Bay Area Tolling Authority
Video Tolling Demonstration Project

Task 11.0: Final Evaluation Report

June 10, 2011

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File Name:	*VT Demo Final Eval Report*	
File Location:		
Deliverable Number:	11.0	
Version Number:	FINAL	
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Acronyms & Definitions

ACS	Affiliated Computer Services, Inc. - BATA FasTrak Consultant
AET	all-electronic tolling (no in-lane cash collection)
AVI	automated vehicle identification (the process of electronically identifying vehicles using a roadside reader and an in-vehicle transponder)
BATA	Bay Area Toll Authority
Caltrans	California Department of Transportation
DMV	Department of Motor Vehicles
EPA	Environmental Protection Agency
ETC	electronic toll collection
FT	FasTrak
GGB	Golden Gate Bridge
GGBHTD	Golden Gate Bridge, Highway, and Transportation District
GPS	global positioning system
HOT	high-occupancy tolling
IVR	interactive voice response
ITS	intelligent transportation systems
OCR	optical character recognition (an automated process used to identify license plate numbers in an image without the use of human review)
ORT	open-road tolling (an open-road tolling system where all forms of accepted payment methods are electronic without a cash option)
PBP	pay-by-plate
Atkins	BATA Consultant (formerly PBS&J)
RCSC	regional customer service center
TCRP	Traffic Congestion Relief Program
TTI	Traffic Technologies Inc. - GGBHTD Consultant
UAT	user acceptance testing
URL	uniform resource locator
USPS	United States Postal Services
VES	violation enforcement system
VOC	volatile organic compounds
vph	vehicles per hour
VT	video tolling (pay-by-plate – pre-registered account using a credit card for toll payment)
VT-I	video tolling invoice (unregistered account using an invoice for toll payment)

1. Executive Summary

With the increase in traffic and lane congestion, transportation engineers and planners are rapidly creating solutions to accommodate this rise in travel demand. When adding capacity to an existing corridor is not a viable solution, intelligent transportation systems (ITS) emerge to help address and mitigate congestion. ITS includes numerous toll-related alternatives such as video tolling (VT), high-occupancy tolling (HOT), and all-electronic tolling (AET). These solutions typically offer not only congestion relief, but other benefits such as reduced capital and labor costs, better customer convenience and safety from the increased throughput and lack of barriers at the toll plazas, and improved air quality and fuel efficiency—all of which translate into cost savings for both the tolling agency and their customers. That is not to say these solutions do not present new challenges, therefore careful consideration must be applied to all project elements to ensure the right ITS solution is determined, planned, and implemented properly.

Under the state of California Department of Transportation's (Caltrans) Traffic Congestion Relief Program (TCRP) Project #11.1, the Bay Area Toll Authority (BATA) has conducted a short-term video tolling demonstration project to study the feasibility of implementing such a solution on state-owned bridges. The project demonstrated two types of image-based tolling: Video Tolling (VT), which allows customers to register a prepaid license plate account and Video Tolling Invoice (VT-I), which bills motorists by mail based on the vehicle's license plate. Neither alternative requires a transponder or payment at a toll plaza.

In studying the feasibility of implementing these programs, components of the demonstration were evaluated and integrated with information from peer projects and industry practices. With many video tolling projects being deployed throughout the United States in the last few years, common trends for successful video tolling models are being identified to increase the likelihood of project success. In the context of potential implementation on several Bay Area bridges, the application of this broadened knowledge may contribute to feasibility being better understood. The areas evaluated for feasibility include the ability to integrate VT and/or VT-I program into the existing regional customer service center (RCSC) system, impacts to back office operations, affects on traffic operations, financial viability, and customer acceptance.

The findings of the evaluation show that it is possible and practical for VT and/or VT-I programs to be integrated with the existing BATA and Golden Gate Bridge, Highway, and Transportation District (GGBHTD) toll collection programs.

The RCSC system is able to support the core functionality of establishing license plate-based accounts in both prepaid and post-paid environments. However, there are system gaps that must be remedied for full implementation of video tolling to be truly viable.

Operationally, full implementation of video tolling would benefit congestion relief efforts, based on improved transaction handling times and increased throughput as a result of maximized lane capacity. The demonstration participants overwhelmingly perceived reduced travel times,

although empirical data collection for travel time was not part of the demonstration scope. Other notable advantages include improved safety and air quality.

Based on surveys of demonstration participants, it is likely that video tolling programs would be widely accepted if the elements of each program and associated education materials are thoroughly developed to address specific types of customers and their needs. The introduction of video tolling is not likely to have immediate impacts to the existing FasTrak (FT) customer base. In general, nearly all participants expressed a preference of not having to stop at a booth, and the most commonly cited benefit of video tolling during the demonstration was the perception of saving time. If the cash payment option was not available, approximately half of the respondents would prefer FasTrak and the other half prefer video tolling, with nearly a 50/50 split between VT and VT-I.

In addition to assessing feasibility, additional considerations and recommendations for full implementation have been provided to give a comprehensive analysis and augment the understanding of critical success factors for video tolling on Bay Area bridges.

2. Introduction

BATA and their consultants, Atkins and Affiliated Computer Services, Inc. (ACS)(the RCSC systems and operations provider), worked together with the GGBHTD and their consultant, Traffic Technologies, Inc. (TTI), to complete the Video Tolling Demonstration (VT Demo) project. This effort was originally initiated by BATA as part of the TCRP. The objective of TCRP Project #11.1 was to conduct analysis, planning, and implementation of a video tolling demonstration on one or more of the state-owned bridges in the Bay Area. The project studied the feasibility of implementing video tolling, which includes charging tolls by reading license plates and billing motorists by mail rather than the current system of cash payment at a toll plaza. Implementation of such a system could alleviate congestion and reduce traffic delays at bridge toll plazas.

Initiated in 2008, the project analyzed and assessed tolling concepts, legislation, legal issues, operational concepts, and financial impacts and reviewed facilities, technologies, and systems. Using the Golden Gate Bridge (GGB), a short-term (2 ½ -month) demonstration period was implemented to determine feasibility by assessing customer acceptance and analyzing the integration with the existing toll systems. This evaluation report considers the findings from the demonstration incorporated with information from project deliverables as described in Section 3.1. Project Phases. Additional context is provided by integrating peer project information when applicable.

2.1. Project Objectives

The primary objective of the project was to assess the feasibility of video tolling and as part of this, to study congestion relief, as indicated by the project definition and funding under the state of California's TCRP. BATA's focus has been on increasing vehicle throughput to reduce

backups at the bridge toll plazas by adding video tolling as an additional means for drivers to pass through the plaza without stopping.

Secondary objectives include the provision of additional toll payment options to the driving public. Video tolling creates a situation where drivers who were once considered violators, due to the fact that they did not pay as they passed through the toll plaza, could now be viewed as customers to be invoiced. They would only become violators if invoices went unpaid, at which point they would be charged higher penalties associated with violating toll-related statutes. Success of full implementation is largely dependent on how many drivers adopt the new payment methods and how the options are used to benefit the customer experience.

An underlying but key objective of both agencies is to test the ability of the RCSC system to successfully deploy and support video tolling functionality. This includes the full transaction lifecycle from the lane through the back office process to the end-user interfaces. The end-user interface may be an invoice for unpaid transactions or an online account statement showing posted transactions. To meet this objective, the performance of the system and all associated interfaces was measured at the transaction level.

Collateral benefits expected of further VT deployment include the potential reduction of operating costs typically associated with cash toll collection and increased safety as a result of the reduced merge and weave situations created by unfamiliar drivers' migration to and from cash lanes.

The addition of GGB to the VT Demo introduced additional emphasis on certain objectives, due at least in part to their study and potential future implementation of AET. Moving to AET would eventually maximize the benefits noted above, since cash collection and the associated costs and travel delays would be completely eliminated. An additional focus on social equity exists in the GGB case, due to the fact that no one will be allowed to pay cash in the lanes once AET is in place. However, impacts on unbanked customers through other means were not included in the VT Demo.

3. Project Overview

3.1. Project Phases

The BATA Video Tolling Demonstration project was initiated in early 2008. Project phases and associated milestones were defined based on an ordered set of deliverables, as follows:

- **Task 1.0. Video Tolling Concepts Review** – This was a survey of video tolling practices across the toll industry in mid-2008 including interviews with several representatives of agencies currently using or in the process of developing video tolling projects. Various types and methods of video tolling were defined for use in upcoming project phases and deliverables. The Task 1.0 report is included as Attachment A.

