ACM Basket	33"	N/A	N/A	36"	N/A	2' 10"		3' 3"	39.1"	3'		42"
		W1 -- Toll Island Width	8'	6'	7' 0"	5' 6"	6'	5' 11"	7'	6'	7' 6"	6' 6"	6' 6"	10'
		W2 -- Width of Typical Toll Lane	10' or 12'	10' 2"	10'	10'	10'	10' 3"	10'	12'	12'	10' 6"	10' 6"	10'
		Wj -- Width of Outside Lane	14' or 16'	N/A	14' 6"	14'	18'	12' to 14'	14'	15'	15'	12'	14"	16'
		S+/S- -- Cross Slope	1.0%	1%	1%	2%	0%	1%	1.5%	0%	0%	1.5%	0%	0.02%
		Ds -- Depth of Concrete Lane Slab	10"	9"	8"	21"	10"	9"	10"	12'	12"	10"	18"	10"

Note: Facility #1 (Grossdle Toll Bridge) Has No Data.

APPENDIX D
TOLL PLAZA DESIGN
TOLL FACILITY OPERATOR QUESTIONAIRE - TOLL LANE APPROACH ELEVATION

NCHRP PROJECT 20-5
TOPIC 25-11

FACILITY	13	14	15	16a	16b	16c	16d	16e	17a	17b	17c	17d	17e
Facility Identification	Tobin Memorial Bridge	Hardy & Sam Houston	International Bridge	Rip Van Winkl Br.	Kingston Bridge	Mid-Hudson Bridge	Newburgh Bridge	Bear Mountain Bridge	George Washington	Holland Tunnel	Lincoln Tunnel	Bayonne Bridge	Goethals Bridge
Ca -- Vertical Clearance	15'	21' 8"	17'	14'	14'	13' 6"	17 '6"	16' 6"	16'	16' .25" - 16' 10"	15'	15'	16'
Cs -- Clearance to Overhead Sign	15'	16' 10"	N/A	N/A	N/A	none	N/A	none	16'		13'	--	--
Cb -- Lateral Clearance	1" 1.5'	6'	1' 2.5"	12"	12'	8"	8"	8.5"	18'	1' 4"	8'	1' 2"	1' 2"
Hb -- Booth Height	10' 4"	13' 8"	8' 7"	9'	9'	8' 6"	9'	9'	8'	10'	8'	6'11"	6' 10'
Hc -- Curb Height (Min./ Desired)	8.5" /	6" /	4" /	8" / 8:	8" . 8"	8" / 8"	8" / 8"	'8" /	8" / NA	'8" /	6" /	6" /	6" /
Ha -- Height of ACM Basket	--	54"	--	N/A	N/A	N/A	N/A	N/A	N/A	N/A		N/A	N/A
W1 -- Toll Island Width	6'	5'	6'	7' 8"	7' 8"	7' 6"	7' 10"	7'	7'	6' 8"	4'	5' 4"	5' 4"
W2 -- Width of Typical Toll Lane	10'	10'	10'	11	11	10' 6"	11' 6"	12'	10'	10' 2"	10' 4"	10' 2"	10' 2"
Wj -- Width of Outside Lane	12'	12'	30.3'	14	14	14"	28'	15'	17'	13'		13'	13'
S+/S- -- Cross Slope	--	0.18%	0.01%	2%	2%	2%	2%	2%	N/A	1.35%		1%	--
Ds -- Depth of Concrete Lane Slab	10'	10"	12"	9"	9"	9"	9"	9"	N/A	14"	8' - 10	12"	--

