The wealth of knowledge accumulated during the 17th IRF World Meeting & Exhibition in Riyadh was the driving force behind our decision to launch the IRF Examiner as a freely available resource for the industry. With this sixth issue, the International Road Federation confirms its role as a leading provider of applied knowledge in areas of vital importance for the global community of road professionals.

As the road sector delivers increasingly sophisticated solutions addressing our societies new mobility needs, the availability of global knowledge resources such as those provided by IRF is now more important than ever. I invite you to make full use of these resources and the associated training programs delivered by IRF.

H.E. Eng. Abdullah A. Al-Mogbel
IRF Chairman

The IRF Student Essay Competition is an annual contest held to recognize promising road research. This competition is open to all students attending an IRF Member university in good standing, as well as IRF Fellows currently enrolled as full time students. It also offers a compelling illustration of IRF’s efforts to pave the way for the next generation of transportation leaders.

This issue of the IRF Examiner presents recent winning essays submitted by promising students. Whether the focus of the essays is alternatives to the gas tax or hazardous roadside management, all are characterized by original thinking and impartial analysis. We can all draw lessons in our work from the ideas and proposals presented here.

C. Patrick Sankey
IRF President & CEO

Creating advances in transportation requires the ability to overcome many obstacles. Researchers and professionals work long hours to bring new ideas to reality. Their efforts to bring modernization to transportation systems have united us with the common bond of connectivity.

As the editor of the IRF Examiner, it has been a privilege to interact with these authors and help them share their work on a global scale. Reaching across borders and boundaries to achieve a common goal of sharing ideas has been one of the main objectives since the launch of the Examiner, and continues to be a cornerstone to overcoming our industry’s challenges.

Sam Enmon
Editor, IRF Examiner
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FUNDING FOR HIGHWAY ASSET CONSTRUCTION AND MAINTENANCE: SUSTAINABLE ALTERNATIVES TO THE TRADITIONAL GAS TAX

Author:
Matthew Volovski
Purdue University
mvolovsk@purdue.edu

INTRODUCTION

The funding needed for highway construction, rehabilitation, maintenance, and operations are obtained from various highway revenue sources. At the current time and in the foreseeable future, most highway agencies face a funding gap which occurs whenever the needed funding exceeds the revenue generated. The increasing levels of needed funding are derived from the depressed state of the United State’s transportation infrastructure, as the roads and bridges have been assigned D and C+ grades respectively (American Society of Civil Engineers (ASCE), 2013).

Researchers and highway related organizations have stated that there is excessive unmet need for highway asset reconstruction, rehabilitation, and maintenance. The nation will need to invest $20.5 billion annually to eliminate the deficient bridge backlog by 2028, which is approximately 60% greater than current funding levels (ASCE 2013). In response to Transportation Equity Act for the 21st Century (TEA-21) and Moving Ahead for Progress in the 21st Century Act (MAP-21), federal, state, and local capital investments in highways have increased to $91 billion annually; however, that is still below the $170 billion annual capital investment that is needed to significantly improve road conditions and performance. These needs can be attributed to the aging highway infrastructure, the consequences of deferred reconstruction and rehabilitation, and increased demand and loading due to population growth that has far outpaced capacity expansion (Figure 1).

The majority of revenue collected by highway agencies is generated from vehicle registrations, license fees, and excise tax (predominately fuel taxes). These revenues are not expected to grow significantly to match needs; a prognosis that arises from recent and ongoing developments in the highway transportation environment including lower fuel consumption (due to increasing vehicle fuel efficiency and increasing percentage of vehicles that use of alternative energy), stagnation of the fuel tax rate, and uncertainty in forecasted travel demand.

The imminent widening of the funding shortfall has precipitated calls for new strategies for highway financing or improvement of existing mechanisms. It is desired that these new strategies help agencies achieve their finance-related goals of revenue adequacy, equity across the various users of the highway system, and feasibility of application from a technological, cost, and...
public relations standpoint. In addressing the issue, this paper identifies, examines, and evaluates a number of alternatives for sustainable funding for highway asset construction and maintenance, particularly in a bid to supplement or replace the traditional gas tax, which, for several decades, has been the primary source of revenue.