- **Task 2.0. Legal and Legislative Analysis** – This provided a compilation and analysis of the state of California legislation and other potential legal issues related to video tolling as of mid-2008. Areas reviewed included privacy and confidentiality, invoicing, differential pricing, and automated enforcement. The Task 2.0 report is included as Attachment B.

- **Task 3.0. Concept of Operations** – This document (included as Attachment C) established a general operational model for BATA's potential video tolling program, including business rules for three potential types of video tolling selected by BATA for consideration and analysis:
    - Option 1 – REG/PRE/BAL: A pre-registered, non-transponder-based customer account with a pre-paid balance from which the video toll amounts are deducted.
    - Option 2 – REG/PRE/CC: A pre-registered, non-transponder-based customer account with a required credit card. The video toll amounts are charged to the credit card on file each night.
    - Option 3 – UNREG/POST: A customer account created by the system based on a license plate read in the video tolled lane. Transactions added to the account are invoiced on a regular basis to the registered vehicle owner's name and address, as provided by the Department of Motor Vehicles (DMV). Unpaid invoiced transactions are escalated to violations based on time periods specified in BATA's business rules.

- **Task 4.0. Facilities Review** – This included a physical review of each BATA bridge facility and analysis of the associated traffic and congestion data. The Task 4.0 report is included as Attachment D.

- **Task 5.0. Technology Review** – This was an inventory and assessment of the technologies and systems supporting BATA's toll operation including the lane tolling and violation enforcement systems and the back office and RCSC system. The Task 5.0 report is included as Attachment E.

- **Task 6.0. Financial Impact Analysis** – This analysis comprises a financial model and report used to forecast the potential revenue and cost implications of the video tolling options. Revenue leakage and capital improvement costs were included, and projections were used to establish the potential fee and surcharge amount necessary to cover the operational costs of video tolling. The Task 6.0 report is included as Attachment F.

- **Task 7.0. Conversion Plan Concept** – This plan focuses on a tentative plan for potential conversion of all BATA bridge facilities to include video tolling functionality. The plan includes the video tolling demonstration period which is part of this project, as

well as the approach to full implementation which will be subject to Board authorization based on the results of the BATA VT Demo project. The Task 7.0 report is included as Attachment G.

- **Task 8.0. Facility Selection for Demonstration** – Included as Attachment H, this provides an analysis of the various factors identified in previous deliverables, resulting in recommendations for the initial application of video tolling to a single BATA bridge toll facility. This task was completed in February 2009 with the intention of deploying the VT Demo on a BATA facility during the months to follow.

- **Task 9.0. Implementation Schedule and Budget** – Delivered in January 2011 as an implementation plan for the BATA VT Demo project. This included the addition of GGB as a participant. The implementation plan is included as Attachment I.

- **Task 10.0. Implementation of the Demonstration Project –** This task is associated with the actual implementation phase of the VT Demo project. It has resulted in various documentation and analyses which will be reported on and referenced throughout this paper.

- **Task 11.0. Evaluation of the VT Demo Project** – This report delivers this task as the final phase based on the information from previous phases, data gathered and analyzed during and after the demonstration period, and information from the industry and similar projects.

3.2. Revised Direction

Following the presentation of the Task 8.0 recommendations in February 2009, several revisions to the project approach were considered by BATA. It was determined that BATA would not be able to charge a fee for video tolling without changes to the associated statutes which could not be effective before early 2010. It was proposed that the VT Demo be deployed on the GGB instead. The GGBHTD would not require statutory changes to charge a fee and as they were considering a move to AET, including them in the VT Demo would benefit both agencies. And lastly, planning for the RCSC system modifications required to support video tolling determined that additional time would be needed to complete preparations for the VT Demo.

A revised approach was developed to address these considerations, and this was submitted to Caltrans for approval of an amendment application to the TCRP grant in May 2009 (see Attachment J). Formal approval was received from Caltrans in July 2009 (see Attachment K).

Expanded group meetings to plan for the revised approach began in July 2009 with the necessary modifications to business rules, requirements, and design identified and incorporated over the next year, partly in parallel with the system development effort. RCSC system modifications began in late 2009, proceeding through completion and testing through January 2011.

3.3. Key Demo Parameters

Prior to commencement of system development activities, it was determined that only two types of video tolling (as referenced in the Task 3.0 report, Attachment C) would be included in the demonstration, as follows:

- **VT** – The previously-defined Option 2 or REG/PRE/CC: A pre-registered, non-transponder-based customer account with a required credit card. The video toll amounts are charged to the credit card on file each night. This program is also referred to as pay-by-plate (PBP).

- **VT-I** – The previously-defined Option 3, or UNREG/POST: A customer account created by the system, based on a license plate read in the video tolled lane. Transactions added to the account are invoiced on a regular basis to the registered vehicle owner's name and address, as provided by the DMV. Unpaid invoiced transactions are escalated to violations based on time periods specified in BATA's business rules.

3.4. Demonstration Facility

Because the original deliverables focused only on the BATA facilities, this report includes a brief overview of the GGB toll plaza and its operation for general familiarity of the demonstration facility.

The GGB toll plaza includes 11 southbound toll lanes, as shown in Figure 1. During the morning and evening weekday peak commute hours, up to five toll lanes are dedicated as "FasTrak Only" toll lanes. During off-peak weekend hours, a minimum of one "FasTrak Only" lane is available. The "FasTrak Only" toll lanes are always located on the left side of the toll plaza because of safety and operational issues. Dedicated FasTrak toll lanes are distinguished by the overhead message which reads "FasTrak Only" and a large FasTrak logo sign which is posted above that.

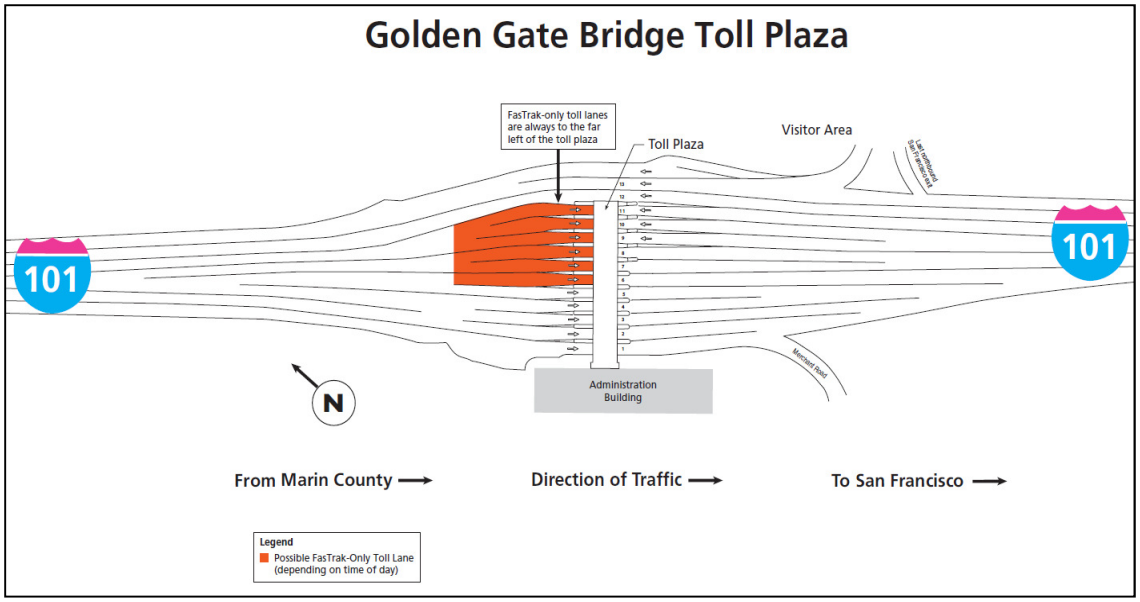

Figure 1: Golden Gate Bridge Toll Plaza

4. Project Implementation

The demonstration project was conducted from February 1 to April 15, 2011. The elements of project implementation are thoroughly described in the implementation plan (Attachment I). The sections below summarize the components that provide the fundamental basis for the evaluation, not including factors already covered elsewhere in this report.