APPENDIX D
TOLL PLAZA DESIGN
TOLL FACILITY OPERATOR QUESTIONAIRE - TOLL LANE APPROACH ELEVATION

NCHRP PROJECT 20-5
TOPIC 25-11

FACILITY	17f	18a	18b	18c	18d	19	20a	20b	21	22	23a	23b	23c
Facility Identification	Outerbridge Crossing	Ben Franklin Bridge	Betsy Ross Bridge	Walt Whitman Bridge	Commadore Bridge	Buffalo, Fort Erie Bridge	Dallas North Tollway	Mountain Creek Lake Br	E-470	Ilinois State Toll	Brooklyn Battery Tunnel	Queens-Mid Town Tunnel	Cross Bay Bridge
Ca -- Vertical Clearance	↓	14' 7"	16'	15' 10"	15'	14'	16'	15'	17'	16' 9"	15'	15'	16' 11"
Cs -- Clearance to Overhead Sign	↓	11' 1"	11' 11"	11' 9"	11' 4"	N/A	12' 4"	12'	17'		13'	12' 9"	16' 3"
Cb -- Laternal Clearance	↓	8"	1' 8"	1' 8"	1' 6"	6"	11"	1'	14"	3'	11'	1'	1'
Hb -- Booth Height	↓	9'	7' 8"	8'	7' 4"	10'		8'	10'		15'	15' 3"	7' 7"
Hc -- Curb Height (Min./Desired)	↓	9" /	8" /	8" /	8" /	N/A	6" /	6" /	10" /	6" /	9" /	9" /	7" /
Ha -- Height of ACM Basket	↓	2' 10"	2' 10"	2' 10"	2' 10"	3' 2"	3'	3'			42"	3' 9"	4' 3"
W1 -- Toll Island Width	↓	6' 8"	7'	7' 6"	7'	5' 6"	6' 6"	6' 6"	6'	6' 6"	6'	6'	6' 2"
W2 -- Width of Typical Toll Lane	↓	9' 6" and 10'	10'	9'	10'	10'	10'	10'	12'	10'	10'	10'	10'
Wj -- Width of Outside Lane	↓	22'	30'	34' 1"	30'	22'	10'	10'	12 + 4' sh.	12'	12'	10'	12' 2"
S+/S- -- Cross Slope	↓	varies	2%	1.4%	2%	2%	1%	1%	2%		0%	0.6%	2%
Ds -- Depth of Concrete Lane Slab	no info	10"	10"	10	9"	14"	10"	8"	10"	10"	9"	12"	12"

APPENDIX D
TOLL PLAZA DESIGN
TOLL FACILITY OPERATOR QUESTIONAIRE - TOLL LANE APPROACH ELEVATION

NCHRP PROJECT 20-5
TOPIC 25-11

		FACILITY	23d	23e	23f	23g	23h	23i	24a*	24b					
		Facility Identification	Triborough Bridge	Marine Parkway Br.	Henry Hudson Br.	Throgs Neck Bridge	Verrazano Bridge	Bronx-Whitestone	Orlando Orange (Main)	Orlando Orange (ramp)					
		Ca -- Vertical Clearance	15'	15' 7"	14' 9"	15'	16'	21'	17' 6"	17'					
		Cs -- Clearance to Overhead Sign	15'	14' 11"	13' 3"	15'	16'	16'	14' 6"	--					
		Cb -- Lateral Clearance	10'	1'	1"	1.25'	12"	1'	1' 0"	9"					
		Hb -- Booth Height	7' 6"	12'	7' 9"	13'	8'	18'	8' 10"	10'					
		Hc -- Curb Height (Min./Desired)	9" /	10" /	9" /	8" /	9" /	9"	6" / 6"	3" / 3"					
		Ha -- Height of ACM Basket	2' 6"	3' 7"	42"	3' 5"	3'	3.5'	3' 2"	3' 2"					
		W1 -- Toll Island Width	4'	6'	5'	6'	8'	5'	6' 0"	6' 0"					
		W2 -- Width of Typical Toll Lane	11' 6"	9' 10"	0'6"	12'	10'	10.5'	12' 0"	12'					
		Wj -- Width of Outside Lane	15'	10' 11"	12'	15'	16'	11'	15' 0"	15' 0"					
		S+/S- -- Cross Slope	0.08%	2%	0%		2%	2%	0%	--					
		Ds -- Depth of Concrete Lane Slab	10'	N/A	8"		9"	9"	12"	9"					