TRENDS THREATENING THE ADEQUACY OF TRADITIONAL FUNDING MECHANISMS

The current and ongoing developments in the highway transportation environment pose serious obstacles to the long-term sustainability of the current funding sources. First is the loss of purchasing power because fuel taxes are not indexed to inflation or fuel price. Thus, while fuel prices have increased since the late 1990s, fuel tax rates have not resulting in a decrease in the effective fuel tax rate (Federal Highway Administration (FHWA), 1997). Wachs (2003) suggested that raising fuel taxes would be more effective, efficient, and equitable than other revenue-generation mechanisms. However, most elected officials are unwilling to increase gas taxes, rather opting for borrowing, local sales tax, and other initiatives. Second is the influx of alternative energy sources. As alternative energy systems become more common, fuel taxes are not expected to generate the needed revenue for highway management (Whitty, 2003). Third is the increased fuel efficiency, driven by regulations and consumer demand, which is resulting in lower fuel tax receipts per mile traveled (Figure 2). The Transportation Research Board (TRB), 2006) estimated that with continued improvements in fuel economy, the average fuel consumption per vehicle mile can be expected to reduce by 20 percent by 2025. Fourth is the erosion of established finance practices. As pointed out by the TRB in its 2005 special report, some potential sources of stress in highway financing are evident, particularly in certain states where the local share of responsibility is high, for example, pressures to spend portions of highway revenue on non-highway purposes.

PAST RESEARCH ON ALTERNATIVE FINANCING MECHANISMS

Transportation administrators and researchers have long recognized the problem of inadequate highway revenue and have made efforts to address the issue from the needs side through better materials and design and from the revenue side by identifying and evaluating sources of additional revenue. Reno and Stowers (1995) identified and evaluated alternatives to motor fuel taxes for financing surface transportation improvements, TRB's Special Report 285 (2005) provided a comprehensive review of different sources of additional revenue including increases in the gas tax, debt financing, toll pricing, and mileage charging; and individual states have commissioned studies to identify evaluate alternatives to the gas tax (Oh et al., 2008; SCDOT, 2003; Oregon, 2003; Adams et al., 2001). Goldman et al. (2001) and Hamideh et al. (2007) examined the effectiveness of local option transportation taxes, and Verhoef and Rouwendal (2004) examined the pricing and financing in transportation networks. Wachs (2003) offered multiple reasons for increasing the gas tax, and the effectiveness of doing so was evaluated by VTPI (2005).

EVALUATION CRITERIA FOR FUNDING ALTERNATIVES

The criteria for evaluating the highway funding alternatives include sufficiency, economic efficiency, equity (spatial and across vehicle modes), and accommodation of jurisdictional and functional independence, practicality, and ease of implementation. First, the pricing scheme should be sufficient in that it should generate adequate revenue to not only replace current funding sources but also to close the funding gap going forward. Second, economic efficiency considerations dictate that the funding mechanism should contribute to the success of the highway program by helping ensure a positive return on the investment and therefore ensure that motorists are charged prices that closely matched the cost of their road use (TRB, 2005). Equity in a transportation system has three facets: cost, benefit, and ability to pay (Adams et al., 2001). Often, equity is measured on the basis of user costs due to difficulty in measuring user benefits or determining the appropriate level of regressiveness for implementation.

With regard to jurisdictional and functional independence, it is noteworthy that the highway system in any state is typically administered and maintained...
by several different levels of government (the most visible of which are state and local). However, not every governmental unit is self-financed. Lower-level governments are often subsidized by their higher-level counterparts at levels that depend on their asset inventory. Further, it must be practical to develop estimates for any proposed financing mechanism using available data. Also, it must be feasible to implement the new financing mechanism considering the additional investment in hardware, software, manpower, and other resources for administration and enforcement.

REVENUE GENERATION ALTERNATIVES AND A PROMISING SOLUTION

The simplest alternative to the current funding mechanism is to increase the current gas tax rate. While easier to implement compared to other mechanisms, the primary obstacle is the political difficulty of raising the existing fuel taxes (Feigenbaum, 2012). Another alternative is to index the fuel tax rates to inflation or roadway costs. The Carbon Tax (VTPI, 2005b) is an alternative that could be imposed to reflect the amount of carbon emitted and could have a secondary benefit of controlling emissions. A third option is to implement a general sales tax to motor fuel; this could generate large amounts of revenue in a favorable economy but is extremely volatile and susceptible to economic fluctuations (Feigenbaum, 2012). Yet another option is to implement a value tax, which is a personal property tax based on the car’s value. The value tax could be deducted from the federal income tax, thus transferring tax revenue from the general budget to the United States Department of Transportation, removing some equity issues that are associated with flat registration fees.

