Optimizing the effectiveness of the 3+ toll policy on State Route 91

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Executive Summary

A balanced relationship must exist between encouraging freeway motorists to participate in rideshare arrangements (a vehicle that carries two or more individuals) and operating a toll facility as effectively as possible. Effective operations of a toll facility include collecting adequate toll revenue to repay the debt incurred to construct the facility, maximizing the flow of traffic using the facility, and ensuring the facility operates in such a way that the tolls collected correspond to the level of use on the facility. Without effective operations, a toll facility runs the risk of being unsuccessful which can cost public agencies, the private sector, and the motoring public time and money.

Through original and secondary research, this paper aims to identify a more effective 3+ toll policy, specifically on the State Route 91 Express Lanes (SR-91 toll facility). Vehicles traveling on the SR-91 toll facility that carry three or more occupants are eligible to enter the facility using the 3+ declaration lane. The current SR-91 toll facility policy allows these vehicles to use the facility toll-free, with the exception of a two hour period each weekday when the toll is half-price. This research paper explores the rate of violation (motorists who uses the lane but do not qualify for the discount) in the 3+ declaration lane. Then, identifies an emerging method for electronic enforcement of vehicle occupancy. And finally, based on the violation rate and the lack of substantial enforcement of the policy, this research paper concludes with two alternate recommendations: for the agency that owns the SR-91 toll facility to consider not offering such a generous 3+ toll policy or to pursue implementing electronic enforcement of the existing 3+ toll policy.

Background

In 2008, California's Governor, Arnold Schwarzenegger, approved Senate Bill (SB) 1316 which gave the Riverside County Transportation Commission (RCTC) authorization to collect tolls on new transportation facilities built on SR-91 within Riverside County. Part of the authorization specified that RCTC could use toll revenues to pay for capital and operating costs related to the toll facilities. In addition, SB 1316 gave RCTC permission to issue bonds in association with building transportation facilities on SR-91 and to use toll revenues to pay for the associated debt service costs[i].

More than a decade before the state approved SB 1316, it gave essentially the same authority to RCTC's westerly neighbor, the Orange County Transportation Authority (OCTA). Because OCTA received tolling authority on SR-91 and built its toll facility[1] prior to RCTC, SB 1316 specifies that the agencies' toll facilities must operate in coordination with one another[ii]. As RCTC began the process of developing its blueprint for its portion of the SR-91 toll facility, when it came to policies and operations, the agency mirrored what OCTA already had in place.

A few important policies OCTA developed and RCTC adopted for its own portion of the toll facility on SR-91 include: congestion management pricing, requiring the use of a transponder, and offering a 3+ toll policy.

Congestion management pricing means the price of the toll varies by time of day (read that: level of congestion) and direction of travel. The current OCTA toll policy allows for tolls

[1] OCTA did not in fact build the Orange County portion of the SR-91 toll facility. To avoid the complicated history of what transpired between 1995 when the facility was built and 2003 when OCTA acquired the franchise rights to the facility, the statement has been over-simplified.

to be adjusted when traffic flow in the toll lanes becomes unstable[iii]. Tolls changed based on this instability can only be changed every six months[iv]. Tolls are posted in advance and are based on past traffic volumes rather than changing dynamically and being based on real-time congestion. By utilizing congestion pricing, the toll operator seeks to encourage more users to travel during less-congested, less-expensive periods to keep the toll facility in a free-flow state. When a motorist observes the cost of driving in the toll lanes before actually entering the toll facility, he or she makes a decision whether or not the cost is worth the guarantee of a faster trip. The toll facility must maintain both a federally mandated level of operational performance[v] and its users' confidence that the facility will get the motorist through the length of the toll facility uninhibited. If a motorist begins to question the reliability of free-flowing traffic in the toll facility, the motorist's confidence in the facility will waver, *potentially* making the motorist less inclined in the future to pay the toll. Therefore, speed, reliability, and maximized level of service on the toll facility are paramount to its success.

OCTA requires users of its toll facility to sign up in advance for an account and to get a transponder to place in the user's vehicle. Essentially, there are two account types: usage-based accounts and a special access account. Usage-based accounts are typically for solo users who select an account based on how often they expect to use the facility. The special access account requires that the user meet one of several criteria. Criteria include: users "who always drive with three or more people in their vehicle, drive a motorcycle, a pure zero-emission vehicle, or have a disabled veteran or disabled person license plate issued by the DMV[vi]." For the purposes of this paper, the type of account a user has is not especially important because the 3+ toll policy applies to all accountholders. The existing 3+ toll policy gives SR-91 toll facility users the ability to use

the toll lanes for free any time except when traveling eastbound between 4:00 and 6:00 p.m., Monday through Friday, at which time the cost is 50% of the posted toll. According to OCTA's SR-91 toll facility website, 91ExpressLanes.com, OCTA adopted the policy that allows three or more occupants in a vehicle to ride free in 2003[vii]. OCTA believes, "this innovative policy encourages carpooling[viii]."

RCTC will offer a similar 3+ toll policy to users of the Riverside portion, not only for continuity with the existing OCTA toll lanes, but also to continue to encourage ridesharing. (The term ridesharing is more universal than carpooling as used by OCTA because ridesharing encompasses vanpooling and buspooling in addition to carpooling.) As RCTC constructs the Riverside portion of the SR-91 toll facility, it is removing the HOV lane. If RCTC were to opt not to offer a 3+ toll policy like OCTA's, existing users of the HOV lane would essentially be penalized by having to use the regular lanes or having to pay the toll.

Problem

While touring the OCTA toll operations facility located between the eastbound and westbound SR-91 toll lanes, a problem was observed by the RCTC Toll Operations Manager. The rate of single occupancy vehicles illegally traveling in the 3+ declaration lane was significant. Thus the question arose: How can RCTC solve the problem of single occupancy vehicles traveling in the SR-91 3+ declaration lane?

First, I will explore why this is a problem. Second, research into toll facilities around the country will be conducted to explore their high occupancy toll (HOT) policies and possible

problems and solutions. Third, original research will be conducted to determine the extent of the problem on the OCTA SR-91 toll facility. Finally, policy revisions will be proposed in an attempt to help OCTA and RCTC optimize their 3+ toll policy.

Why are 3+ toll violations a problem?

One problem created by 3+ toll lane violations is the potential to not collect a significant amount of toll revenue. When a user enters the 3+ declaration lane, the user is committing that he or she has two or more passengers in the vehicle or he or she is qualified based on their special access account[ix]. By traveling in the 3+ declaration lane, the transponder will deduct the toll that is due: $0 or 50% of the posted toll if traveling eastbound between 4:00 and 6:00 p.m. Monday through Friday.

Another problem created by 3+ toll lane violations is the unnecessary demand placed on the toll facility. The concept of a toll facility works because users weigh the cost of the toll versus the travel delay savings. Because vehicles transporting three or more people are likely a small minority of the entirety of vehicles on SR-91, allowing ridesharers to travel on the toll facility at no- or low-cost should not unnecessarily congest the facility. However, single occupancy vehicle users entering the toll facility at no or low-cost under the guise of a ridesharer causes the congestion management pricing model to fail because there is no disincentive for that unqualified user choosing to drive in the 3+ declaration lane. Compounding this problem is the potential for this additional, unpaid-for congestion to force an increase in tolls to paying users. If tolls are raised above a certain threshold, it may discourage some users from paying to use the

facility in the future. This once again results in degraded success of the congestion management pricing model.

Questions:

As a means of trying to develop a more effective 3+ toll policy, a series of research questions should be answered. In order to most effectively organize the questions and the research that is found to answer those questions, each question will be assigned a tag, such as 3A. These tags will be used later in this research paper to associate the research methods with the questions the methods are intended to answer.

1. When a motorist violates the 3+ toll policy, does the system recognize a violation?
    - 1A. If the system recognizes a violation, what is the consequence?
    - 1B. If the system does not recognize a violation, how can policy correct this?
2. Why do motorists violate the 3+ toll policy?
3. What is the estimated rate of 3+ toll violations on the OCTA SR-91 toll facility?
    - 3A. How much revenue is lost through 3+ toll policy violations?
    - 3B. How much capacity is lost through 3+ toll policy violations?