4.1. Participant Requirements and Selection

Approximately 65 people volunteered to participate in the demonstration project. The majority of the participants were GGBHTD personnel, but also included some BATA, TTI, Atkins, and ACS employees. To limit untracked variables, participants were asked to use one vehicle for the demonstration and to comply with specific instructions. They were also divided into specific groups to demonstrate new account scenarios:

- Group 1 – Create a VT account *before* crossing the bridge for the first time in the demonstration period.
- Group 2 – Create a VT account *by the second full calendar day after* crossing the bridge for the first time in the demonstration period.
- Group 3 – Create a VT account *on the third full calendar day after* crossing the bridge for the first time in the demonstration period.
- Group 4 – Create a VT account *between the 7th and 10th full calendar day after* crossing the bridge for the first time in the demonstration period.

- Group 5 – Create a VT account *before* crossing the bridge for the first time in the demonstration period *and* indicate 2/28/2011 as the 'Account Closure Date' upon registration. This group should receive invoices for any tolls incurred after February 28, 2011.
- Group 6 – Take no initial action other than crossing the bridge without stopping at a toll booth throughout the demonstration period. This group will receive invoices from for payment (VT-I).
- Group 7 – Take no initial action other than crossing the bridge without stopping at a toll booth throughout the demonstration period until an invoice is received *and then* convert their VT-I account to a VT account.
- Group 8 – Special scenarios were identified to test atypical situations including:
    - Pre-Register for a VT account with a credit card expiration date within the demonstration period.
    - Create a VT account for rental car.
    - Create two VT-I accounts at the same address but different owner names.
    - Partially pay an invoice.
    - Create a VT account without removing FasTrak account information.
    - Convert a VT account to a FasTrak account.

GGBHTD participants were instructed to use a GGBHTD-issued credit card to maintain their VT accounts and pay their VT-I invoices throughout the demonstration period. All non-GGBHTD participants provided their own method of payment for tolls.

4.2. Video Toll Rate

The rate schedule to be used for the demonstration period included the rate and invoice fee as indicated below:

VT: $6.00 toll VT-I: $6.00 toll + $1 per-invoice fee

4.3. System Preparation

Requirements, design, development, and testing of the RCSC system are substantial components of the demonstration. Understanding the viability of the system requires some basic knowledge of the process used to increase the functionality for video tolling and how it was monitored and analyzed for performance. For this reason, this topic is covered in its own section (Section 5 System Preparation).

4.4. Participant Communications and Coordination

Working with the participants to carry out the demonstration objectively, monitor their activities, and solicit their feedback for evaluation was an involved process during planning and implementation. Information relevant to understanding the findings and recommendations in this report is included in Section 6 Customer Acceptance. More detailed information on preparation and implementation for participant coordination may be found in the full implementation plan (Attachment I).

4.5. RCSC Operations Coordination

The RCSC call center did not directly support the VT Demo participants in order to avoid any unintended impacts to existing FasTrak operations and customers; contact with participants was instead routed to a GGBHTD coordinator. However, customer service representatives were provided with a training memorandum containing summary-level information about the demonstration and instructions on routing any unanticipated calls from demonstration participants.

The existing RCSC Web and interactive voice response (IVR) phone system operated as usual for all regular FasTrak account holders and violators. A separate set of Web pages for use only by demonstration participants was developed and deployed and a demonstration-specific uniform resource locator (URL) and username/password were provided to participants. Again, this partition ensured that customers who were not participating in the demonstration were not affected.

5. System Preparation

Once decisions were finalized regarding which bridge the VT Demo would be deployed on and the general business rules for that implementation, specific business rules used to define what the system will do; requirements on system functionality; and the design, development, and testing of the system took place. Systems-related phases completed during preparation are as follows.

5.1. Business Rules

The initial step necessary for the development of any system is the definition of the business rules to be implemented. Business rules are typically either high-level policy decisions or more detailed operational decisions necessary to define how the business should work once the system modifications are complete. For the demonstration project, there were more than 30 business rules established. Some of these business rules are listed below:

- A customer can register for a VT account before or up to three full calendar days after they cross the bridge for the first time, without any penalty.
- Unlike a FasTrak account, no prepaid deposit or replenishment amount is required for VT or VT-I accounts.
- A single VT account may have up to ten vehicles connected to it. A VT-I account, however, may only have one vehicle connected to it because each account is based on a unique license plate.
- VT statements will be electronic (accessed via Web or sent via email) only, with no associated fee. No paper statements will be provided to a VT account holder.
- VT-I invoices will be mailed on a regular schedule and may include an invoice fee.

5.2. Business and Technical Requirements

Based on the business rules established for the demonstration project, detailed business and technical requirements were defined to ensure that the final system would implement these rules. Requirements are generally a further breakdown of the business rules into the details required for incorporation and tracking of each feature through design, development, testing, and implementation.

The requirements for VT and VT-I were developed and tracked in two documents and each went through several review cycles. Some of these requirements are listed below:

- VT accounts may be established by a customer directly on the Website, by phone, or by walk-in.
- VT accounts will not use transponders so the FasTrak functionality related to requesting, adding, and maintaining transponders on an account will not be enabled for VT accounts.
- The customer may be able to specify an account close date, beyond which no transactions will be posted to the account.
- VT transactions will be billed to the credit card on file on a nightly basis.
- A VT-I account will be automatically created for a unique license plate not already linked to a FasTrak or VT account.
- VT and VT-I transactions will only be allowed for facilities where VT and VT-I functionality has been enabled. Transactions occurring on facilities where VT and VT-I functionality are not enabled will be processed using standard FasTrak and violation processing rules.

As part of the requirements development process, a transaction flow chart was developed as a basis for common understanding and negotiation of processing flow. The overall flow is included as Attachment L.

5.3. Systems Design

Prior to development of system components, ACS developed design documentation for VT, VT-I, and modified Website functionality. Design documentation is important to ensure that system developers have the same understanding of the rules and requirements as the business users. This will avoid misunderstandings and confusion and ensure that development time and effort is not wasted. For example:

- A clear definition of system functionality that should be triggered by user activity (e.g., creation of a VT account) versus functionality performed by the system as part of a behind-the-scenes batch process (e.g., creation of a VT-I account) is needed.
- Mockups showing the planned modifications to customer Web interfaces will allow team members to confirm that the customer process will work as intended before it is developed.

- New functionality, such as the escalation of unpaid VT-I invoice transactions to violations or the conversion of one account type to another, require particularly detailed design.

5.4. Systems Development and Testing

Based on the established business rules, requirements, and systems design documentation described previously, ACS modified the existing back office system. During this process, changes were made to associated requirements and system design documentation as directed prior to or in parallel with revision of system development direction.

Test scripts were developed and after ACS provided validation of functionality through their internal test process, the new functions for video tolling were demonstrated for BATA and GGBHTD staff during client testing. This was done primarily from the customer interface perspective to ensure that user functions worked as defined.

6. Data Analysis and Evaluation

To measure the project objectives, criteria for evaluation were grouped into four categories: traffic operations, RCSC operations, financial performance, customer support, interaction and behavior. All of these categories are covered in this report, but more detailed information can be found in the implementation plan (Attachment I). The following sections review the data and analysis conducted throughout the project to qualify, and quantify when possible, these elements for evaluation.

6.1. System Monitoring and Findings

The system was monitored on a bi-weekly basis from the beginning of the demonstration (February 1) to two weeks after the demonstration concluded (April 15) using system-generated reports. The post-demonstration reports allowed the system to complete all processing of transactions received within the demonstration period. These contained information that reflected the demonstration activities at the transaction level and were used to evaluate system performance.

The demonstration included 65 participants with one license plate each, except for one participant who had two license plates assigned to test a special scenario. Therefore, a total of 66 plates were included in the demonstration. In section 4.1, the participant groups are described, and Table 1 below shows by group that a total of 34 VT accounts and 36 VT-I accounts were successfully opened, 91 invoices were sent, four accounts were converted from VT-I to VT, and two accounts were converted from VT to FT during the demonstration period.

Table 1: Total Demonstration VT and VT-I Account Statistics

Group	Number of Plates	Crossed Bridge	VT Accts	VT-I Accts	Invoices Sent	Conversion	
						VT-I to VT	VT to FT
Group 1	11	10	8	3	8		
Group 2	7	6	6				
Group 3	6	4	4	1	1		1
Group 4	6	6	5	6	8		
Group 5	6	6	5	5	10		
Group 6	15	11		11	31		
Group 7	9	7	2	7	24	2	
Group 8	6	6	4	3	9	2	1
Total	66	56	34	36	91	6	

6.1.1. Transaction Processing

The summarized VT and VT-I transaction processing times can be found in Tables 2 and 3 below, and the individual statistics by participant can be found as Attachment M. Table 2 shows the average transaction processing times for VT and VT-I transactions, and Table 3 shows average processing times for violations.