The sixth option is tolling: a toll program is typically more appropriate for specific assets but is an efficient mechanism (because it is based on vehicle miles traveled (VMT) and vehicle class) and hence could raise sufficient revenue for reconstruction and rehabilitation of specific highway segments. It could also provide additional benefits such as managing congestion and helping to gain public appreciation of direct user charging. However, tolling introduces problems of equity across the income classes. The fifth option is the VMT Tax, where user pays according to distance traveled (and in some cases, weight). Using information and communication technology, the fees are assessed according to VMT, the functional class of roads used, vehicle class and weight, and traffic conditions. Other options include bonds, grants, loans, and public-private partnerships (PPPs).

The VMT fee appears to be the most promising technique for directly assessing road users for the costs of individual trips within a comprehensive fee scheme that will generate revenue to cover the costs of highway programs. This mechanism could be used to offset external environmental and societal costs (reduced cost for lower emission vehicles or vehicles manufactured within the state or country). Data is currently available to establish the VMT pricing scheme: expenditure data is available from sources including FHWA’s Highway Statistics, funding needs data from a needs assessment studies, and travel demand data from the states’ Statewide Travel Demand Models (ISTDM).

VMT fees can be used to promote funding equity. A transportation policy may, by design or default, treat user groups differently according to residential or work locations. It is not uncommon for higher-level governments (federal or state) to subsidize highway construction in areas that have small populations. To address spatial equity, the VMT fee can be developed by decomposing the state highway network into rural and urban classes. Also, in developing a VMT fee, equity can be incorporated by decomposing the entire system into user groups (vehicle classes and weight groups) and facility classes (highway functional class) and establishing separate welfare functions for each of these clusters. Thus, the VMT fee can help achieve equity across vehicle modes. For example, the FHWA’s Highway Cost Allocation Study (1997) established that single-unit trucks over 50,000 lb pay only 40% of the damage costs they inflict on the system while pickups yield more revenue than the costs they incur. VMT fees can help correct such imbalances by applying appropriate fee rates for the different vehicle classes. With regard to jurisdictional and functional independence, the VMT fee mechanism allows user fee rates to be established for each jurisdictional or functional highway class to cover expenses within that jurisdiction.

CONCLUSION

This paper examined the experience of federal and state agencies that have used or experimented with innovative funding mechanisms. This helped identify the design of the pricing scheme impacts on users, technology issues, legal and institutional issues and barriers to implementation including public acceptability. A VMT fee mechanism offers what may promise to be the most sustainable solution because it has the greatest potential in achieving revenue adequacy and equity among the different classes of highway users. However, the implementation of the VMT fee is expected to involve a large capital outlay at its inception due to technological hardware and software. Also, issues related to change inertia and privacy are expected to cause public opposition at least at the initial stages of its implementation. Governments must decide on the goals
of the effort, authorities for setting fees and controlling revenue, the basis for determining fees, and how best to involve the private sector. Resolution of privacy and fairness concerns will be a prerequisite. As Oh and Sinha (2007) pointed out, the experience of several agencies has shown that the costs and barriers to implementation are expected to decline as the initial period wears off.

As cautioned by the TRB Special Report 285 (2005), a reformed finance system would remain subject to many of the external political and economic constraints that limit the revenue potential of the present system. However, reform would help transportation agencies manage capacity and target investment to projects with the greatest benefit to the public. Each dollar spent would be more effective and it is conceivable that the public would be willing to pay more for transportation programs that worked better.

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International Road Federation
INTEGRATED TRAFFIC TICKETING MANAGEMENT SYSTEM

Author:
Davis Chacon-Hurtado
Purdue University
dchacon@purdue.edu

We only measure what we care about and we only care about what we measure (1)

Diverse reports and corruption indices demonstrate the intrinsic relationship between the degree of a countries’ economic development and the levels of corruption (2, 4). Healthy sustainable development is disrupted by wars, poverty, terrorism and other factors that enable corruption across all levels of government, including police departments and transportation agencies. Therefore, measures against corruption in any sector are usually carried out through general policies (such as national or macro regional strategies) in an attempt to reach globally across all governmental and societal sectors. Nevertheless, the implementation of local efforts in subsectors is still possible and might establish a precedent as well as benchmarks for wider national strategies. This essay presents the idea of creating an Integrated Traffic-ticketing Management System (ITtiMS). The main goal of the system will be to manage, monitor, and promote a healthy and transparent traffic ticketing process controlled by a joint agency. By implementing an integrated system, the corruption would be reduced gradually and in the long run; this system might generate additional synergies with other control systems. The steps for the implementation of this system, which are directly related to the steps to reduce traffic police corruption, are discussed next.