Literature Review

In the United States, there are many types of toll facilities. Among the variety of toll facilities, there are a multitude of toll policies that may include allowing for special access, low-income assistance, limits on vehicle types, and even whether or not pricing is static or dynamic. As pointed out by Gardner, et al.[x], the existing toll lanes on SR-91 in Orange County were the

first HOT lanes in the country. Because of this fact and because the facility is now over 20 years old, much research and analysis have been conducted on the SR-91 toll facility.

However, much of the literature specifically about the SR-91 toll facility focuses particularly on the overall use of the facility, the policies implemented, and the perceived success of the facility as seen in a report by the U.S. Department of Transportation's Federal Highway Administration[xi]. Other HOT lane facilities built throughout the United States have been studied as well (see Halvorson and Buckeye's report on the I-394 MnPASS facility[xii]). As is to be expected, each facility's background and profile differs slightly from the next one, whether it be the average daily traffic on the adjacent route, the requirement to have an account and transponder in order to use the facility, or the policy by which toll rates are set.

Though by and large specific research pertaining to the topic of this research paper was not found, a significant amount of relevant background and policy information was discovered. The literature cited in this section will be used to help inform the research method and analysis for this research paper.

The notion of congestion pricing

Some of the arguments that exist for tolling and congestion pricing may help shed light on how to most effectively reduce improper use of the lanes.

The idea of charging a price for the negative effects of congestion was first argued for by world famous economist, Arthur Cecil Pigou, in his 1920 textbook[xiii]. Since then, many

economists have supported congestion pricing, but it was not until 1995 that the first HOT lane facility in the world was opened on SR-91 in Orange County[xiv]. With the passage of SAFETEA-LU, the federal transportation authorization bill of 2005, the federal government authorized conversion of HOV lanes to HOT lanes[xv]. As stated by Konishi and Mun, "Congestion pricing is the only policy that will make a noticeable difference in peak congestion," though they note that the policy is politically infeasible due to social inequity concerns[xvi]. Konishi and Mun's statement was based on literature produced in 1997. It is evident that their policy concern never came to fruition as "more than a dozen states have successfully implemented HOT lanes" with several other HOT lanes projects currently in development[xvii].

Gardner, et al. point out that HOT lane policies' objectives are two-fold: (1) maximizing throughput of the entire corridor, and (2) keeping the HOT lanes in a free-flow state[xviii]. An example of the former policy is when the SR-91 toll facility was opened, travel delays on the adjacent general purpose lanes were reduced by 75%[xix]. Achieving the latter objective requires that the number of single-occupancy vehicles be regulated which is effectively accomplished by congestion pricing[xx]. Studies indicate that vehicle drivers will choose whether or not to pay the toll based on the total value to be received in exchange, which includes: "the user's value of time, value of reliability and the travel time savings gained from taking the HOT lane[xxi]." The U.S. Department of Transportation's Federal Highway Administration states, "One of the most important selling factors to users is the reliability of traffic conditions in the Express Lanes. Users value the security that they are unlikely to experience congestion in the Lanes and that any traffic incidents will be addressed quickly and cleared[xxii]." It is necessary to periodically adjust tolls to avoid the HOT lanes becoming overly congested as congestion increases on the adjacent

corridor[xxiii]. According to de Palma and Lindsey, "HOT lanes are the smallest-scale existing congestion pricing schemes. Tolls are only paid on part of the capacity of a single road[xxiv]."

De Palma and Lindsey also explain why congestion pricing works: "Congestion pricing has a big advantage over other transportation demand management policies in that it encourages travelers to adjust all aspects of their behavior: number of trips, destination, mode of transport, time of day, route, and so on, as well as their long-run decision on where to live, work and set up business.[xxv]"

Why offer a 3+ toll policy

Konishi and Mun succinctly state that, "HOT policy has an adverse effect in that it discourages carpooling[xxvi]." This statement is particularly relevant to toll facilities that used existing HOV lanes for right of way to create the toll facility, thereby taking away from ridesharers free access to free-flow lanes. To this end, a study done early on in the operation of the SR-91 toll facility indicated that when the toll policy changed and 3+ users were charged half of the posted toll, nearly one-third of 3+ users stopped using the toll facility[xxvii]. Despite this fact, according to the same study, the policy change did not appear to discourage ridesharing which is evidenced by the one-third of 3+ users who left the toll facility and showed up in the adjacent corridor[xxviii]. While it is positive to observe that the toll policy did not appear to influence the existence of rideshare arrangements, the tolling agency may be perceived negatively for not offering an incentive or reward to commuters who, by ridesharing, contribute to positive congestion management.

Yang and Huang offer a different perspective. In their research, they state that commuters will generally choose to drive alone unless they are given an incentive to rideshare[xxix]. Based on a proof laid out in their report, they believe that travel time and delay are minimally associated with individuals' motivation to rideshare[xxx]. As such, Yang and Huang state that "without any external intervention," individuals will not form rideshare arrangements for purposes of reducing congestion[xxxi]. However, given the opportunity to share the cost of commuting, thereby saving money, individuals may find motivation to rideshare[xxxii]. This opportunity is only available through public policy decisions that allow for managed lanes like HOV or HOT, or through policies like providing the opportunity for users of HOT facilities to pay low- or no-cost tolls for ridesharing. In a report by Konishi and Mun, the authors indicate that reduced tolls should be offered to 3+ users because they create a lower congestion cost to the facility and its users[xxxiii].

Seemingly there is evidence of Yang and Huang's theory being applicable to the SR-91 toll facility. As reported by Burris, et al., "after one year of operation … there was a 40 percent increase in HOV3+ vehicles" during the two-hour peak period; at the time of the report, 3+ users of the facility went toll-free[xxxiv]. Interestingly, the same report indicates that when the toll policy changed to charge 3+ users paying half price during the two-hour peak period, only 3% of those users opted to complete their trip outside of the two-hour peak period[xxxv]. By only 3% of users altering their commute behavior to fall outside of the two-hour peak period, it appears the vast majority of 3+ users still find value in, or feel rewarded by, the 50% reduced toll. As will be explored in the subsection below titled, "The importance of effective 3+ enforcement," there are enforcement concerns as it relates to offering these low- or no-cost tolls as incentives.

Enforcement

The SR-91 toll facility requires the use of a transponder when any user enters the toll facility. A motorist that enters the toll facility without a transponder will have the vehicle's license plate read and a citation will be sent to the registered owner of the vehicle. Once a motorist signs up for an account and receives a transponder, that individual is eligible to use the SR-91 toll facility. As previously described in the background section of this research paper, 3+ users who want to receive discounted or free tolls on the facility are required to travel in the 3+ declaration lane. How is the 3+ declaration lane enforced?

On the SR-91 toll facility, as well as other HOT lane facilities throughout the country, such as Minnesota's I-394 MnPASS facility, similar enforcement methodologies are used and are comprised of the following: law enforcement and enforcement beacons. The toll facility owner enters into an agreement with the local law enforcement agency having jurisdiction over the facility to reimburse the agency for providing law enforcement services. Law enforcement entails monitoring of the facility for motorists' compliance with applicable vehicles codes, in addition to ensuring proper use of special access accounts and 3+ declaration lanes.

The California Highway Patrol (CHP) provides law enforcement on the SR-91 toll facility. A CHP officer working on the facility will position him or herself in an enforcement area about 100 feet from the gantry from which the transponder in each vehicle is read. On this facility, there are two lanes for regular toll users to enter and there is a 3+ declaration lane for vehicles carrying three or more people and for special access accountholders. By having

separate entrance lanes into the facility, the toll-collection software is able to appropriately charge a user's account based on the entrance he or she used. The officer on duty is able to observe from the enforcement area whether or not the vehicles entering through the 3+ declaration lane actually contain three or more occupants or meet the other eligibility criteria for special access. If a vehicle is observed to not have the required number of people, the driver may be issued a citation by the CHP officer.

Another mode of enforcement relates less to meeting the 3+ toll policy criteria and more to simple enforcement of the requirement to possess a transponder to use the facility. On both the SR-91 toll facility as well as the I-394 MnPASS facility, enforcement beacons are mounted on the back side of the gantry at the toll facility entrance[xxxvi]. There is one enforcement beacon per designated entrance, so in the case of SR-91, there is one above each entrance lane for the regular toll users and one above the 3+ declaration lane. The beacon will flash based on whether or not a valid transponder was detected upon the vehicle entering the facility[xxxvii]. This process is important for two reasons: (1) motorists who attempt to use the facility without a valid transponder need to be reproached and (2) if a motorist who does not meet the criteria travels in the 3+ declaration lane to avoid paying a toll, he or she needs to be reprimanded.