Note that during the demonstration project optical character recognition (OCR) was suspended on the GGB from February 9 to March 15 due to testing unrelated to the demonstration. Because of this, two processing transactions are shown for VT in Table 1—OCR and Non-OCR. The difference in processing time with and without OCR was about three days and seven days on average, respectively. Nonetheless, it was noted that some transactions were processed within two days and others took as long as 12 days to get processed.

Total processing time begins from the day the participant crossed the bridge to the day each toll transaction was posted to the VT account or to the day that payment was posted to the customer's account. During the demonstration, this VT process took six days on average. The VT-I portion of the table shows that it also took about six days for a VT-I account to be created in the system, but it took an additional 15 days for the first invoice to be generated for a total of 21 days, on average.

Table 2: VT and VT-I Transaction Processing Times

VT				
Average Days – Transaction to Payment			Days	
Total Processing Time	OCR Processing Time *	Non-OCR Processing Time	Min Processing Time	Max Processing Time
6	3	7	2	12

VT-I					
Average Days					
1st Transaction to VTI Creation	VTI Creation to 1st Invoice	1st Transaction to 1st Invoice	VTI Transaction Conversion (Posted to VT or FT Account)	Invoice to Payment Post Time	Total Processing Time
6	15	21	15	11	30

*OCR was suspended for the GGB operation in February and went back online on March 15.

The fourth column (VTI Transaction Conversion [Posted to VT or FT Account]) in the VT-I portion of the table reflects the average time for a transaction that was originally invoiced to be posted to a VT or FT account. This is measured from the invoice generation to VT or FT account creation or conversion and subsequent posting of the transaction to the new account. This occurred when the customer either converted their VT-I account to VT or FT or when they opened a new VT or FT account and the VT-I transactions were swept to the new account. This statistic is not a strict measure of system performance as it includes customer activity that would naturally vary. However, it is included to illustrate that account conversion processing timeframes were longer than anticipated, despite relatively quick initiation by most demonstration participants.

Similarly the fifth column (Invoice to Payment Post Time) is not a strict measure of system performance. This statistic includes the printing and mailing of the invoice by the mail house, the delivery of the invoice by the United States Postal Service (USPS), and the customer's payment of the invoice. The mail house used for the demonstration was located out of state, and postal delivery times were likely longer than they would have been with the in-state mail house that is currently used for violation mailings. Also, mail house printing and mailing performance measures may not have been the same as the current mail house and may not have been strictly enforced due to the "pilot" nature of the demonstration. Additionally, customer payment timeframes will vary in either a demonstration or full-production environment.

The average total processing time for all VT-I transactions is reflected in the last column (Total Processing Time). This includes the time from the participant's trip across the bridge when the transaction is created to closure of that transaction through payment, account conversion, and/or posting. As with the previous two columns, this data was included as an illustration of the timeframes for demonstration activity.

Table 3: Violation Processing Times

Violation	
Transaction to Violation Time	**Invoice to Violation Time**
Average Days	
34	17

As shown in Table 3, the average time for transactions generated by a participant that escalated to violations due to a non-payment was 34 days. These were primarily VT-I transactions associated with invoices that were generated and mailed but never paid by the participant. Although scenarios were not planned for a participant to receive a violation, this was anticipated, and the associated statistics were tracked to demonstrate that the system worked properly, which it did. Table 3 also shows that invoiced transactions that went unpaid escalated to violations within 17 days from the invoice generation date.

6.1.2. Analysis Results

Overall, system processing times that were measurable without or despite factors external to the demonstration (e.g., customer action, mail house times, etc.) were consistent. This would include durations for account creation, invoice generation times, escalation to violation, and others mentioned previously. Some durations for processing were slightly longer than anticipated prior to the demonstration, but this was primarily due to physical data handling and exchange times. For example, GGBHTD manually releases violations to the RCSC system for processing generally one to three days after the transaction occurred.

System processing times were based on configurable parameters including a three-day grace period before a VT-I account is created, 15 days from the first account creation to the first invoice, 15 days from invoice mail date to invoice due date, and 15 days from invoice mail date to unpaid invoice escalation to violation. Some timeframes were abbreviated to allow enough processing time within the demonstration period and would be adjusted for full implementation, but the unanticipated days added by data handling, invoice delivery, etc. need to be factored in. In addition, days must be adjusted to ensure that unpaid invoice transactions are not escalated to violations on or before (or maybe even the day after) the invoice due date.

Conversion of VT-I accounts to VT and FasTrak accounts was successfully performed, but timeframes were longer than originally anticipated and transaction handling was not as efficient as it could be. This appears to be due to system handling of VT-I transactions, which were not considered available for transition to the new account until they posted on a generated VT-I invoice. This conversion process needs to be examined, designed, and revised prior to full deployment.

The advantage of OCR processing is clear in the timeframes—anywhere from five to ten days was saved per transaction. This allows for quicker processing and posting of VT transactions and quicker establishment of system-generated VT-I accounts. Ensuring that image capture and

processing components on all bridges are working effectively will support more efficient processing.

6.2. Participant Issue Tracking

Participants were asked to provide information about the difficulties they experienced during the registration process and throughout the demonstration project. This feedback was captured in the participant issue tracking log (Attachment N) to track, investigate, and analyze the system issues experienced by participants.

A disposition was assigned to each of the participants' issues to categorize them for evaluation and to identify items that need to be resolved prior to full implementation. The definitions of all of the types of dispositions and the completed log are included as Attachment N.

The most common disposition assigned to issues was "user/ops." This means the problem is remedied by customer communication and education or a slight change to the operations approach. For example, some of these issues included customer uncertainties about dates of when invoices were going to be received or when VT transactions were going to be shown in their online account. The second most common disposition was "low level system" meaning it required a minor change to Web copy, mapping, etc. For example, error messages received by participants were not clearly worded and caused confusion. While this problem must be resolved prior to full implementation, it does not require a substantial system development effort. However, some other issues will require additional system development efforts by ACS and the specific functionality must be considered further. These are referred to as "system gaps", meaning there is a gap between the system that was developed for the demonstration and the system that should be developed for full deployment.

6.3. Traffic Operations

To provide a more comprehensive review of the effect of video tolling on traffic operations, GGBHTD and BATA data were integrated with research on different tolling approaches in use on toll agencies throughout the United States. This research shows that non-stop toll collection increases the capacity of a conventional toll lane by a factor of two when comparing it with an automatic vehicle identification (AVI) lane dedicated for electronic tolling such as FasTrak or video tolling lanes and a factor of three when comparing it with an express lane such as open-road tolling (ORT) or barrier free lanes. Consequently, the toll plaza would be able to accommodate the increasing traffic without having to add additional lanes. Below are the average numbers of transactions per hour per type of lane based on national averages, except for dedicated AVI which is based on measured traffic on BATA facilities:

- Manned toll booth – 350 vehicles/hour
- Mixed AVI (manned and ETC) – 700 vehicles/hour
- Dedicated AVI (ETC/FasTrak only) – 1,350 vehicles/hour
- Express AVI (ORT) – 1,800 vehicles/hour

To measure the relevant impacts of video tolling on throughput at the GGB, or any BATA facility, a few thousand participants would be needed to generate enough transactions to identify any change to traffic patterns. Although the scale of the demonstration did not generate enough transactions for that purpose, the use of electronic toll options over cash collection has been widely recognized to reduce congestion at toll plazas and increase throughput. At a high level, basic logic compares the time necessary to complete a cash transaction to the time it takes for an electronic transaction to be generated by the system. This and other methods that support reduction in congestion and improved travel time are analyzed below.

6.3.1. Transaction Handling Rate

In order to provide a basis for comparing the typical cash transaction processing time to the nearly instantaneous processing time of a VT or VT-I transaction, it was important to measure cash transaction processing times in the lanes.