The first step will be the creation of a pilot project in which all the logistics and plans will be laid down in order to build the Integrated System (ITtiMS) for a specific region. To this end, it is necessary to assume that local agencies such as Departments of Transportation and police departments can establish cooperation links or reinforce existing ones. This agreement would include the allocation of resources and personnel from both sectors (transportation agencies and police departments) centralized in a joint supervision office that will be in charge of implementing and managing the system. Additional resources, such as academia and public involvement, can be used to enrich this stage. Initially, the main goal of this office would be the creation of a timeline and master plan for the system’s implementation that would show all steps clearly. ITtiMS will have to adopt a holistic approach that takes into account all essential stakeholders and processes involved in the traffic-ticketing systems. The stakeholders include the driver, the authority (police officers), the ticketing tools, and current policies. The system will have specific components addressing each of the elements and their current limitations, with a special focus on control measures to avoid police corruption. The master plan will include each system component in the following order: Training and Branding, Salary and Rewards, Enforcement, Ticketing System, and Drivers Education. Additionally, since the system requires a mechanism for quantifying the degree in which the objectives are being achieved (5, 6), performance measures (PM) will be assigned to each step.

Once the master plan has been created and approved, then the first stage, Training and Branding program, can be implemented, again as a pilot project in a specific location. This step focuses on the most important stakeholder of this system, the authority figures. The Training part aims to reinforce the education of police officers in both ethical practices and the role of their profession in society. Furthermore, training will teach them how the new ticketing system will work as part of the master plan. This program would be implemented in the local police academy so that future traffic police officers will install the information provided as part of their core values and obligations. Meanwhile, the Branding aspect of the program will aim to create a new image for both current and future police officers. This is expected to have an impact on how society perceives officers as well as how police officers perceive themselves. To this end, media, open houses and special events inside and outside police departments will be implemented (e.g. creating marketing commercials about policemen rejecting bribery or creating awards for police who have outstanding ethical conduct). However, this step might
require diverse sources of funding. A possible source is proposed in the following section. The PM for this step might include periodical written questionnaires for policemen, public opinion surveys, and the amount of money spent in marketing commercials, among others.

Parallel to the effort in changing the conduct and public perception of police officers, efforts to financially support the program and allow for supplementary salary improvements for officers must be implemented (since a common factor in places with high corruption levels is the low salaries policemen receive). This effort would be part of the Salary and Rewards program, which would be implemented parallel to the first step. The reason is because it is easier to justify this component when some initial successful outcomes are obtained as part of the stage started previously. The salary improvements as well as the financial resources for the system will come not only from government subsidies and taxes, but also from a fixed percentage of the traffic-ticket revenues. The latter might be especially effective for police officers because they would be able to receive a percentage of the revenues from the total amount of traffic tickets they issue. The performance measures for this step include the aggregated and disaggregated number of tickets issued in a given period of time. Additionally, monthly financial reports of the tickets revenues should be issued periodically.

The fourth component and probably, the most difficult to implement and manage in the system is Enforcement. Because corrupt agents might be in both streets and police department offices, ITtiMS will have a supervisory committee composed of members not only from the police department and transportation agency but also external collaborators such as the division of police investigators or third party auditors. These investigators or auditors will be expected to coordinate operatives and contra-intelligence strategies to detect corrupt agents or suspicious conduct. Depending on the seriousness of the culpability, they might generate warnings or initiate administrative and/or judicial processes. The performance measures include periodical reports of the number of suspicious cases under investigation, and the number of agents processed or found guilty. They might also report the number of operatives they performed.

Once all previous steps are being implemented, a fifth program can be put in place. This involves the Ticketing System. It would be important to establish a new and transparent scale of fines for each violation. For example, the first fine would be a warning and then the fines will increase gradually according to type and frequency of the violation. Also, it is proposed that police do not establish the amount of the fine at the moment they issue the infraction ticket. This amount should be calculated by the agency based on the frequency and type of the violation, as explained above. The collected data through ITtiMS would enable comparisons on the type and quantity of tickets given as a function of time or geography, and can be used to generate appropriate performance measures. For instance, reports on geographical location and type of violation would help to identify zones with specific issues such a corridor with inappropriate speed signage.