Note: * 24a Cs "Cars Only" Sign

APPENDIX E

TOLL FACILITY OPERATOR QUESTIONNAIRE—TOLL ISLAND SIDE ELEVATION

APPENDIX E
TOLL PLAZA DESIGN
TOLL FACILITY OPERATOR QUESTIONAIRE - TOLL ISLAND SIDE ELEVATION

NCHRP PROJECT 20-5
TOPIC 25-11

		FACILITY	2	3	4	5*	6	7	8	9 (Main)	9 (Midsize)	9 (Small)	10	11	12
		Facility Identification	Indiana East-West Toll Road	Mackinac Bridge	Ponchatrain Causeway	Chesapeeke Bay Bridge	W. Virginia Parkway	Garden State Parkway	N.Y. State Thruway	Southern Turnpike	Southern Turnpike	Southern Turnpike	Oklahoma Turnpike	Mass. Turnpike	PA Turnpike
1		Plaza Configuration													
	a	Mainline		√	√	√	√			√					
	b	Ramp (Entry / Exit)	√								√	√			
	c	Both						√	√						√
		Highway Appr. Speed/Plaza	55/25	45	35	55	55	55	55	65	40-45	35	--	55	25-35
2		Geometric Criteria -- Lengths in Ft/in.													
		AL1 -- Attenuator	0	0	20' 9"	0	20'	11' 9"	12' 6"	29' 9"	17' 9"	17' 9"	19' 8.875"		20
		Al 2 -- Attenuator	0	0	--	0	20'	N/A		29' 9"	17' 9"	17' 9"	N/A		0
		Sd -- Design Speed	25	--	60	0		45	40	70	70	55	70		70
		Design Vehicle (Pass Car, Trk <8k, Hd Trk)	--	--	--	0		45.9k							
		R1 -- Approach Rampart	20'	3	0	16'	0'	20' 3"	N/A	8' 6"	8' 6"			20' 9"	68'
		Cb1 -- Crash Blk.	4'	1	2'	*	2'	2' 6"	3' 2"	8'	8'		17'	2' 6"	7'
		O1 -- Opening (Str. Well)		0	68'	0	17'	10'	N/A	4' 4"	0		N/A	0	0
		Cb 2 -- Crash Blk.	0	0	3'	0	2' 7"	2' 6"	N/A	16' 6"	0		N/A	0	0
		O2--Opening	4'	17' 2"	8'	30"	3' 10'	3' 3"	3' 10'	14' 9"	12' 3"		5' 6"	2' 9"	3' 3"
		B1 -- Booth	20'	11' 5"	8'	9'	10' 10"	12'	12'	14'	14		10'	11'	14'
		O3 -- Opening	4'	12' 5"	5'	0	3' 10"	3' 3"	3' 10"	0	14' 9"		N/A	2' 9"	18' 2"
		Cb3 -- Crash Bulk		1'	3'	0	2' 7"	2' 6"	3' 2"	0	0		N/A	2' 6"	0
		O4 -- Opening (Str. Well)		0	0	0	17'	10'	N/A	12' 3"	0		N/A	0	0
		Cb4 -- Crash Blk.	4'	0	0	0	2'	2' 6"	N/A	8'	8'		N/A	0	0
		R-2 Departure Rampart	20'	3	0	0	0'	20' 3"	8'	8' 6"	8' 6"		N/A	20' 9"	16'
		IP2 -- Island Length (Departure side only)		21' 2"	22'	20'	N/A	32'	41'	35' 9.5"	31' 3"		30' 6"	35' 6"	38'
		Lts -- Concrete Toll Island Slab	260	49' 3"	97' 6"	45'	57'	91'	82'	157'	82' 6"		67'	80'	130'
		Hb -- Height of Crash Blk.	4'	--	3	42'	4'	4'	26" -- 33"	3' 6"	3' 6"		4"	2' 9"	2'9"
		Cw -- Width of Canopy	--	22	32	22'	32' 4"	30'	27' -- 50'	72' 11"	52' 1"		34'	30'	60'