For that purpose, cash handling rate data was collected on Thursday, January 20, 2011, during the morning peak hour (8:00 am); Saturday, January 22, 2011, during the afternoon peak hour (5:00 pm); and on Tuesday, January 25, 2011, during the afternoon peak hour (5:00 pm). Those dates were chosen in order to capture weekday and weekend peak rates and to coincide with the travel-time data that was collected (see Section 6.3.5). The cash handling data was collected for periods of 30 minutes each day for a single toll booth lane, which captured the transactions of a total of 220 vehicles. The cash handling rate was measured from the time the motorist stopped to pay to the time the vehicle began to drive away.

Figure 2 shows that 95 percent of the vehicles were served in 20 seconds or less and the other 5 percent was served between 21 and 63 seconds. It takes on average between 21 to 25 seconds to process the cash transaction of a motorcycle, and all motorcycle drivers that have a FasTrak account stopped at the toll booth to make sure their transponder was being read making the electronic toll collection (ETC) transaction for a motorcycle longer than an ETC transaction for a car.

The data collected shows that it takes on average seven seconds to process a cash transaction, as compared to one second or less to process an ETC transaction. Again, this does not include the time for deceleration upon approach and acceleration during departure.

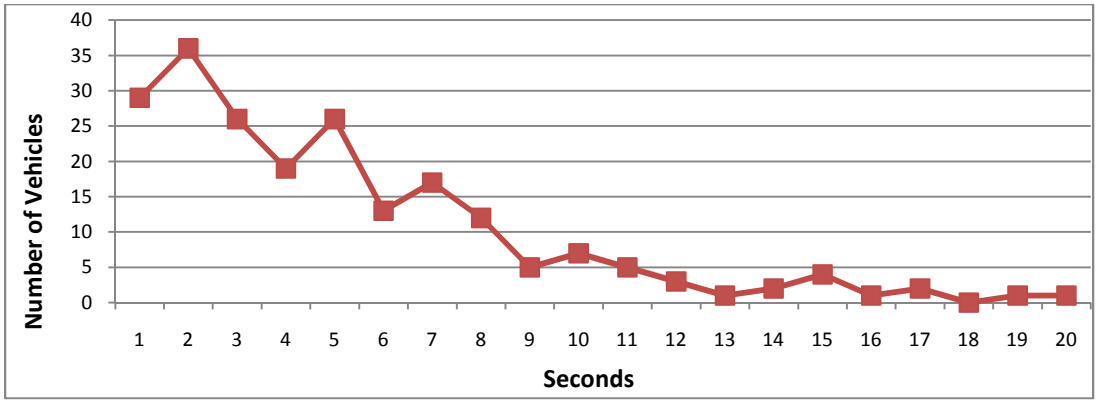

Figure 2: Cash Handling Rate for the 95th Percentile

In terms of evaluating the transaction handling rate for video tolling, a VT or VT-I transaction is equal to an ETC (FasTrak) transaction as vehicles do not have to stop in the lane and can travel through the plaza at the same speed that FasTrak customers currently travel. Hence, processing a video tolling transaction in lane and per the customers' perspective will only take one second or less leading to a six second time savings per transaction per car.

6.3.2. Transaction Type Switch

Other toll agencies have found that providing additional payment options to customers will result in a move from cash transactions to electronic transactions, resulting in a decrease in the percentage of cash transactions.

One such illustration can be found on the Loop 1 North toll facility in Austin, Texas (operated by the Texas Department of Transportation). This is a 3-mile long facility with one mainline toll plaza which accepts electronic transponder payments, video tolling, and cash. All collection methods were implemented at the same time upon opening in October 2006. According to the Department's published Central Texas Turnpike Fiscal Year-to-Date Transaction Reports, Loop 1 cash transactions have decreased by nearly half (from 15 percent to 8 percent of total traffic) in the last two years as shown in Table 4. The majority of the cash transactions have shifted to the VT program, but with an overall increase in traffic volumes the ETC penetration has also increased.

Table 4: Texas Loop 1 North Transactions by Type (Comparison 2008 – 2010)

Year	Fiscal Period	% of Total Transactions*		
		ETC	VT	Cash
2008	1st Quarter	75%	10%	15%
2010	1st Quarter	77%	15%	8%

** These figures have been rounded to whole numbers.*

Frequent commuters are the main reason ETC penetration rates remain high on certain facilities. During a recent frequency study conducted by GGBHTD, it was noted that

approximately 65 percent of their customers use FasTrak and 10 percent of the cash customers are *frequent* drivers who cross the bridge at least four times per month. The study also shows that 80 to 85 percent of their customers use their FasTrak account during rush hour.

It is anticipated that the FasTrak penetration levels will remain steady in the event of full video tolling implementation. Participants who are existing FasTrak customers are extremely unlikely to change to a new tolling program. Based on other toll conversions, it appears that cash customer are likely to migrate toward a video tolling program and then potentially convert to a transponder-based program if there are benefits such as discounted tolls.

6.3.3. Toll Booth/Lane Capacity in FasTrak Lanes

In order to determine whether the existing FasTrak lanes on the GGB can accommodate an increase in traffic from cash vehicles converting to video tolling, it is necessary to estimate the current lane capacity in the FasTrak lanes. Based on 2010 vehicle demand data on the GGB and using the national standard of 1,350 vehicle per hour (vph) (the maximum capacity per dedicated FasTrak lane), it was determined that only about 66 percent of the total peak hour capacity on the GGB is being utilized and, therefore, there is an unused capacity of about 34 percent or about 460 vehicles per lane during the peak hour. This means there is sufficient excess capacity in the FasTrak lanes to accommodate any significant increases in traffic volumes from video tolling vehicles. With the introduction of video tolling, overall plaza capacity could be improved by converting more mixed lanes to FasTrak, VT, or VT-I only lanes.

6.3.4. Vehicle Throughput in Cash Lanes

In order to better understand the cash demand on the GGB, 2010 data was obtained and is shown in Table 5. Table 5 shows that on average 18 percent of the total number of transactions during a weekday morning peak time period are cash transactions versus 45 percent during weekend afternoon peak. Based on the information for weekdays, cash lanes are processing approximately 22 percent of the transactions processed in an ETC lane during the same periods.

Table 5: 2010 GGB Highest Vehicle Demand

Data Collection Period			Cash		ETC		Violation		Total
			Txns	% of Total	Txns	% of Total	Txns	% of Total	
Weekday	23-Mar	8am	1,145	18%	5,115	81%	84	1%	6,344
	8-Mar	8am	1,121	18%	4,920	80%	84	1%	6,125
	4-Feb	8am	1,109	18%	4,889	80%	85	1%	6,083
	17-Mar	8am	1,142	19%	4,835	80%	81	1%	6,058
	24-Feb	8am	1,106	18%	4,870	80%	81	1%	6,057
	Averages:			**18%**		**80%**		**1%**	
Weekend	24-Apr	5pm	2,031	44%	2,498	54%	125	3%	4,654
	24-Apr	6pm	1,986	43%	2,502	54%	120	3%	4,608
	25-Apr	5pm	2,017	45%	2,337	52%	109	2%	4,463
	14-Feb	5pm	2,179	49%	2,146	48%	101	2%	4,426
	10-Apr	5pm	1,915	43%	2,389	54%	120	3%	4,424
	Averages:			**45%**		**53%**		**3%**	

With vehicle demand data, assumptions can be used to determine the impact of transactions shifting from cash to video tolling to calculate the impact on throughput. For example, if we were to assume that 50 percent of the current weekday cash customers (or about 9 percent of the overall weekday traffic) switch to VT or VT-I and current ETC and violation percentages remain stable, an approximate 562 vehicles per weekday could move to the dedicated FasTrak lanes. Based on the earlier estimated transaction handling time savings, this move could result in a six second savings per vehicle or a total time savings of approximately 56 minutes per weekday peak hour.

It is unlikely that the weekend traffic would reflect the same level of transaction shifts away from cash, since it includes less workday commuters and more tourist traffic. However, if for example 20 percent of the weekend cash traffic moved to VT or VT-I the resultant savings could average 40 minutes per weekend day peak hour.

While the time savings estimated above are based on broad assumptions, both indicate that traffic could be moved more quickly through the toll plaza by deploying VT and/or VT-I. The resulting reduction in the bottleneck created when plaza lanes reach maximum capacity would then be expected to reduce traffic delays upstream.

6.3.5. Travel Time

If the above estimates could be applied to actual travel times and associated traffic delays, it might be possible to illustrate the possible impact of video tolling on traffic congestion. To that end, GGB travel time and delay data was collected by Cambridge Systematics.