All measures discussed above focus on police officers, but also affect the other stakeholders in the ticketing process. The role a driver plays is equally important. If there are corrupted agents, there have to be drivers who try to bribe them to avoid the fines. For that reason, an Education and Enforcement tandem program needs to be implemented. The Education component is a preventive measure that would aim to create civic consciousness and educate drivers about the consequences of bribery. The Education program has to be implemented as a requirement for drivers when they acquire their licenses or as a way to reduce the record of the drivers’ violations. Enforcement, on the other hand, could be implemented as the gradual ticketing system, in which there is a scale of penalties, such as suspension of one’s driving privileges and court appearances for repeat offenders. One performance measure would be the reports of drivers’ violation records. The database would enable the easy identification of repeat offenders and those processed for bribery. Additionally, since the judicial processes are independent of the system, the time and status of each case in court can be traced and reported aggregately. These statistics can be used to promote or encourage changes in bribery prevention policies and laws at governmental levels. For instance, promoting expedited court processes for those who commit bribery.

As mentioned above, all steps, including those focused on policemen and drivers, will be provided with PM to track its effectiveness. But they will lack of usefulness if ITtiMS is not provided with a mechanism to manage and sustain a record of all PM collected in each step. Moreover, this mechanism will also record all drawbacks and issues encountered. Since this constitutes a pilot project, a formal process for feedback and improvement in all processes should be provided. This will enable ITtiMS to be adjusted to specific conditions in an iterative process, and later on, extended to different regions.

In the context of developing countries, there are additional barriers and difficulties that will have to be overcome for a successful implementation of this system. These include the limited availability of resources in the public sector. Therefore, external sources such as non-governmental organizations or bank loans might be evaluated. Lack of technology constitutes another important factor since it limits the application of certain
strategies. For example, police departments might not be able to provide video recording devices and wireless audio transmitters in police cars. Also, it is known that many developing countries have high levels of bureaucracy that may bring additional delays to the master plan. Another important aspect would be the sustainability of the system, especially due to political risks. Many of these projects are dependent on the goodwill of the policy-makers, for that reason the project must develop a strong organizational structure with low sensitivity to political changes. Finally, it is expected that the implementation of the system would encounter a lot of opposition from other political parties and even from corrupted agents in the government.

In conclusion, traffic police corruption is a problem that cannot be addressed with a single program. These joint strategies are feasible to implement since many of the aspects proposed herein are already undertaken at different levels or scopes by different agencies. However, the author is convinced that the idea of having a coordinating local agency (ITtiMS) in charge of the whole ticketing system is essential for the success of such efforts. ITtiMS would manage the system and track its effectiveness thought performance measures. Moreover, it will create a basic platform for the implementation and adjustment of various different strategies, not only to reduce police traffic corruption, but also increase the effectiveness and efficiency of the whole system.

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International Road Federation
ON EN-ROUTE DIVERSION BEHAVIOR: EMERGING DATA COLLECTION TECHNIQUES AND MODELING METHOD

Author:
Chenfeng Xiong
Graduate Research Assistant
Department of Civil and Environmental Engineering
cxiong@umd.edu

ABSTRACT
Intelligent Transportation Systems (ITS) require accurate and abundant data sources. One example is the implementation of Dynamic Message Signs (DMS) for the purpose of diverting drivers in order to mitigate congestion. This paper discusses the methods for modeling and calibrating drivers’ en-route route changing decision with behavior data collected from emerging data collection techniques including laboratory driving simulators and field blue-tooth detectors. The behavior models are not based on assumptions of perfect rationality. Instead a novel descriptive approach based on naïve Bayes rules is proposed and demonstrated. The en-route diversion model is first estimated with behavior data from a driving simulator. Subsequently, the model is re-calibrated for Maryland based on blue-tooth detector data, and applied to analyze two dynamic message sign (DMS) scenarios on I-95 and I-895. This calibration method allows researchers and practitioners to transfer the en-route diversion model to other regions based on local observations. Future research can integrated this en-route diversion model with microscopic traffic simulators, dynamic traffic assignment models, and/or activity/agent based travel demand models for various traffic operations and transportation planning applications.

BACKGROUND
Drivers’ en-route route choice under information provision has been traditionally modeled by the econometric theory of random utility maximization (Ben-Akiva and Lerman 1985). Mahmassani and Liu (1999) adopted a multinomial probit framework to model the commuters’ joint pre-trip departure time and en-route diversion behavior in response to real time information, based on data from a laboratory interactive driving simulator. The study suggests that commuters switch routes if the expected travel time savings exceed an indifference band which varies with the remaining trip time to destination. Abdel-Aty et al. (1997) developed logit models to capture the effect of real-time information on en-route diversion using stated preference data. Khattach et al. (1995) estimated a bivariate ordinal probit model of drivers’ diversion and departure time choice when traffic information is available.