Note: 5, 2cb, Crash BLK included in approach Rampart

APPENDIX E
TOLL PLAZA DESIGN
TOLL FACILITY OPERATOR QUESTIONAIRE - TOLL ISLAND SIDE ELEVATION

NCHRP PROJECT 20-5
TOPIC 25-11

		FACILITY	13*	14	15	16a	16b*	16c	16d	16e*	17a	17b	17c	17d	17e
		Facility Identification	Tobin Memorial Bridge	Hardy & Sam Houston	International Bridge	Rip Van Winkl Br.	Kingston Bridge	Mid-Hudson Bridge	Newburgh Bridge	Bear Mountain Bridge	George Washington	Holland Tunnel	Lincoln Tunnel	Bayonne Bridge	Goethals Bridge
1		Plaza Configuration													
	a	Mainline	√		√	√	√	√	√	√	√	√	√	√	√
	b	Ramp (Entry / Exit)													
	c	Both		√											
		Highway Appr. Speed/Plaza	45	55	65/35 (P)	25	40	40	40	25	55	35	--	45	45
2		Geometric Criteria -- Lengths in Ft/in.													
		AL1 -- Attenuator	N/A	0	N/A	N/A	N/A	N/A	N/A	N/A	6' 6"	9' 6"			
		Al 2 -- Attenuator	N/A	0	N/A	N/A	N/A	N/A		N/A	N/A	0		0	
		Sd -- Design Speed			30									45	45
		Design Vehicle (Pass Car, Trk <8k, Hd Trk)			N/A										
		R1 -- Approach Rampart	*	10' 6"	N/A	N/A	*	N/A		none	N/A	0			
		Cb1 -- Crash Blk.	20'	4'	1' 1"	30"--24"	23' 6"	3'	3' --2'	3'	42"	3' 10"		2'	3'
		O1 -- Opening (Str. Well)	5'	10' 0"	N/A	N/A	N/A	N/A	N/A	6'	0	0		11'	0
		Cb 2 -- Crash Blk.	4'	4'	1' 1"	N/A	N/A	N/A	N/A	2.5'	N/A	0		2'	0
		O2--Opening	1' 11.5"	4'	N/A	15'	5' 6"	9'	17'	2'	15' 3"	14'		3' 6"	9'
		B1 -- Booth	10' 1"	0' (M), 16' (R)	11'	16'	17'	14'.	12'	16'	19' 6"	11' 1"	8	8' 10"	9'
		O3 -- Opening	10' 11.5"	4'	N/A	15'	14' 6"	9'	17'	2'	N/A	0		0	0
		Cb3 -- Crash Bulk	18'	4'	N/A	30" -- 24"	2'	3'	3' -- 2	2.5'	N/A	0		0	0
		O4 -- Opening (Str. Well)	N/A	10' 9"	N/A	N/A	N/A	0	N/A	6'	N/A	0		0	0
		Cb4 -- Crash Blk.	N/A	4'	N/A	N/A	N/A	0	N/A	1.5'	N/A	0		0	0
		R-2 -- Departure Rampart	N/A	10' 6"	4' 2"	N/A	N/A	0	N/A	L1-6', L2-19'	N/A	0		0	0
		IP2 -- Island Length (Departure side only)	47' 4.5"	45'	24'	N/A	N/A		--		34' 3"	29' 9.5"	10"	35'	30' +/-
		Lts -- Concrete Toll Island Slab	84'	90'	90'	60	70'	44'	59'	1-34', L2-45.5	69' 9"	70'	20'	86'	100'
		Hb -- Height of Crash Blk.	3' 6"	4'	N/A	24'	2' 7"	30"	30"	3'	38"	2' 8"		3' 6"	--
		Cw -- Width of Canopy	35'	30'	25'9"	60'	46'	40'	40'	18'	36' 3"	48'	24'	36'	48'

* Notes: 13, 2, R1 Including Cb 1
16b, 2, R1 including Cb 1
16e, R2, Lts L1 - Lane 1, L2 - Lane 2