When the Los Angeles Metro ExpressLanes system (Los Angeles system) opened in 2012 and 2013[xxxviii], it gave its users a different method for stating vehicle occupancy than the SR-91 and I-394 MnPASS facilities use. The Los Angeles system requires users to use a manually switchable transponder to select the number of people in the vehicle[xxxix]. Depending on what position the switch is placed in when the motorist passes under the gantry, the motorist's

account is charged accordingly.[xl] In terms of enforcement, CHP officers carry a device in their vehicles that indicates the number of vehicle occupants claimed by the motorist on their switchable transponder; this allows officers to visually verify if the number of occupants in the car matches the number the motorist selected on the transponder[xli].

The importance of effective 3+ toll policy enforcement

When it comes to enforcement, it is essential for a HOT facility to be successful, considering that the facility is reliant upon both revenue to repay debt service incurred by construction and price to manage the flow of traffic[xlii]. Therefore, "it is important to limit the number of non-paying vehicles to those legally qualified to be in the lanes[xliii]."

As stated by Halvorson and Buckeye, "rigorous enforcement is essential to manage the traffic on the I-394 MnPASS lanes. Uncontrolled use of the HOT lanes by unauthorized vehicles will cause overcrowding and jeopardize the success of the project[xliv]." This statement epitomizes the importance of the research question attempting to be answered in this research paper. Without effective enforcement of toll policies that are intended to encourage and reward high-occupancy travel, the policies have the potential to be publicly scrutinized and possibly even revoked.

In a preliminary three-year observation of the SR-91 toll facility, on any given day, 15% of 3+ users did not possess a transponder[xlv]. In 1999, the highest peak period toll on the facility was $3.50[xlvi]. If approximately 10,000 people use the facility every day and 15% are deemed to not possess a transponder; that is potentially $5,250 lost per day. Due to the SR-91 toll facility's

use of cameras to read vehicle license plates, it is probable that facility is able to recoup those tolls plus additional revenues from citations. However, there is an administrative cost to processing violations and it is also likely that a number of violators will never pay due to the facility operator being unable to identify and locate the registered owner of the subject vehicle.

Options for better administration and management of 3+ toll policies

In a study conducted by the Reason Foundation, research was conducted to identify developing technology-based equipment for enforcing occupancy requirements in HOT lanes. The study ultimately concluded that there still is not a single technology that would provide the level of accuracy needed, particularly to detect the third passenger in the backseat of a vehicle, for less manual enforcement[xlvii]. Instead, this study proposed policy changes for more effective enforcement of 3+ lane violations. The first policy suggestion already exists on the SR-91 toll facility; require all vehicles participating in a rideshare arrangement to have a transponder[xlviii]. The second policy suggestion is to require "pre-registration of eligible carpools with an employer or ride-sharing agency[xlix]." While it is likely that the second policy may be effective in reducing 3+ toll policy violations, it would probably significantly reduce the number of rideshare groups using the facility. Some may view this as a positive since the majority of the time those groups are not paying a toll to use the facility.

Related to the first policy suggestion from the Reason Foundation's study is a finding from the Los Angeles system. It was previously discussed that the Los Angeles system uses switchable transponders. By using the switchable transponders instead of standard transponders like the SR-91 toll facility uses, the violation rate is said to have decreased to 10 percent[l].

However, this is in comparison to similar HOT facilities that allow ridesharers to enter and exit the toll lanes without having a transponder at all in which it is stated that the violation rate is between 20 and 25 percent[li]. Unfortunately, it is not known at this time what the violation rate is using the switchable transponders versus standard transponders as used on the SR-91 toll facility.

Enforcement and its associated problems include the fact that visually verifying vehicle compliance with the 3+ toll policy is unreliable, costly in labor, and also costly to implement due to the need for additional right of way to be carved out on the facility to facilitate observation by law enforcement[lii]. This finding and the others noted in this sub-section indicate that there does not currently appear to be any feasible options for better administration and management of 3+ declaration lanes on toll facilities.

Summary of literature review

While some of the literature reviewed does not specifically attempt to provide a solution for more effective management of a 3+ toll policy, the literature provides a deeper understanding of toll facilities. The literature reviewed in the subsection on congestion pricing provided a background on why and how toll lanes came to be and ultimately why they often have a high-occupancy vehicle component to them. This segued into the next subsection providing an understanding of the need for the facilities to operate in a congestion-free manner. It put into perspective the fact that high-occupancy vehicles do not have to be given the privilege of using the facility toll-free but that it is an effective way to encourage more efficient use of the corridor as a whole.

The literature available on enforcement resulted in one common finding: there is no fool-proof enforcement mechanism. It appears that many agencies experience difficulty in the 3+ declaration lane enforcement arena. This validated the need for this research paper and emphasized the importance of good policy as a means of making a toll facility operate as successfully as possible. A major idea for this research paper that came out of the literature reviewed about enforcement and the importance of enforcement is to attempt to better understand the logic model built into the SR-91 toll facility's electronic toll collection system. It is unclear at this point whether or not the 3+ declaration lane has a built-in mechanism for identifying 3+ toll policy violators. The most feasible way of determining this is likely interviewing staff who work for the public agency owner or the private consultant operator.

Overall, the literature review served as a means of developing a greater understanding of the importance of providing a high-occupancy vehicle option in a toll facility and of the imperfections that still exist with enforcing the eligibility of customers who use 3+ declaration lanes. These concepts reaffirmed the importance of attempting to propose a more effective 3+ toll policy for use on the SR-91 toll facility. Ultimately, the original research that will be conducted as part of this research paper should provide the final pieces of information needed to propose a more effective 3+ toll policy. The methods for conducting the research and the information that is expected to be a result of that research are detailed next in the Research Design.

Research Design

To answer the research questions, two research methods were utilized: (1) on-site data collection and (2) interviews. Each method was intended to supplement the other in case data from one method was not available or applicable to the research questions. On-site data collection entailed conducting visual observations of 3+ declaration lane violators on five separate occasions during peak commute times. At least one of the interviews was aimed at determining the actual rate of violation on the SR-91 toll facility, as well as whether or not the system recognizes violations and what the consequences are for a violation. By conducting interviews, I sought to answer all of the research questions, including the more subjective question of why motorists violate the 3+ toll policy. It is intended that the research obtained through the two research methods can be used to influence a more effective 3+ toll policy that may optimize the monetary success and available capacity of the SR-91 toll facility.

Method 1: On-site data collection

Determining the approximate rate of violation was critical to understanding just how big of a problem 3+ declaration lane violations are. This data likely informs the decisions of toll facility owners like OCTA and RCTC to act on a 3+ toll policy revision or not. The most ideal data collection would utilize the largest possible sample size. Realistically, due to needing approval from OCTA toll facility management to be on-site, data collection consisted of a small fraction of the throughput associated with the 24 hours a day operation of the facility.

The on-site data collection took place on five separate occasions: on three weekdays, one hour each during three peak morning commutes and one hour each during two peak evening commutes. To minimize the impact on OCTA toll facility management, data collection took

place simultaneously with other data collection being conducted by an RCTC consultant that was observing the number of zero-emission vehicles using the existing SR-91 toll facility.

It was anticipated that data collection would be conducted from inside toll utility buildings (an on-site toll operations room located adjacent to the gantry at the entrance of the facility). In actuality, data collection was conducted on the freeway median behind a concrete barrier. Prior to each session, I met the toll facility manager or a customer assistance patrol worker who drove me to the on-site data collection location. For one hour during each peak commute, I tallied the number of vehicles passing through the 3+ toll lane entrance and the number of vehicles that did not have three or more occupants. Figure 1 illustrates the data collection worksheet that was used. This procedure was done five times which resulted in the collection of five separate periods of 3+ declaration lane violation counts.