The data was collected during the following timeframes:

- Thursday, January 20, 2011: 7-11 am and 3-7 pm, cash and FT
- Tuesday, January 25, 2011: 7-11 am and 3-7 pm, cash and FT
- Saturday, January 22, 2011: 3-7 pm, cash and FT
- Saturday, January 29, 2011: 3-7 pm, cash and FT

The delay data was collected using global positioning units (GPS) units. The units measured travel time and speed from the north end of the Waldo Tunnel to the GGB toll plaza which is approximately 2.9 miles. The majority of that distance in the southbound tolled direction is three or four lanes upstream of the toll plaza widening out to as many as 11 lanes through the toll plaza location and then converging back into three lanes downstream of the plaza.

Figure 3: Map of Waldo Tunnel and GGB Toll Plaza

The summarized results of the travel time study can be found in Table 6 below.

Table 6: Weekday and Weekend Peak period Travel Time Delays (In Minutes)

	Cash		FasTrak	
	Travel Time	**Delay**	**Travel Time**	**Delay**
Weekday - AM				
Average	3.9	1.0	3.8	0.9
Highest Value	4.4	1.5	5.3	2.4
Lowest Value	3.4	0.5	3.3	0.4
Weekday - PM				
Average	4.3	1.4	4.3	1.4
Highest Value	12.0	9.1	14.9	11.8
Lowest Value	3.5	0.6	3.4	0.5
Weekend - PM				
Average	7.3	4.4	6.3	3.4
Highest Value	18.1	15.2	19.1	16.2
Lowest Value	3.2	0.3	3.4	0.5

In general, average FasTrak times are slightly faster than cash times. A review of individual occurrences and key peak times however, does reflect times when the FasTrak lanes are slower than the cash lanes. This may be due to the overall configuration of the lanes crossing the bridge, and the following must be considered:

- On the north end of the route, from the Waldo Tunnel south to the north end of the bridge, are four lanes in the southbound direction. This may create a slight bottleneck at the north end of the bridge.
- Only a small segment of the bridge length is the actual toll plaza. The rest of the bridge is only three lanes wide, both upstream and downstream of the plaza.
- In addition, the speed limits through the toll plaza are considerably slower at 5 to 15 mph than the rest of the bridge which is 45 mph.
- If the cash lanes back up significantly, the backlogged traffic may be in the three lanes approaching the plaza in which case the FasTrak lanes would also be blocked.

These factors, taken in combination, may explain the lack of a time advantage for the dedicated FasTrak lanes in the periods analyzed. Shifting traffic from the cash lanes to VT or VT-I could reduce cash-lane backups in the approach to the plaza, also potentially reducing associated blockage of the FasTrak lane approach. Without traffic data specific to the plaza area at these same times however, it is not possible to estimate the impacts. Regardless, it still stands to reason that video tolling would result in higher throughput reducing backups and their associated travel delays.

6.3.6. Safety Analysis

Maintaining a safe roadway is a priority. An accident evaluation for any location is best described by its crash rate, as it takes into account exposure and crash data. The crash rate is the combination of crash frequency and vehicle exposure (traffic volume). Since the safety aspect of video tolling is being evaluated in this report, a *spot crash rate* method was used. A spot location is generally defined as a location of 0.3 miles or less in length; therefore, the toll plaza and its influence area can be treated as a spot location.

The 2010 *Annual Vehicle Accident Report* provided by the GGB sergeant was examined to consider only the crashes in the toll plaza influence area and crashes that occurred in the southbound direction since only the southbound direction is tolled. In 12 months, there were 11 incidents where a total of 22 cars were involved and two people were injured. More than half of the incidents were rear-end crashes and the remainder were caused by the driver colliding with a traffic barrier, curb, or sign.

The crash rate for the GGB toll plaza was calculated to be 0.57 per million entering vehicles. A high-crash rate is defined either as being above 1.0 or well above a comparable facility. In the case of GGB for example, the crash rate for the Carquinez Bridge may be used for comparison. The Carquinez Bridge crash rate is 0.77, so by either means of assessment the GGB crash rate cannot be considered high. Nevertheless, all crashes involve an economic impact and some even result in injuries. Video tolling may aid in the reduction of some types of accidents by increasing through traffic in the dedicated FasTrak lanes and reducing the weave, merge, and stop-and-go patterns associated with cash lanes.

In reviewing data from other toll agencies, video tolling has proven to reduce the number of toll plaza rear-end crashes since customers do not have to stop at the toll booth and sideswipe crashes since customers do not have to change lanes to get in the cash or FasTrak lanes at the last minute. In the last few years, multiple studies have shown that conversion to electronic tolling and ORT dramatically increase safety around toll plazas. For example, when Florida's Turnpike Enterprise began removing cash collection from many of its toll lanes, they experienced an average crash reduction of 62 percent. In terms of hard data, at the most crash-prone plaza vehicle collisions were reduced from 52 to 13 over an 11-month period.

6.3.7. Air Quality Analysis

The Environmental Protection Agency (EPA) has been working with the transportation industry to reduce on-road motor vehicle emissions which account for 45 percent of the air pollutants in the United States. Video tolling reduces the number of vehicles that have to decelerate, accelerate, or idle at the toll plaza approach which directly reduces harmful vehicular emissions.

Although an acknowledged benefit of electronic tolling, an extensive amount of data must be to be collected before and after conversion to quantify improvements which was not done for the VT Demo project. However, a study of the New Jersey Turnpike Authority's E-ZPass in 2000 showed a reduction in emissions of volatile organic compounds (VOCs)—a key component of smog—by 0.35 tons per day. This reduction is attributed to an 85 percent decrease in toll plaza delay due to electronic toll collection. And in 2009, the Central Texas Regional Mobility Authority conducted a vehicle emissions study that compared parallel facilities US 183 and US 183A toll road. In addition to a 26 percent reduction in fuel consumption, the study found that US 183A toll road annual reductions of emissions in the following quantities:

- Carbon Dioxide (CO2) emissions reduced by 28 percent (7,231.9 tons/yr)
- Carbon Monoxide (CO) emissions reduced by 47 percent (21.8 tons/yr)
- Nitrogen Oxides (NOx) reduced by 56 percent
- Total Hydrocarbon (THC) emissions reduced by 37 percent

Air quality was more recently linked to the health of infants living near an E-ZPass toll plaza. In the study *Traffic Congestion and Infant Health: Evidence from E-ZPass* (October 2009; Currie, Walker) by Columbia University's Department of Economics, reduced congestion was correlated with a 10.8 percent drop in premature births and an 11.8 percent decline in low birth weight for mothers living within 1.25 miles of the plaza. In the Bay Area, approximately 28,000 people live within 1.25 miles of a toll plaza, most of which are near the Carquinez Bridge.

Any implementation of toll collection that reduces the toll plaza queue is expected to yield similar benefits in air quality including conversion of cash lanes to video tolling.

6.4. Customer Acceptance

6.4.1. Methodology

Demonstration participant requirements, selection, coordination, and communications were developed to monitor and evaluate the customer experience and understanding of the video tolling programs. The methodology and description of communication activities, as well as the approach to receiving feedback are documented in detail in the implementation plan (Attachment I).

In general, participant feedback activities included:

- Bi-weekly online surveys.
- Final participant survey.

At the end of each month, bi-weekly online surveys were compiled and analyzed. When possible and relevant, responses were calculated into statistics that allowed the project team to monitor the activities of the participants. For example, figures were derived each month for the number of participants who received an invoice and paid their invoice online using a credit card. Other data within the bi-weekly survey was provided in freeform text fields, allowing participants to explain problems and make suggestions. In this case, the data was reviewed and considered to develop recommendations in the context of future implementation.

A final participant survey (Attachment O) was conducted at the end of the demonstration period to provide a mechanism to capture thoughts on future implementation, gain perspective on preferences, and identify areas for future improvements. The results of the final survey are discussed below.

6.4.2. Final Participant Survey Findings

The final survey conducted at the end of the demonstration provides the most pertinent information for future implementation, as it translates participant feedback into a projection of customer acceptance.

The survey was comprised of ten questions. The first series asked participants to choose which toll payment options (FasTrak, VT, or VT-I) they would most likely use if cash were not an option and then offer reasons for their selection including the perceived advantages and disadvantages. Then the survey asked for explanations of why the other options were less desirable to them and for their preferences or suggested changes for each option. The feedback has been consolidated by payment option below.