APPENDIX E
TOLL PLAZA DESIGN
TOLL FACILITY OPERATOR QUESTIONAIRE - TOLL ISLAND SIDE ELEVATION

NCHRP PROJECT 20-5
TOPIC 25-11

		FACILITY	**17f**	**18a**	**18b**	**18c**	**18d**	**19***	**20a**	**20b**	**21**	**22**	**23a***	**23b**	**23c**
		Facility Identification	Outerbridge Crossing	Ben Franklin Bridge	Betsy Ross Bridge	Walt Whitman Bridge	Commadore Bridge	Buffalo, Fort Erie Bridge	Dallas North Tollway	Mountain Creek Lake Br	E-470	Ilinois State Toll	Brooklyn Battery Tunnel	Queens-Mid Town Tunnel	Cross Bay Bridge
1		Plaza Configuration													
	a	Mainline	√	√	√		√		√	√		√	√	√	√
	b	Ramp (Entry / Exit)													
	c	Both													
		Highway Appr. Speed/Plaza	45	55	50	45	50	30	45	35	65	55	50	--	40
2		Geometric Criteria -- Lengths in Ft/in.													
		AL1 -- Attenuator	17' 9"	N/A		N/A	18'	N/A		N/A	22'	0	N/A	N/A	
		Al 2 -- Attenuator		N/A		N/A	N/A	N/A		N/A	N/A	0	N/A	N/A	
		Sd -- Design Speed	45	N/A			60			N/A	60	60			
		Design Vehicle (Pass Car, Trk <8k, Hd Trk)		N/A						N/A					
		R1 -- Approach Rampart		N/A	8' 4"	N/A	8	8'3"	14' 6.5"	15' 6"	3'	15'	8' 9.5	8' 10"	10'
		Cb1 -- Crash Blk.	5'	2' 8"	1' 6"	N/A	4'	*	1'	1"	5' 6"	2' 6"	2' 2.5"	2' 6"	2'
		O1 -- Opening (Str. Well)	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		25.30 - 19.29'	13' 4"	12' 6"
		Cb 2 -- Crash Blk.	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		2'	2' 6"	2'
		O2--Opening	10'	24'	20' 10"	N/A	16' 10"	1' 6"	3'	11' 2"	37'		5.5"	3' 1"	3'
		B1 -- Booth	10'	8' 8"	12' 5"	16' 11"	14' 8"	10'	12' 10"	11' 2"	14' 2"	9'	5'	14"	12'
		O3 -- Opening	0	24'	20' 10"	N/A	8' 2"	9' 3"	3'	2' 11"	N/A		24- 12'	5' 2"	3'
		Cb3 -- Crash Bulk	0	N/A	1' 6"	N/A	4'	3' 3"	1'	N/A	N/A		5'	2' 6"	2'
		O4 -- Opening (Str. Well)	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		25.30 - 19.29'	N/A	12' 6"
		Cb4 -- Crash Blk.	0	N/A	N/A	N/A	N/A	N/A	N/A	1'	N/A		2' 2.5"	N/A	2'
		R-2 -- Departure Rampart	0	N/A	8' 4"	N/A	8'	N/A	14' 6.5"	15' 6"	N/A		8' 9.5	20' 5"	10'
		IP2 -- Island Length (Departure side only)	35'	35						26'	N/A			34' 5"	34' 6"
		Lts -- Concrete Toll Island Slab	75'	70'	37' 6"	64'	76'	34' 6"	71"	92'	100'	76'	80'	72' 4"	69'
		Hb -- Height of Crash Blk.	4'	N/A	3'	N/A	3'	2' 9"	N/A	N/A	3'	3' 4"	3' 6"	2' 9"	2' 7"
		Cw -- Width of Canopy	35'	32'	40'	42'	40'	35' 6"	30' 3"	24'	72'	42'	40'	40' 6"	39'

*Notes: 23a; 2 O1, O4 6 at 25.3' and 4 at 19.29'
19, 2cb1 blk including in R1
N/A Not Applicable