The goal of obtaining this data was to determine the real cost of 3+ declaration lane violations to the financial success and the available capacity of the SR-91 toll facility. It was hypothesized that the data sample would indicate that the rate of violation is substantial enough to consider altering the existing 3+ toll policy in order to maximize revenue and save available capacity for policy-abiding customers. The on-site original research was aimed at answering Question 3: What is the estimated rate of 3+ toll violations?

Upon answering Question 3, the data can then be used to estimate the answer to Question 3A regarding revenue loss by assuming that the violators should have paid the posted toll for the hour in which they committed the violation. Question 3B may potentially be answered using the

data collected on-site by assuming that the violating motorists would not have otherwise been willing to pay the posted toll and therefore, would not have used any of the available toll facility capacity.

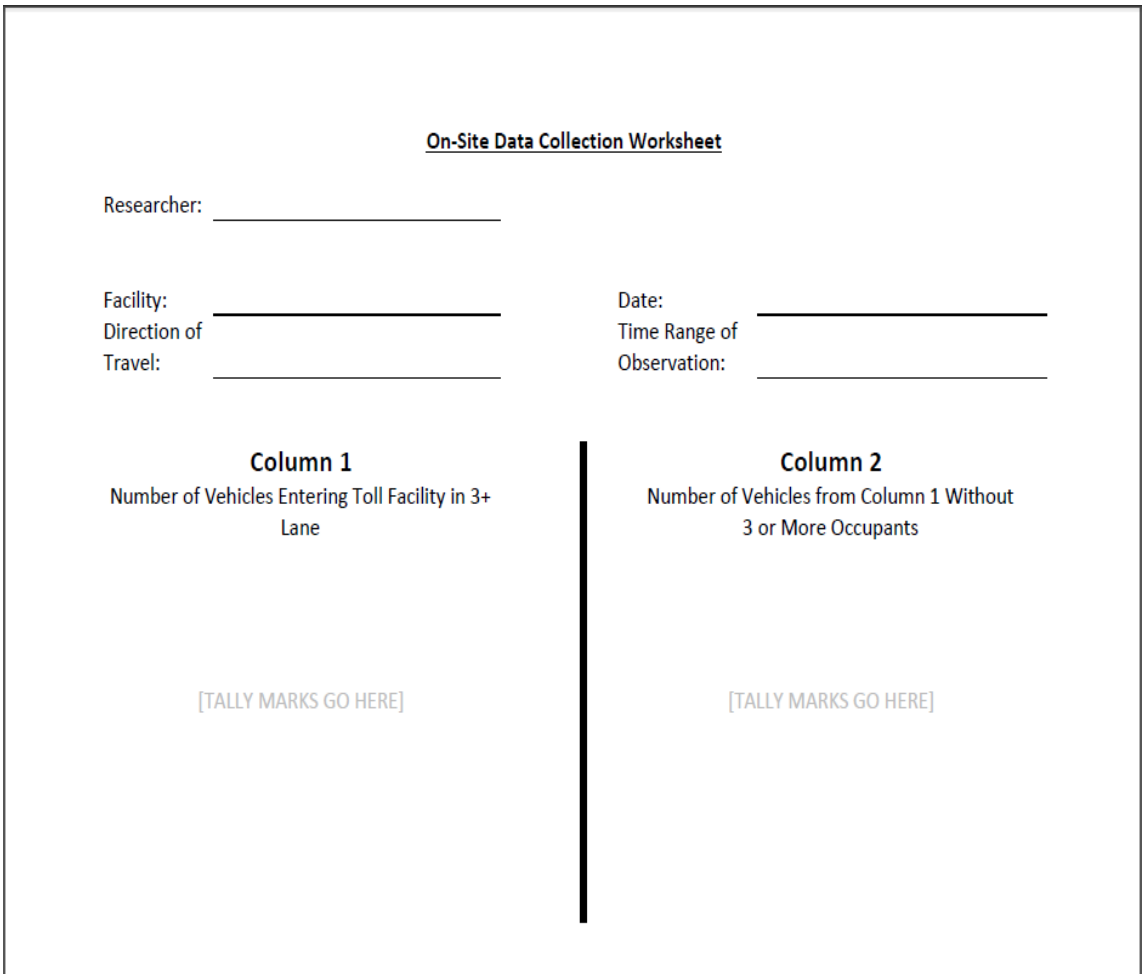

Figure 1: On-Site Data Collection Worksheet

Method 2: Interviews

Interview One

Due to the age of the OCTA SR-91 toll facility, I expected that there would be more than enough data available to answer Questions 3, 3A, and 3B. Because the owners of the facility have a financial and operational interest in such data, it was anticipated that the data being

sought for this research paper would be available. Ideally, the existing data would be used for comparing the on-site data that was collected using Method 1 to determine if the sample collected was consistent with existing data. Another important use for the existing data was intended to answer Questions 1 and 1A.

To obtain data that was most applicable to the questions being asked in this research paper, I asked the RCTC Toll Facility Manager to identify a contact at OCTA. I contacted Ellen Lee with OCTA to set up a phone or email interview. Ellen was emailed questions regarding data that would indicate whether or not the OCTA system recognizes violators of the 3+ toll policy which was intended to directly answer Question 1. Essentially, to answer Question 1, a simple yes or no response was sought. In follow-up to getting Question 1 answered, Question 1A was intended to be answered using data that I expected could be found in an operations manual or system report. Under perfect circumstances, OCTA would have also had quantifiable data to indicate the frequency at which their system recognizes a violation and how the violation is processed.

By seeking an answer to Question 3 using existing data collected in the interview with Ellen, the on-site research that was conducted could have been verified. In addition, the answers to Questions 1 and 1A could influence the ultimate recommendation that comes out of this research paper. If the OCTA SR-91 toll facility system does recognize 3+ declaration lane violations, and if there is always a consequence for that violation, it is possible that a revision to the existing 3+ toll lane policy is not necessary. However, if it is determined that there is not a consequence for violating the 3+ toll policy, or if the consequence is not applied 100% of the

time, that will likely influence the policy that may ultimately be recommended at the conclusion of this research paper. Following the interview with Ellen, the relevant responses were analyzed and applied to the appropriate research questions.

Interview Two

While attending a meeting for an unrelated program through the course of my day-to-day job as a Management Analyst, I was introduced to Kathy McCune who works for the Los Angeles County Metropolitan Transportation Authority (Metro) administering its two toll facilities. In a conversation with her, she indicated that detection software was being tested on the Los Angeles system. We exchanged contact information so that I could reach out to her for the purposes of conducting an interview to obtain information that may be useful for this research paper.

In April 2016, I connected with Kathy via email and asked if she would be willing to participate in a 30-minute phone interview. I provided her with a list of approximately eight questions to give her an idea of what my train of thought was for the interview. Based on Kathy's availability, the interview was scheduled for Friday, April 29, 2016 at 2:00 p.m.

Despite this research paper being focused on the SR-91 toll facility, I believed that interviewing someone from any toll system, in this case Kathy with Metro, could be insightful and may shape the ultimate answer to the research question. Following the interview with Kathy, I analyzed her responses and applied answers to the appropriate research questions.

The information obtained through the planned interviews is presented in a narrative format in this research paper. Based on the research questions that were answered in the interviews, it was expected that a revised 3+ toll policy may be developed that could lead to the more efficient and effective operation of the SR-91 toll facility.

Expected Results

It is expected that the results from Method 1 will be easily relatable to tables similar to those shown in Tables 1 and 2 below. Following input of the data into tables, analysis will ensue that estimates the rate of violation and further extrapolates what monetary impact this violation rate likely has on the facility. In addition, a hypothesis for what kind of operational impact the results have on the facility may be made.

	Direction of Travel	Length of Observation	Posted Toll Amount	# of Vehicles Traveling in Lane	# of Violators
April X, 2016	91 Westbound	7:00 – 8:00 am	$	X	X
April X, 2016	91 Westbound	7:00 – 8:00 am	$	X	X

Table 1: Westbound AM Peak On-Site Data Collection Results Table Format

	Direction of Travel	Length of Observation	Posted Toll Amount	# of Vehicles Traveling in Lane	# of Violators
April X, 2016	91 Eastbound	7:00 – 8:00 am	$	X	X
April X, 2016	91 Eastbound	7:00 – 8:00 am	$	X	X

Table 2: Eastbound PM Peak On-Site Data Collection Results Table Format

Based on the RCTC Toll Program Manager's reaction to how many violators she observed during our tour of the toll facility in November, I hypothesize that the violation rate will be approximately 30%. If I estimate there are 300 users per hour in the morning, and estimate an average morning toll rate of $5.00, I hypothesize that the system loses approximately $450 per hour during the peak morning commute. If I estimate there are 400 users per hour in the evening, and estimate an average evening toll rate of $8.00, I hypothesize that the system loses approximately $480 per hour during the peak evening commute (this accounts for 3+ declaration lane users having to pay 50% of the posted toll during this time).