Note that nearly all participants expressed a preference of not having to stop at a booth, and the most commonly cited benefit of video tolling during the demonstration was the perception of saving time. Despite the healthy mix of preferences, all respondents cited ease-of-use and convenience as the reason for their stated selection.

6.4.2.1. FasTrak

Nearly half of respondents (47 percent) preferred to maintain a FasTrak account, while the other half preferred a video tolling program. The most common reasons cited by participants for opting for FasTrak were:

- Convenience.
- Interoperability for all bridges in the Bay Area.
- Automation of tolls being deducted from a prepaid balance.
- Credit card replenishment.
- Low maintenance for account.
- GGB discount (FasTrak® toll is $5, VT toll is $6, and VT-I toll is $6 plus a $1 invoice fee).

However, there were some drawbacks recognized with the requirements to be a FasTrak customer:

- Prepaid balance.
- Credit card information on file.
- Detailed setup process.
- Ongoing account updates.
- Deposit for transponder.

These appear acceptable for a program that is more convenient the majority of the time, but there was also a perception that technical problems with the transponders lead to erroneous charges.

Existing FasTrak users also noted that as a current customer, they were already signed up for one account to handle their transactions and they were comfortable with the technology and a credit card being held on the account. Most of the reasons FasTrak customers did not prefer either of the two video tolling options were the converse of the benefits (lack of interoperability, not as convenient, more bills or payments to manage, and no discounts available). Additional disadvantages of VT and VT-I were provided and are included in the sections below on each respective program.

6.4.2.2. VT-I (Invoices)

Other survey respondents preferred VT-I (29 percent) over VT (24 percent) by a narrow margin. For those who preferred the VT-I program, the primary reasons are listed below:

- No credit card required.
- Pre-registration of an account not required.
- No transponder required.
- Offers option for occasional users.
- If no cash option is available, provides convenient option for drivers who may not have a credit card (because they could pay an invoice using a check or money order).

For those who did not prefer the VT-I program, the primary reasons are listed below:

- Lack of interoperability with all Bay Area bridges.
- Concerns about license plates being accurately captured, obtaining good information for the invoice, and a timely mail process.
- Cost for an agency to physically mail paper invoices.
- Potential surcharges added to invoices.
- No discounts for tolls.
- Ongoing account updates.
- Paper billing and no automation; time-consuming account management and payments.
- Invoice mailed for one transaction perceived as unreasonable.
- Concerns about an agency not getting paid on time or at all.

The concern over an agency not collecting tolls reflects a concern about fairness to customers who are compliant in paying their tolls. Similarly, some comments questioned the methods of enforcement and others were curious about how rental cars would be handled.

Nearly all respondents who participated as a VT-I customer during the demonstration understood the invoice they received and how the program worked, but suggestions were made about making the payment process easier to understand and making it easier to pay online. More than half of the respondents opted to pay online rather than mailing a check, which increases the importance of streamlining online payments for customers and operational efficiency.

6.4.2.3. VT (PBP)

Respondents who preferred the PBP video tolling program stated the following reasons for their selection:

- No transponder required.
- Minimal account maintenance (automated payment).
- No deposit required.
- Less paperwork than VT-I.
- Good option for occasional users.
- Convenient to manage multiple vehicles on one account.

Those who preferred PBP had few concerns, but among them were:

- Lack of interoperability.
- Credit card required and retained on file.
- Not enough transparency of payments being charged.

Transparency of payments was a commonly noted concern. Many thought the credit card statement would be the only record of toll payments and they would only know how much they paid after incurring the charge.

More than half of the respondents said that if they used PBP they would register for their account before crossing the bridge, but most like the convenience of being able to set up an account afterwards because it offered flexibility.

7. Recommendations and Considerations

Based on findings throughout the project, evaluation of the demonstration, and research conducted to validate feasibility of video tolling, the following sections identify recommendations and considerations that are critical should BATA or GGBHTD move forward with a full deployment of video tolling.

7.1. System Gaps and Improvements

During the system development phase and throughout the demonstration, information on system functionality that was not included as part of the demonstration project but would be required for future implementation was captured in a system gap list (Attachment P). The system gap list is comprised of more than 30 items that were not required or were not in the scope for the demonstration. For example, customer notification letters for VT credit card expiration and VT or VT-I account closure were not developed in the RCSC system for the demonstration, but this will have to be done for full implementation. As another example, the IVR system was not modified for the demonstration project to handle VT or VT-I calls from participants; however, it will need to be modified for full implementation.

In addition to the testing that would be conducted as part of any system deployment, it is recommended that user acceptance testing (UAT) is conducted for customer online interfaces (i.e., Website). Customer self-service is a common objective because it is not only operationally efficient and cost effective, but customers express a preference for being able to manage their activities online. UAT allows optimal performance of a Website to meet the customers' needs intuitively and quickly, thereby reducing points of contact through phone, email, correspondence, etc. Below are some more specific areas for which improvement and usability testing is necessary to meet this objective.

7.1.1. Account Registration

Groups of participants were selected to register online for VT accounts before or after they crossed the bridge for the first time during the demonstration period. During the registration process, a few participants received internal error messages that were not clear. In other cases, if a person took too long to enter their information, the Website would timeout and then required them to start the process over. Other comments reflected a lack of clear guidance for the steps and information involved in the registration process.

It is recommended that the registration process be reviewed and modified to include more customer-friendly guidance. A simple step-by-step set of instructions and intuitive Website navigation should both be employed. The Website should clearly identify what information the

customer will need to have before starting the registration process and also inform them of the amount of time they will have to complete the registration process before the Website times out.

The recommendation can be implemented by adding instructional and informational content, conducting usability tests, and modifying system parameters to be more customer-focused (e.g., extending the amount of time allowed for online registration before the Website times out).

7.1.2. Online Account Management and Payments

Participants were instructed to access Web pages that were specifically developed for the demonstration project. These special Web pages were used to register, convert, manage, and monitor their accounts and to make invoice payments. Based on participant feedback about their experience with the Web interface, the following recommendations are made:

- Improve Web navigation (employ usability testing if possible).
- Display transactions in a way to clearly indicate if they have been paid and by which method (credit, check, etc.).
- Include an explanation for when the credit card will be charged on the same Web page that prompts the card data to be entered.
- Ensure credit card security measures are conveyed to customers using the Website.
- Streamline and speed up the online payment process; simplify instructions.

These recommendations will improve the customer experience and increase satisfaction of customer self-service. Online account management is the most efficient method for customers to help themselves at their convenience so ease of Website navigation and understanding of instructional content for usability is critical. In turn, a streamlined experience will reduce calls to the service center and increase customer acceptance of the payment method that is most beneficial to the agency.

7.2. Program Development

Throughout the United States, video tolling has successfully been implemented as an additional collection method or as a replacement for cash collection. One of the most critical success factors for these projects is the program being developed to fit the customers and the facility. Video tolling programs offer benefits to the customer and the agency, but also present many new challenges. A methodical and informed development process ensures that the most important objectives (usually satisfied customers and protection of revenue) are met. Much of the fundamental information needed to develop video tolling was captured during the demonstration.

Based on demonstration feedback, participants expressed positive and negative qualities of the VT and VT-I programs, as well as FasTrak (see Section 6.4.2). It is recommended that this information be used to further develop, promote, and communicate programs as this will efficiently match customer types with preferred programs, but also help BATA set benchmarks and expectations for video tolling adoption. Specifically, the following considerations should be made:

7.2.1. FasTrak Program Considerations

Projects that have successfully implemented video tolling typically have a high penetration rate of customers who already use electronic tolling. This is because transponder-based tolling is usually the most cost efficient for the frequent customer and the agency. It is unlikely that the existing FasTrak customer volume will decrease, but it is recommended that the promotion of FasTrak continues to counteract natural attrition.

Preferences and characteristics of the FasTrak customer that should be targeted are:

- Interoperable payment method for all bridges.
- Minimal effort needed for account maintenance (automatic credit card replenishment).
- Discounted tolls; no surcharges/fees.
- Frequent users (commuters).

7.2.2. VT Program Considerations

Customers who adopt VT as their preferred toll program may be less frequent users, but not necessarily. As shown by the following qualities of VT accounts that are perceived as beneficial, these customers may find a VT account less involved than FasTrak or VT-I:

- Minimal effort needed for account maintenance (automatic credit card payment).
- Pay-as-you-go method is more attractive than a large prepaid balance.
- No need for a device, a deposit, or paperwork.
- Easy registration process.