APPENDIX E
TOLL PLAZA DESIGN
TOLL FACILITY OPERATOR QUESTIONAIRE - TOLL ISLAND SIDE ELEVATION

NCHRP PROJECT 20-5
TOPIC 25-11

		FACILITY	23d	23e *	23f	23g	23h	23i	24a	24b	25				
		Facility Identification	Triborough Bridge	Marine Parkway Br.	Henry Hudson Br.	Throgs Neck Bridge	Verrazano Bridge	Bronx-Whitestone	Orlando Orange (Main)	Orlando range (ramp	Foothill Trans Corridor				
1		Plaza Configuration	√	√	√	√	√	√	√		√				
	a	Mainline								√					
	b	Ramp (Entry / Exit)													
	c	Both													
		Highway Appr. Speed/Plaza	--	40	--	50	40	50	55	45	55				
2		Geometric Criteria -- Lengths in Ft/in.													
		AL1 -- Attenuator	N/A	--	none	N/A	none	N/A	31' 0"	14' 9"	19.25'				
		Al 2 -- Attenuator	N/A	0	none	N/A	none	N/A	--						
		Sd -- Design Speed		10					65	50					
		Design Vehicle (Pass Car, Trk <8k, Hd Trk)		Pass Car					--						
		R1 -- Approach Rampart	8' 9"	7' 7"	9'6"	10'	11'	11'	8' 6"	10'					
		Cb1 -- Crash Blk.	1' 9"	2' 3"	2'	1.83'	1' 10"	4'	8' 0"						
		O1 -- Opening (Str. Well)	12' 4"	12' 4"	11' 6"	12'	12' 4"	58'	26' 0"	21					
		Cb 2 -- Crash Blk.	1' 8"	1' 8"	1' 8"	1.67'	1' 8"	2'	6' 0"	--					
		O2--Opening	2' 8"	3'	4'	3.5'	2' 6"	3'	2' 3"	3'					
		B1 -- Booth	12' 2"	12' 6"	12'	8'	12' 11"	12'	10' 11"	28' 8"	12'				
		O3 -- Opening	2' 8"	3'	none	6'	2' 6"	3'	12' 8"	--					
		Cb3 -- Crash Bulk		1' 8"	none	3.5'	1' 10"	3'	8' 0"	--					
		O4 -- Opening (Str. Well)	12' 4"	12' 4"	none	N/A	0	9'	--	--					
		Cb4 -- Crash Blk.		2' 3"	none	N/A	0	2'	--	--					
		R-2 -- Departure Rampart	8' 9"	7' 8"	none	22'	0	N/A	8' 6"	--					
		IP2 -- Island Length (Departure side only)	34'	33'	28'	34'	34	23'	31' 6"	--					
		Lts -- Concrete Toll Island Slab	68	68'	59'	68'	68'	114'	97' 6"	16'	75'				
		Hb -- Height of Crash Blk.	2'	2' 6"	2' 7"	2.83'	2'	--	3' 6"	3' 7"					
		Cw -- Width of Canopy	40'	42	42'	40'	40'	40'	72' 9"	32' 6"					

*Note: 23e, 2AL1 - Hydro- Cell

APPENDIX F

TOLL FACILITY OPERATOR QUESTIONNAIRE—TOLL LANE EQUIPMENT CONFIGURATION

APPENDIX F
TOLL PLAZA DESIGN
TOLL FACILITY OPERATOR QUESTIONAIRE - TOLL LANE EQUIPMENT CONFIGURATION

NCHRP PROJECT 20-5
TOPIC 25-11

		FACILITY	4	5	9 (Main)	9 (Midsize)	9 (Small)	14	15	18a	18b	18c	23a	23a	23b	23e
		Facility Identification	Ponchatrain Causeway	Chesapeeke Bay Bridge	Southern Turnpike	Southern Turnpike	Southern Turnpike	Hardy & Sam Houston	International Bridge	Ben Franklin Bridge	Betsy Ross Bridge	Walt Whitman Bridge	Commadore Bridge	Brooklyn Battery Tun	Queens Midtown Tun	Marine Parkway Br.
1		Plaza Configuration														
		LI -- Entry / Arming Loop		+ / -3'	-9'	-2'	-10'									
		T -- Treadle		+16' 10"	-15'	+20'	+14'	19'		+12' 3"	+12' 11"	+10' 11"	-24' 5"	-12'	+11' 9"	6'
		Dc -- Collector Door					0			-2' 4"	-2	-4' 2"	-3' 7"		-1' 4"	
		P -- Patron Fare Indictor		+8	+8'	+16'	+3'		+12' 4"	0	0	0	+2' 2"			
		Pcs -- Pre-Class Sensor			--											
		Lz -- Transection / Exit Loop			(+18'-26')					+37' 4"	+40' 11"	+40' 4"	+42'			
		Gate	-41'	-19'	+17					+21' 2"	+22' 6"	+25'	+22' 5"			
2		AUTOMATIC LANE														
		Li -- Entry / Army Loop (Scale)			-12' 6"	-2' 10"	-1' 6"			-37' 7"			+33'	-63.34'		
		T -- Treadle	-42.5'		-15'		+14'		+18'						+11' 3"	
		A -- ACM			+1' 8"	+5	0			+1' 6"	+2' 2"	+1' 6"	+1' 6"	-5' 9.5"	-9' 7"	-8'
		Vl -- Camera (left)			+26'		-18'									
		Vr -- Camera (right)												-20'	-20'	-6'
		Vo -- Camera (OH)								+16'			+20	+20	+20	+6
		Ts -- Traffic Signal		+18' 6"	+24' 6"	+32'	.+21' 6"									
		G -- Exit Gate	+50		+17'	+24	+16'	+5'				+25				
		L2 -- Transaction Loop			+1"											
		L3 -- Exit Loop			+(18'-26')		+24' 6"									
		O -- Optical Gate Sensor			+18' 4"	+30										
		Bar Code Reader/Pre Class Sensor	(-35')		--					-10' 7"	-7' 1"	-8' 10"	9 11'			
3		ETC Lane														
		L1 -- Entry / Arming Loop					-11'6"									
		AVC -- Automatic Vehicle Classifier/Veh Sep.			-15'		+14' 10"									
		Ea1 -- ETC Antenna (OH)			-15'	-28'	-9 / 14'6"									
		Ea2 -- ETC Antenna (Is. Mtd)			--											
		Pcs -- Pre-Class Sensor														
		Vl -- Camera (left0			+26		+25' 6"									
		Vr -- Camera (right)														
		Vo -- Camera (OH)														
		P -- Patron Fare Indicator			+8'		+12 6"			+20' 2"	+21' 9"	+21'	+16'			+12'
		O -- Optical Gate Sensor			+18' 4"		NLU									
		G - Exit Gate			+17'											
		L3 -- Exit Loop			+(18' - 26')											
		Ts -- Traffic Signal			+24' 6"											