Research Findings and Analysis

Original data and interview responses were collected over the course of four weeks. The most relevant information is presented below, followed by challenges to obtaining the data and, where applicable, lessons learned that might be useful to consider when conducting similar research in the future.

Method 1: On-site data collection

FINDINGS

The on-site data collection yielded adequate results to be analyzed for the purposes of this research paper. Each data collection period and the associated counts of users are summarized in Table 3.

Date	Freeway Direction	Time	# Vehicles Using 3+ Declaration Lane	# Vehicles Using 3+ Declaration Lane without 3 or More Occupants
2/23/2016	WB	7:23 - 8:22 am	198	41

2/23/2016	EB	4:31 - 5:24 pm	414	91
2/24/2016	WB	6:57 - 7:56 am	277	62
2/24/2016	EB	4:44 - 5:43 pm	402	132
2/25/2016	WB	6:48 - 7:47 am	307	63

Table 3: On-Site Data Collection Results (basic)

An unexpected finding from the last day of on-site data collection resulted from CHP conducting an enforcement day. After I completed the morning westbound counts, I was invited on a ride-along with a CHP officer. From the front passenger seat, the officer and I observed a vehicle that entered the toll facility through the 3+ declaration lane. The motorist in the vehicle appeared to be alone, did not display a handicap placard or license plate, and the vehicle did not have a zero-emission vehicle sticker on it, so the officer determined the motorist was likely a violator. The officer conducted an enforcement stop during which he asked the motorist why he entered the toll facility using the 3+ declaration lane (see Figure 1). The motorist's response was that he simply was not paying attention[liii].

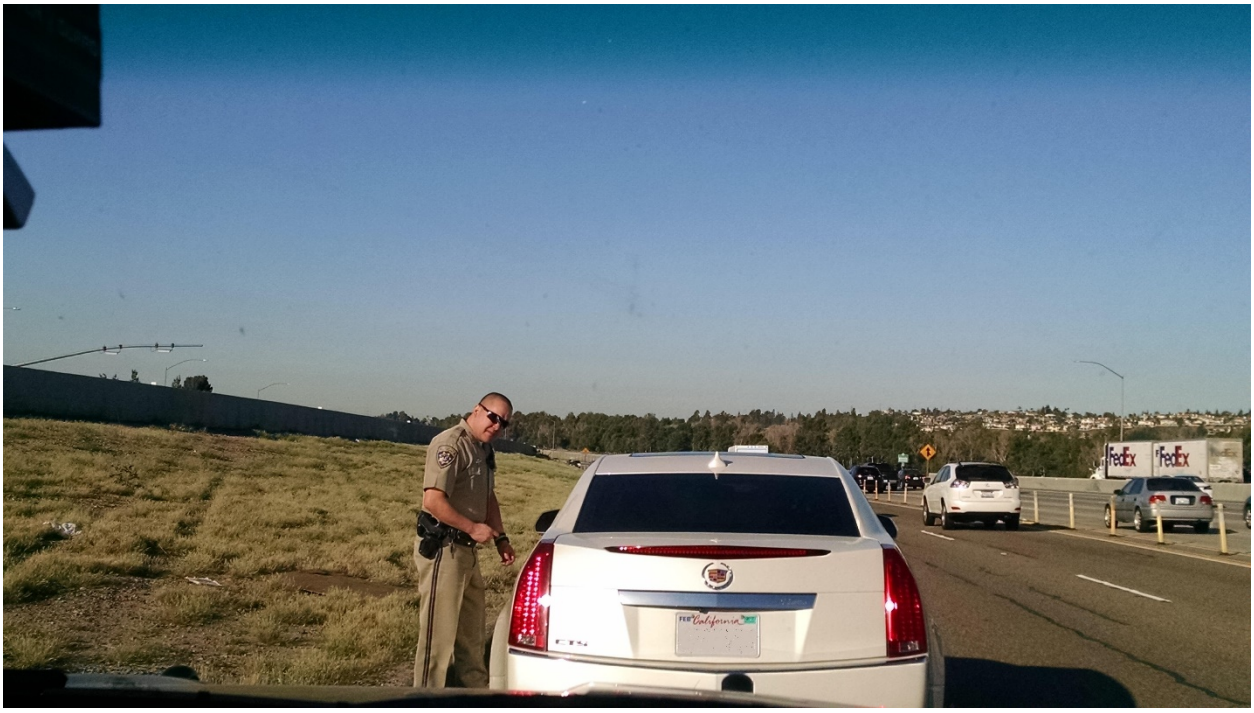

Figure 2: CHP Enforcement Traffic Stop of 3+ Declaration Lane Violation

The on-site data collected provides insight into Questions 2, 3, and 3A. Being able to talk to the CHP officer who conducted the enforcement stop on February 25 was extremely helpful in understanding at least one motorist's reason for violating the 3+ toll policy (Question 2). First and foremost, there is an assumption that the primary reason motorists violate the policy is to avoid paying a toll, or at least half the toll when traveling eastbound between 4:00 and 6:00 p.m. The secondary reason is what I was seeking to find; in the case of the enforcement stop on February 25, the motorist stated that he simply was not paying attention when driving in to the 3+ declaration lane. Because I was not present for additional 3+ enforcement stops, I was not able to determine why any other motorists violated the 3+ toll policy that day.

The estimated rate of 3+ toll violations on the SR-91 toll facility is listed in Table 4. The average violation rate for the periods I collected data on-site was 22% with the exception of

Wednesday, February 24 during the evening. This data answers Question 3 and can be used to estimate an answer to Question 3A. If the average amount of lost revenue during peak commute times is $272 (derived from Table 5 and excludes February 24 evening data), it could be reasonable to assume there are six peak commute hours per day, five commute days per week, and four weeks per month. The estimate for monthly revenue lost to 3+ toll violators is $32,640 or $391,680 annually. Question 3B can more technically be answered with the use of a traffic engineering equation, but for the purposes of this paper, the most simplistic way to answer how much capacity is lost through 3+ toll policy violations is to use the average violation rate of 22%. This amount of lost capacity is not insignificant. Further study of this problem would possibly indicate a greater associated loss of revenue due to other motorists' perception that the facility is too congested to be worth paying the posted toll.

ANALYSIS

Upon collecting the on-site data, simple calculations were performed to determine the rate of violation for each one-hour segment. During four of the five segments, the violation rate was very consistent, varying by only two percent. Data from the remaining segment, however, indicates there were either significantly more violators or some external factor(s) skewed the data. It is noteworthy that the percentage of motorcyclists using the 3+ declaration lane did vary considerably from day-to-day, ranging anywhere from 9 to 19 percent as indicated in Table 4. This may indicate it could be reasonable to believe that on some days 3+ declaration lane violations are higher than on other days.

The violation rate observed during the on-site data collection period seems realistic, though the literature review did not yield any indication of what a typical violation rate is on toll systems. Nevertheless, removing the outlier from the evening of February 24 shown in Table 4 and using the recorded number of violations equates to approximately $272 in lost tolls per peak hour (see Table 5). Running the preceding simple calculations using the estimated number of violators, multiplied by the posted toll amount for the time of the violation, multiplied by the estimated number of weekdays in a month results in the amount of toll revenue lost to violators. However, it is difficult to truly quantify the lost revenue for two reasons: (1) if the violator knew he or she would actually have to pay the posted toll, it is possible the person would not have entered the toll facility at all, and (2) there is a cost from the violator adding congestion inside the toll facility that is unquantifiable because it would require knowing if other motorists did not enter the facility due to the perception of congestion in the facility and if the added congestion led to a toll increase in the future.