It is recommended that development of VT focuses on these traits and that they are incorporated into any messaging or communications.

7.2.3. VT-I Program Considerations

Customers most likely to use the VT-I program have the following preferences and characteristics:

- Unlikely to have a credit card or uncomfortable keeping a credit card on file; may prefer cash option.
- Occasional/infrequent user.
- No device or deposit is strongly preferred.
- No account registration/prepayment seen as a benefit.

Participants were selected to receive invoices for crossing the bridge without stopping to pay, without their transponder, and without registering a VT account. Other than the information on the invoice and having the demonstration credit card information, there was no special instruction provided for payment being made. Considering this, the following recommendations are made based on the demonstration feedback:

- Allow sufficient time for customers to receive and pay their invoice before the due date.
- Allow customers to see their transactions online at anytime (even before they get posted to an invoice).
- Improve the quality of the image printed on the invoice to reduce potential for disputes.
- Simplify invoice instructions on how to make a payment.
- Provide clear language about the steps of escalation due to nonpayment including costs and timeframes.

It is further recommended that revised versions of invoices and other customer correspondence (e.g. letter notification about credit card expiration or account closure) be tested in sample user groups prior to deployment.

7.2.4. Considerations for Cash Accessibility

Many agencies struggle with meeting the needs of cash customers once video tolling fully replaces the in-lane cash option. However, several AET systems successfully serve their cash customer by using existing partnership and new technologies. In Florida, small kiosks allow SunPass customers to pay at over 3,000 retail locations.

If implementation of video tolling leads to elimination of cash collection in the lanes, it is highly recommended that cash accessibility be addressed in the early phases of full AET implementation. In addition to expanding the options (places and methods) for customers to physically pay cash, successful practices for understanding and communicating with the cash customer include:

- Assess the volume and demographics for the cash customer base.
- Research (e.g., surveys and focus groups) the customer base to identify specific concerns and needs.
- Begin outreach early and use existing partnerships for information outlets.
- Use the cash lanes to disseminate targeted information and messaging.
- Develop strategies to proactively manage negative perceptions and equity issues.

7.3. Video Tolling Program Communications

For the demonstration, kickoff meetings provided basic information about the video tolling project and how it would test alternate methods of paying tolls. Although this minimal information sharing was intended, the feedback and continuous communication with the participants throughout the testing period demonstrates the importance of customer education on video tolling programs.

It is recommended that a comprehensive communication plan must be developed for successful implementation of video tolling. The plan should detail the core components and nuances of VT and VT-I, and it should put them into the context of existing FasTrak and cash toll collection. As the final participant survey shows, different elements of each toll payment option are seen as benefits or disadvantages based on each type of customer. For example, FasTrak customers

see a credit card on file as an advantage because it minimizes their effort through automation. Others see a credit card on file as a security risk or as a problem because they do not have a card or cannot manage payments being debited without their knowledge (common for cash-based customers). It is recommended that information on customer preferences be used to marry customer types with likely program preferences and then develop supporting communications accordingly.

The communication plan for full implementation should address project objectives; for example, encouraging customers to pay online with a credit card rather than by mail with a check. These objectives should be used to develop the messages and calls to action for customers. With a clear understanding, customer behavior is more consistent and their satisfaction is more likely. General communications, like free and paid media, should be employed to reach a large audience, while the Website and service center literature can serve as an outlet for more detailed and specific information.

Proper roadway signage will be an important component for the successful adoption of VT and VT-I programs in an environment that continues to collect cash. Adequate signage and the appropriate message should be implemented in order to minimize motorist confusion at the toll plazas. Including this component within the plan for communications will ensure consistent messaging on and off the roadway.

7.4. Back Office Operations Support

A large component of success for implementing video tolling will be the operational support. Although this relates to RCSC system functionality, this section is referring to the peripheral systems and vendors and operational processes that are performed by staff on a daily basis to support video tolling programs.

7.4.1. Staff Planning and Training

It is likely that the call center staff at the RCSC are not yet familiar with video tolling, but they are the front line of support for customers. It is recommended that plans be put in place to adequately train staff on program elements and be able to identify and resolve the specific needs of a video tolling customer. In addition to a training plan, additional staff resources should be identified to supplement current levels should call volumes suddenly increase at the time of full deployment.

7.4.2. Mail House Processing

It was noted in section 6.1 that the total time from invoice printing and delivery through customer payment posting varied widely. Several factors are included here, two of which could be better handled during full VT-I implementation.

- First, mail house performance measures related to invoicing must be established and enforced to ensure that the turnaround time for invoicing printing and mailing is consistent. This was not the case during the VT Demo project, since a separate mail

house was used and clear performance measures for invoicing had not been established.

- Second, the use of a mail house within a reasonable proximity of the Bay Area will ensure shorter and more consistent USPS delivery times. This would be in contrast to the VT Demo project mail house, which was located in the northeast and thus resulted in longer mail delivery times.
- The last factor is customer time-to-pay, which naturally will vary. However, invoices must be consistently delivered to VT-I customers with adequate time remaining before invoice expiration.

These variances would negatively impact a VT-I program because they do not ensure that customers receive invoices within a reasonable and predictable timeframe, allowing them to make their invoice payment before the invoice due date.

7.4.3. Vehicle Registration Information

Successful video tolling through the use of invoices is partially dependent on accuracy and availability of vehicle registration information from the DMV. The volumes of information sent through an interface for this data may increase exponentially with a VT-I program in particular, and collection of the toll on the first invoice will rely on the accuracy of the name and address provided for that particular vehicle. Many agencies concentrate address verification efforts on the frontend of the invoice process by checking the National Change of Address (NCOA) database or "skip tracing" (a common investigatory method to locate or confirm a person's whereabouts) *before* the first invoice is mailed to the customer. Doing so reduces operational costs incurred for printing, mailing, and postage plus reprocessing returned mail. For these reasons, the current volumes of undeliverable or returned mail and the accuracy level of DMV data should be assessed and actions should be taken to correct erroneous or out-of-date registration data prior to implementing VT-I.

7.5. Revenue Assurance Plan

As previously mentioned, Task 6 involved a comprehensive analysis of the financial impacts of video tolling implementation. BATA should consider developing a revenue assurance plan, which makes assumptions about program adoption and use (i.e., how many customers will choose FasTrak, VT, or VT-I and at what frequency), set benchmarks for post-implementation figures, and identify areas for improvement prior to implementation to mitigate revenue loss where possible. Thoroughly addressing leakage mitigation is critical to successful revenue assurance. It is recommended that strategies for the following areas are considered for inclusion:

- Perform lane audits to assess performance/accuracy of hardware and software.
- Conduct image processing review including image capture and review as well as OCR accuracy.
- Improve image capture quality to ensure high quality on invoices, which will reduce potential for disputes.

- Validate business rules for revenue-related practices (write-offs, disputes, etc.).
- Measure compliance of back office operating procedures and internal controls.
- Review rental car agreements (or agreements with third-party rent car toll service providers).
- Evaluate out-of-state vehicle registration data gathering.
- Identify necessary legislative changes for recourse of lost revenue (for example, legislation to reduce the use of paper/temporary car dealer plates which result in transactions that cannot be pursued).

7.6. Other Issues for Consideration

In addition to the recommendations described above, specific issues and constraints previously identified in the earlier tasks will need to be addressed for future video tolling projects. These include:

- Legislative recommendations made under Task 2 (Attachment B).
- Facility limitations identified in Task 4 (Attachment D).
- Impacts of the toll accounting system replacement and the violation enforcement system (VES) as described in Task 5 (Attachment E).
- Operational cost models detailed in Task 6 (Attachment F).
- Approach to full video tolling implementation described in Task 7 (Attachment G).

8. Conclusion

Based on the evaluation of the VT Demo project, VT and VT-I are feasible toll payment options. The findings show that the RCSC system functionality is capable and customer adoption is likely. In addition to improving the customer experience with more payment options and faster travel times, throughput can be increased by converting lanes to dedicated video tolling lanes. Collateral benefits of air quality and safety will also be realized by the decrease in traffic queues at the plaza. However, in order to move from a demonstration to full video tolling implementation, VT and VT-I programs must be more thoroughly developed to promote customer acceptance, protect revenue, maintain safe and effective facilities, and ensure operational efficiency.