*Notes: All measurements from transverse center line of Toll Barrier -- Station) +))
(-- dimensions on Approach Side, + dimensions on Departure Side).
NLU - No Longer Used
23e, 2, Bar Code Reader is actually Patron Fare Indicator

APPENDIX F
TOLL PLAZA DESIGN
TOLL FACILITY OPERATOR QUESTIONAIRE - TOLL LANE EQUIPMENT CONFIGURATION

		FACILITY	23g	23h	24a*	24b									
		Facility Identification	Throgs Neck Bridge	Verrazano Bridge	Orlando range (Main	Orlando Orange (ramp)									
1		Plaza Configuration													
		Ll -- Entry / Arming Loop	-6'		-9' 6"	-9' 10"									
		T -- Treadle	+14'	-12'		+38' 8"									
		Dc -- Collector Door			-5'	0'									
		P -- Patron Fare Indictor		+2' 6"	+8	+37' 5"									
		Pcs -- Pre-Class Sensor			-11' 8", +35'	-12' 4"									
		Lz -- Transection / Exit Loop	+23'		+39' 8"	+43' 8"									
		Gate (Signal)	+16 (exit)		(+38' 7")										
2		AUTOMATIC LANE													
		Li -- Entry / Army Loop (Scale)		-10'	-9' 6"	-9' 10"									
		T -- Treadle													
		A -- ACM	-6'	-7' 8"	-2'	+3' 7"									
		Vl -- Camera (left)													
		Vr -- Camera (right)		-6' 5"	-6' (booth)	-2' (booth)									
		Vo -- Camera (OH)		+26' 5.5"											
		Ts -- Traffic Signal			+38' 7"										
		G -- Exit Gate	+16'		+37' 3"	+40' 3"									
		L2 -- Transaction Loop													
		L3 -- Exit Loop	+23'	14' 6"	+39' 8"	+43' 8"									
		O -- Optical Gate Sensor													
		Bar Code Reader/Pre Class Sensor			(-11' 8", +35')										
3		ETC Lane													
		L1 -- Entry / Arming Loop			-9' 6"										
		AVC -- Automatic Vehicle Classifier/Veh Sep.													
		Ea1 -- ETC Antenna (OH)			6' pavement										
		Ea2 -- ETC Antenna (Is, Mtd)													
		Pcs -- Pre-Class Sensor			-11' 8"										
		Vl -- Camera (left0			+6' (booth)										
		Vr -- Camera (right)			-6'										
		Vo -- Camera (OH)													
		P -- Patron Fare Indicator			+8'	+37' 5									
		O -- Optical Gate Sensor													
		G - Exit Gate			+37' 3"										
		L3 -- Exit Loop			+39' 8"										
		Ts -- Traffic Signal			38'7"										

* Notes: All measurements from transverse center line of Toll Barrier -- Station 0 + 00
(-- dimensions on Approach Side, + dimensions on Departure Side).

* 24a, 1 Pcs - Vehicle Separator
24a 2 Pcs - Vehicle Separator
24a 3P - Also used with ACMS's

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