On the last day on-site data was collected, CHP was conducting an enforcement day. CHP enforcement days consist of a few officers that position themselves just beyond the toll gantry. Using the lights on the backside of the gantry which indicate whether or not each passing vehicle has a valid transponder, the CHP officers pursue toll facility violators. In addition, using visual enforcement, CHP officers pursue unqualified motorists who use the 3+ declaration lane. The enforcement day for which I was present took place on Thursday, February 25, 2016. Upon arriving to the toll facility and prior to beginning the data collection for that morning, I checked a popular crowd-sourced traffic smartphone application called Waze. The Waze app had a notification that law enforcement was present in the toll facility.

It is unknown how many toll lane users that morning may have used the Waze app and changed their behavior, whether reducing their vehicle's speed to be at or below the posted speed limit or not driving in the 3+ declaration lane if they were unqualified. Furthermore, because the entrance into the toll facility is significantly further east than where law enforcement was stationed, it is unlikely users were able to see law enforcement prior to making the decision to violate or not. Interestingly, based on the data I collected that morning, it did not appear that the presence of law enforcement decreased the number of 3+ lane violators. As indicated in Table 4, the percentage of violators was similar to those seen on most other mornings that week.

In analyzing the traffic stop in which the motorist indicated that he violated the 3+ toll policy because he was not paying attention, common sense indicates the motorist was not being truthful. Entering the 3+ declaration lane requires a very deliberate action in that a lane change is required to get into it and then requires the motorist to merge into the first of the two toll lanes after passing under the gantry. The motivation for not being truthful would most likely be to increase the motorist's chances of not receiving a citation for the violation he committed. In any case, the motorist did still receive a citation. What would be interesting to know is how many times prior to February 25, 2016 that motorist evaded the toll by driving in the 3+ declaration lane as well as whether or not receiving the citation has deterred him from evading additional tolls. With the unavailability of numerous resources, I am unable to determine the answers to these questions.

One possible explanation for the February 24 peak evening data being considerably higher than the rest of the data collected relates to the price of the posted toll. Table 5 illustrates the posted toll for that period of on-site data collection was an average of $7.15. This amount is $1.30 more than the average posted toll for a similar period the day before. It is possible that this higher toll amount is enough to entice typically law-abiding, toll-paying motorists to use the 3+ declaration lane to pay half the toll. Had this hypothesis occurred to me during the week data was collected, it would have been beneficial to extend the data collection period to include the peak evening on Thursday from 4:00 to 6:00 p.m. and Friday from 3:00 to 5:00 p.m. when average tolls are $9.43 and $10.05 respectively[liv]. If violation rates during those times were similar to the 34% violation rate observed on February 24, the higher violation rate may be validated rather than appearing to be an outlier.

Date	Freeway Direction	Time	# Vehicles Using 3+ Declaration Lane (not incl. ZEV, ADA, or motorcycles)	# Vehicles Using 3+ Declaration Lane without 3 or More Occupants	Percent	# Motorcycles Using 3+ Declaration Lane	Percent	# Vehicles Using 3+ Declaration Lane Showing ADA placard	Percent	# Vehicles Using 3+ Declaration Lane Showing ZEV Sticker	Percent
2/23/2016	WB	7:23-8:22 am	195	41	21%	Not Collected	-	Not Collected	-	3	1.5%
2/23/2016	EB	4:31-5:24 pm	403	91	23%	41	9%	Not Collected	-	11	2.7%
2/24/2016	WB	6:57-7:56 am	266	62	23%	61	19%	4	1.5%	11	4.0%
2/24/2016	EB	4:44-5:43 pm	390	132	34%	47	11%	3	0.8%	12	3.0%
2/25/2016	WB	6:48-7:47 am	305	63	21%	47	13%	3	1.0%	2	0.7%

Table 4: On-Site Data Collection Results (advanced)

Date	Freeway Direction	Time	Toll Price	3+ Toll Price	Toll Price	3+ Toll Price	Average Toll	Average 50% Toll	# Vehicles Using 3+ Declaration Lane without 3 or More Occupants	Percent	Unpaid Tolls by Violators for Observation Period
2/23/2016	WB	7:23-8:22 am	$5.20	-	$4.70	-	$4.95	-	41	21%	$202.95
2/23/2016	EB	4:31-5:24 pm	$6.15	$3.08	$5.55	$2.78	$5.85	$2.93	91	23%	$266.18
2/24/2016	WB	6:57-7:56 am	$4.70	-	$5.20	-	$4.95	-	62	23%	$306.90
2/24/2016	EB	4:44-5:43 pm	$7.40	$3.70	$6.90	$3.45	$7.15	$3.58	132	34%	$471.90
2/25/2016	WB	6:48-7:47 am	$4.70	-	$5.20	-	$4.95	-	63	21%	$311.85

Table 5: Lost Revenue during On-Site Data Collection Period

CHALLENGES

On-site data collection was facilitated through my communications with the RCTC Toll Program Manager. For business reasons, RCTC was in the process of coordinating consultant staff to conduct zero-emission vehicle counts on the SR-91 toll facility. As such, an early opportunity arose to conduct multiple on-site data collection surveys. Many logistical obstacles were encountered and overcome throughout the data collection period which started on Tuesday, February 23, 2016 and ended on Thursday, February 25, 2016.

In order to get to the data collection site for each collection period, I had to drive to the 91 Express Lanes Administration Office in Anaheim, California, and then be driven by an employee of Cofiroute USA (the facility maintenance and operations contractor) into the toll facility. Just getting to the office was a challenge; despite it only being 16 miles from Riverside, it took more than an hour to get there each morning. This experience was timely and appropriate as it illustrated the importance of RCTC extending the existing SR-91 toll facility into Riverside County.

Once the RCTC consultant staff and I arrived at the office each morning, one of the SR-91 toll facility's customer assistance patrol workers drove us in to the toll facility. In the case of the morning counts, this did not take a significant amount of time due to the close proximity of the office to the westbound entrance of the toll facility. However, getting from the office in to the toll facility on the eastbound side took a considerable amount of time, as it required us to sit through the traffic queue to enter the toll facility. This was another enlightening experience. As a non-user of the toll facility, I was unfamiliar particularly with the eastbound entrance of the toll

facility just west of State Route 55. The traffic queue for vehicles waiting to enter the toll facility was approximately two miles long and took at least 30 minutes to get through while traffic in the general purpose lanes was free-flowing. Congestion immediately cleared at the toll gantry. Based on knowledge I have obtained by conducting research for this paper, it seems this congestion is bad for business and should be addressed by OCTA in order to entice more motorists to use the toll facility to travel eastbound.

An environmental challenge that was faced during data collection was the sun rising and setting during the peak morning and evening data collection periods. The morning was less of a challenge because the sun rose behind the toll utility building I stood behind to conduct the counts. In the evening, though, there was a significant glare from the sun setting. This made it challenging to see into vehicles from a further distance, giving me less time to observe the number of occupants in each vehicle as they passed.

Overall, it was very challenging to observe the number of occupants in vehicles driving through the 3+ declaration lane. Many of the vehicles had medium or dark tint on a majority of the windows, making it difficult to see in to the vehicle. All of the vehicles entering the toll facility were traveling at high rates of speed which made it extremely difficult to determine if there was a third occupant in the vehicle. For these reasons, the data collected is likely to have an undetermined error rate (the rate cannot be determined because there is no control present).

A final challenge encountered during on-site data collection was recognizing the special access account-holders that are permitted to use the 3+ declaration lane without three or more

occupants in their vehicles. These special access account-holders can typically be identified by a handicap placard hanging from the rear-view mirror or by a disabled person or disabled veteran license plate; by a zero-emission vehicle sticker on the rear bumper of the vehicle; or by identifying the vehicle as a motorcycle. During the first counts conducted the morning of February 23, I had not considered the presence of special access account-holders, with the exception of motorcycles, which were simply not counted. During the evening count that day, I began counting the number of motorcycles, particularly to understand how their usage contributes to the overall use of the 3+ lane. On the morning of February 24, I saw a few single-occupancy vehicles that displayed a handicap placard. At that point, I began counting those users separately. Fortunately, the RCTC consultant team that was on-site was counting zero-emission vehicles so that data was collected for all but the last set of counts I conducted alone on February 25. On February 25, the RCTC Toll Manager assisted with identifying zero-emission vehicles. With that data being collected separately, I was able to keep the violator counts as accurate as possible, with the exception of my own error rate as described above.

LESSONS LEARNED

The biggest lesson learned after conducting on-site data collection was that the counts should have begun at the top of the hour. When the analysis of the data commenced, it was realized that the tolls on the SR-91 toll facility change every hour which made it difficult to conduct a sound estimate of unpaid tolls. If counts started at the top of the hour, the posted toll for that hour would more accurately be applied to the number of violators. This would result in a more accurate estimate of violators' cost to the system. It should be noted, though, that a much larger sample size would be required to develop a statistically valid analysis of lost toll revenues.

Method 2: Interviews

Interview One

FINDINGS

On May 13, 2016, I received answers to my interview questions via email from Ellen Lee, Principal Transportation Analyst at OCTA. All of the interview-style questions were answered but most of the questions about existing data unfortunately were not able to be answered. The only existing data provided was account information, including: on the SR-91 toll facility, there are currently 119,000 accounts and of those accounts, 7,800 are special access accounts[lv].

Regarding 3+ declaration lane violations, Ellen did confirm the answer to Question 1, that on the SR-91 toll facility, currently the only way to enforce the 3+ toll policy is using CHP on-site enforcement[lvi]. Aside from the general enforcement that is conducted daily on the facility for 17.5 hours, additional enforcement is provided for eight hours per month[lvii]. Answers to questions regarding how many 3+ declaration lane violators are cited and whether or not a decrease in the rate of violation is observed following additional enforcement were not known[lviii].

Seemingly, because the SR-91 toll facility has no other way than manual enforcement to observe 3+ violations, it currently is unknown what the estimated violation rate is[lix]. As such, it is also unknown what the estimated loss of revenue is due to 3+ violations[lx]. In light of having little information about 3+ violations on the SR-91 toll facility, Ellen did express interest in

considering implementing an enforcement technology in the future[lxi]. The cost of implementation would require some consideration, though, before deciding to adopt an enforcement technology[lxii].

The interview with Ellen also provided a partial answer to Question 1B. The question is only partially answered because I did not ask Ellen how violation rates could be reduced specifically through policy as sought by Question 1B. Instead, I asked if Ellen had any thoughts on how 3+ violation rates could be decreased. In Ellen's opinion, increased CHP enforcement and possibly increasing the cost of citations could help to correct 3+ toll policy violations[lxiii].

ANALYSIS

Confirming that the SR-91 toll facility is currently only able to enforce the 3+ toll policy with the presence of CHP enforcement may raise additional concerns over violation rates. For calculation purposes, assume a CHP officer can cite one violator every 30 minutes. Assuming during the eight hours of additional enforcement per month there are four CHP officers working, plus 17.5 hours per weekday of regular enforcement, in a month that has 22 weekdays, there is a chance for a maximum of 834 citations to be written per month. Based on the average violation rate of 22% observed during on-site data collection, if an average of 292 motorists use the SR-91 toll facility's 3+ declaration lane every hour during the six daily peak hours, that equates to 385 violations per weekday. In a month with 22 weekdays, that is 8,479 violations during peak hours; less than 1% of these violations have the potential of being cited. This calculation assumes the CHP officers only cite for 3+ violations and not for transponder and other vehicle

code violations. For violators who understand the odds, it would not be surprising if the enforcement currently conducted does not serve as a big deterrent to 3+ toll policy violators.

Based on a maximum monthly citation rate of 1%, it can reasonably be concluded that the eight additional hours of CHP enforcement per month do not lead to a substantial reduction in violations following an enforcement period. It should be noted, though, that even if only 1% of violators receive a citation, it is likely that a number of other toll lane users who observe a violator receiving a citation will be deterred, along with the violator, from violating the 3+ toll policy in the immediate future. Based on the preceding analysis, it appears that significantly increased enforcement, implementing occupancy detection when it is commercially available, or doing away with the current 3+ toll policy are the three solutions for solving the 3+ toll policy violation issue.

CHALLENGES

Without knowing actual violation rates as either collected or calculated by OCTA, it is difficult to assess with a great deal of accuracy the amount of lost tolls to 3+ violations. Furthermore, if the vehicles driven by violators were able to be identified, the positive effects of enforcement on violators' behavior immediately following enforcement periods may be discernable.

Conducting an interview via email communications was especially challenging because it did not lend itself to conversation and asking follow-up questions. Coming up with initial interview questions was relatively easy as I generally knew what questions I had for OCTA.

However, some of the questions could have had follow-up questions depending on the interviewee's responses but the timeframe for completing the initial interview did not leave time for follow-up questions to be asked. The most obvious way this possibly could have been avoided is by conducting the initial interview sooner and setting an earlier deadline for its completion. Then, I would have had the opportunity to ask Ellen for a secondary interview.

LESSONS LEARNED

Up to this portion of the research paper, the assumption was made that an existing facility like the SR-91 toll facility would have ample data on all aspects of its usage, including violation rates. Unfortunately, as revealed through the interview with Ellen, that is actually not the case. In the future, I will rely less on assumptions that existing facilities have data available that I am seeking.

Interview Two

FINDINGS

On April 29, 2016, at 2:12 p.m., I conducted a phone interview with Kathy McCune, the Deputy Executive Officer over congestion reduction programs at Metro. During the interview, I was informed that Xerox is the current toll operator on the Los Angeles system[lxiv]. Xerox has been working on developing a detection technology that can detect whether the front passenger seat of a vehicle is occupied and whether the back seats are occupied[lxv]. Because Xerox is currently the toll operator on the Los Angeles system, they have been working with Metro staff to run a demonstration project there[lxvi].

The Xerox technology, described simply, uses infrared technology invisible to the human eye to take a picture of the inside of each vehicle[lxvii]. Combined with facial recognition technology, the irrelevant parts of the vehicle's interior are eliminated, leaving just humans in each image[lxviii]. In order to capture images of the front passenger seat and the rear passenger seats, two Xerox cameras are required[lxix]. Depending on how the system's logic is configured, it will essentially "approve" a transaction if it meets the occupancy requirement set or "deny" the transaction if it does not meet the occupancy requirement (assuming a valid transponder is read)[lxx]. In a small percentage of cases, the system will not be able to approve or deny a transaction due to a set level of uncertainty[lxxi]. These uncertain transactions can be flagged for manual review by a human who can determine whether or not the occupancy requirement was met[lxxii].

At the time the interview was conducted, the cost of purchasing or leasing the detection technology was still unknown[lxxiii]. It was also unknown what the cost to operate the equipment will be[lxxiv]. Though the technology already exists, integration into the existing toll collection system would be required in order to establish the logic for identifying violations and how to process them, which would add to the cost to implement the detection[lxxv].

Upon conducting a demonstration of the technology on the Los Angeles system, it was determined that the technology was positively able to detect each vehicle's correct occupancy 94% of the time[lxxvi]. As previously discussed, some images may be flagged for uncertainty. When those uncertain images were manually reviewed, the system as a whole yielded 99.9% accuracy[lxxvii].

ANALYSIS

Several notable observations can be made from the information provided by the interview with Kathy that ultimately relate back to the primary question of optimizing the effectiveness of the 3+ toll policy on SR-91.

The Los Angeles system has a considerably different configuration than that of the SR-91 toll facility; as discussed in the enforcement section of this paper's literature review, the Los Angeles system uses switchable transponders that enables a driver to select how many occupants are in the vehicle so the proper toll can be charged. This negates the need for a 3+ declaration lane. While it would be interesting to explore the pros and cons of each model, that would deviate from the focus of this research paper. It is relevant to note, though, that when it comes to enforcement, not having a declaration lane makes it visually much more difficult to identify 3+ toll policy violators.

An interesting use of the Xerox demonstration was to verify the current rate of violation on the Los Angeles system. Prior to the demonstration, a manual violation count was conducted in which the 3+ violation rate was estimated at 29%[lxxviii]. Based on the data acquired through the demonstration, the violation rate during the morning peak commute is actually 22%[lxxix]. It is interesting that the on-site data I gathered for 3+ violations during peak commute times (summarized in Table 4) is remarkably similar to the violation rate on the Los Angeles system. Though the Los Angeles system violation rate cannot be used exclusively to verify that the on-

site data I collected is accurate, it is logical to assume the rate of violation on the two systems operating in neighboring counties would at least be similar.

Some obstacles do exist to the implementation of occupancy detection technology. One such obstacle varies in severity depending on the way the toll facility is set up. In the case of the Los Angeles system, high-occupancy vehicles can use either of the two lanes, therefore, the toll facility requires two sets of cameras[lxxx]. The first set of cameras can be mounted on the gantry at the toll entrance to capture the front passenger seat of the vehicles in each lane[lxxxi]. The second set of cameras for capturing the rear passenger seats can be mounted on the center median, but they must be staggered so as to not allow for the vehicles traveling in the inner-most lane to occlude the image capture of the vehicle in the lane further from the median[lxxxii]. Besides this obvious logistic challenge, needing to capture images of vehicles in each lane will likely be costly. In addition, the multiple ingress points into a toll facility warrants detection technology being placed on each toll gantry; also likely to be very costly.

The counter to this obstacle is that toll facilities set up like the SR-91 facility where there is one 3+ declaration lane and currently only one entrance into the facility would require minimal investment in order to implement this occupancy detection technology. Only one camera facing the front passenger seat would need to be mounted on the gantry and one camera to capture the rear passenger seats would need to be mounted on the center median. Based on the success rate from the demonstration conducted on the Los Angeles system described by Kathy, it could be reasonable to believe the system's 94% accuracy would be even higher on a system like the SR-91, especially with the 3+ declaration lane currently being the inner-most lane.

The second obstacle to implementing occupancy detection technology is capturing the occupancy of vehicles with third row seating. As Kathy said, "sometimes it is possible to see the third row but it depends on the angle of the camera[lxxxiii]." When considering the technology may be used to issue citations or, at a minimum, charge a violator the posted toll from the time of their trip, it seems this uncertainty in capturing third row occupancy could require a tolling agency to dismiss a fair amount of suspected violations. Additional data collection from a demonstration would be required to analyze this concept further.

A policy question must be addressed by tolling agencies that consider adopting occupancy detection for the purpose of enforcing a 3+ toll policy. Once detection is operational, what will be the consequence for motorists who mis-declare their vehicle's occupancy on the transponder; or, in the case of the SR-91 toll facility, motorists who use the 3+ declaration lane without three or more occupants? The most generous way to enforce the policy is to send the violators a warning notice. A different way to enforce the policy is to simply debit the violator's account the amount of the posted toll at the time the violation occurred. The most aggressive way to enforce the policy is to issue a citation with a monetary fine for the violation. Certainly, the tolling agency may choose to implement progressive enforcement with more generous action for first-time violators and more aggressive action for repeat violators.

As described in the "Findings" above, the cost to implement this type of system is unknown today. Once the cost to install and then operate this occupancy technology is determined, an analysis should be conducted to determine at what point the system would begin

to generate revenue from lost tolls. The point at which the technology could provide a benefit to a system would depend heavily on both the violation rate of each system as well as the adopted policy for how to deal with confirmed violators as discussed in the previous paragraph. For systems that simply charge the posted toll that should have already been paid, it is evident it would take that system much longer for the cost to implement and operate occupancy technology to pay off. Furthermore, a more complex calculation would be required than simply determining the break-even point because it is likely that once violators realize mis-declaring their transponders is not saving them money in the toll facility, they will either stop mis-declaring or stop using the facility altogether, thereby reducing the amount of recouped revenue over time. It is worth noting that occupancy detection is not likely to save on CHP enforcement costs because CHP would still need to be present to enforce other violations such as not having a transponder.

While the interview with Kathy did not directly answer any of the research questions for this paper, it did provide a wealth of information about occupancy detection that may be available for implementation in the near future that could address 3+ toll policy concerns. Perhaps by implementing occupancy technology, concerns over having a policy that offers free or reduced tolls to 3+ users could be quelled.

CHALLENGES

Because the Xerox demonstration was conducted in April 2016 and the deadline for data collection for this research paper was May 2016, it was not possible to collect several pieces of information that would have been useful for analyzing the monetary benefit of the Xerox occupancy technology. Furthermore, because Metro has yet to prepare a concept of operation,

let alone fully implement the technology, it is difficult to fully assess the value of this technology. All analysis is based on the relatively small demonstration that was conducted and the information I was able to learn from my interview with Kathy.

Conclusions and Policy Implications

The SR-91 toll facility 3+ toll policy is for vehicles with three or more occupants to use the toll facility at no cost, with the exception of weekdays when traveling eastbound between 4:00 and 6:00 p.m. the motorists pay 50% of the posted toll. Motorists with three or more occupants are required to have a transponder and must use the 3+ declaration lane in the toll facility in order to not be charged the posted toll. In the case of the SR-91 toll facility, seemingly the impetus for offering such a generous 3+ toll policy is to motivate motorists to rideshare[lxxxiv]. Based on analysis conducted in this paper, this concept is worth exploring.

As discussed in Method 2: Interviews, Interview One, if a maximum of 1% of violators are caught on the SR-91 toll facility this begs the question: Is it worth it to offer a 3+ toll policy? To answer this question, another question must be asked: Is the full cost of a toll deterring ridesharing? Consider that currently, 2-person carpools are paying the full toll but it only comes at a cost of 50% of the posted toll per rider (assuming the cost is shared). Extend that to a larger rideshare arrangement such as a 6-person vanpool; split evenly among all riders, each rider would only pay 17% of the posted toll. Currently, the highest toll is $10.15[lxxxv]. Divided 6 ways, that only amounts to $1.69 per person. Using the data in Table 6, the weekly cost per person would be $10.67. With an average time savings of 30 minutes[lxxxvi], it seems reasonable to believe that in addition to the other savings motorists realize by ridesharing, ridesharers would be

willing to pay the toll in exchange for the time savings; the crux of why toll lanes are successful. Furthermore, the 22% violation rate must be considered as part of the toll agency's desire to offer a 3+ toll policy. Based on the assumption that most of the existing 3+ declaration lane users would be willing to pay the posted toll and that there is a motivation to stop the estimated 22% of 3+ declaration lane violators, the SR-91 toll facility should discontinue the current 3+ toll policy.

	Westbound @ 7:00 a.m.	Eastbound @ 4:00 p.m.	Cost per Person in 6-Person Vanpool
Weekly Toll Cost	$25.85	$38.15	$10.67

Table 6: Weekly per Person Cost of Tolls for a 6-Person Vanpool

Through the course of gathering information for this paper, particularly in viewing the current toll schedule for the SR-91 toll facility, an interesting observation was made that is worth exploring in relation to the current 3+ toll policy. Seemingly, a business decision was made by OCTA when it developed the 3+ toll policy that it should not offer no-cost tolls during the most expensive peak eastbound commute times, 4:00 – 6:00 p.m. However, because the SR-91 toll schedule is often analyzed and revised to optimize traffic flow, on Fridays the most expensive toll is being charged at 3:00 p.m. Based on the existing toll policy, vehicles carrying three or more occupants travel for free. If the SR-91 toll agency were to insist that maintaining a 3+ toll policy similar to the existing policy is a good business practice, the agency should, at a minimum, consider a revision to the policy to more accurately capture the 50% toll being charged during weekday peak eastbound travel.

An additional consideration for the toll agency, if it chooses to continue to offer the existing 3+ toll policy, is to explore the possibility of implementing occupancy technology. As identified in the interview with Ellen, OCTA may consider this in the future. Assuming implementing this technology would not be cost-prohibitive, this approach would enable the toll agency to maintain a generous 3+ toll policy while deterring violators and recouping, at a minimum, missed tolls from violators. While this recommendation is likely the most expensive to implement, it appears to be the most diplomatic, especially considering it would be challenging, politically, to take away the existing offer to 3+ users. It would also aid in maintaining the traffic flow of the toll facility.

The research question that was answered here is 1B: If the system does not recognize a violation, how can policy correct this? This final section suggests answers to the question utilizing the research conducted for this paper. Ultimately, there is not a singular answer to Question 1B. A variety of answers are put forward for possible consideration by the SR-91 toll agencies or other toll agencies that may be asking a similar question. I am hopeful this paper may be used by agencies that are considering tolling in the future to at least encourage them to explore the issues and considerations for adopting a 3+ toll policy.

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