Limitations exist in the en-route diversion models. First of all, they are often not well calibrated due to data limitation and other issues. The inherent bias of the stated preference data and driving simulator data has long been argued as a major deficiency of the models (Bonsall and Parry 1991). Koutsopoulos et al. (1994) further assert that driving simulators for en-route diversion analysis can be more useful if revealed preference data collected from “actual en-route route choice behavior” and an appropriated designed calibration become available.

Moreover, unlike the decisions of departure time and pre-trip route choice, en-route diversion is a decision triggered by impulsion. When making en-route diversion decisions, a driver usually has very limited reaction time to obtain the real-time traffic information from the sources, process the information, compare the original route and the diverting route, and reach a decision. Therefore, some researchers (Arentze and Timmermans, 2007, Paz and Peeta, 2009) emphasize the need for rule-based computational process models, since it is claimed that utility-maximizing models do not always reflect the true behavioral mechanisms underlying travel decisions (people may reason more in terms of “if-then” structures than in terms of utility maximizing decisions). ALBATROSS applies CHAID decision trees to model the activity scheduling behavior (Ettema et al. 2005). Janssens et al. (2006) develops a Bayesian network augmented tree (BNT) approach to look at multi-facet decision making processes. This approach takes advantage of both Bayesian network and decision tree/rule induction method. Paz and Peeta (2009) employ aggregate behavioral if-then rules and calibrate a weight vectors for these rules so as to match the estimated and
actually observed network states.

**RESEARCH OBJECTIVE**

Other than rules that give only a simple classification, models that give probability estimates are favored in the field of practical data mining and artificial intelligence for their flexibility in applications of combining decisions and sensitivity analysis (Bourlard and Morgan 1990; Duda et al. 2001; Bennett 2003). Naïve Bayes model is one of the most efficient and effective algorithms that predict probability estimates. Although its underlying conditional independence assumption is rarely true in real-world applications, the correlation among variables does not affect the performance optimality of naïve Bayes model, as quantitatively proved by Zhang (2004). Few travel behavior studies have explored this promising approach except some research in mode choice modeling (Wu et al. 2011; Biagioni et al. 2009).

Following this line of research, the paper develops a naïve Bayes classifier to model drivers’ en-route diversion behavior. And then a Bayesian approach to calibrating the Naïve Bayes model is developed to transform the naïve Bayes prediction into more accurate estimates. This calibration approach is practical-oriented and is demonstrated on a real world en-route diversion case study where the Bluetooth based testing dataset is collected. The main contribution of the paper lies in the originality of the model and calibration in en-route diversion behavior.

The remainder of the paper is organized as follows. Section 2 presents the training dataset, as well as the model development. Section 3 presents the testing dataset and the Bayesian calibration process. Conclusions and discussions on future research are offered at the end of this paper.

**DATA COLLECTION**

*Training Data*

The data for developing the en-route diversion classifier is the Massachusetts Driving Simulator Experiment Data (see Tian et al., 2012 for more details about the data). 63 effective subjects were recruited in this driving simulator survey. There are three types of maps in the tests, shown in Figure 1. And each type of the maps appeared six times with randomly assigned travel times. Some social demographic information (i.e. gender, age, and years holding a driver’s license) has also been collected.

In Figure 1, each map contains one routine route with deterministic travel time \( t_b \) and one risky diverting route using \((m, n)\) to denote a random travel time. The risky branch gets more complicated in topology from Map A through C. Map A contains one simple diversion, with a possible low travel time \( t_L \) and high travel time \( t_H \). In Map B, a bifurcation is added to the diverting route, where the safe detour has a deterministic travel time \( t_H \). The risky route has a low travel time \( t_L \) and a prohibitively long delay \( t_M \), which could be due to an incident. At Node i, a subject will receive real-time information on the realization of the travel time on the diverting route. Map C adds another bifurcation to the diverting route, upstream of the one in Map B, with two possible outcomes \( t_b \) and \( t_M \). Real time information is available at Node i1 and i2 on the realized travel time. Similarly the information at either node could help drivers avoid the extremely high travel time \( t_M \) on the diverting route. And a driver, while driving, takes into account the real-time traffic information to some extent in making en-route diversion choice at the Divert Point.

*Testing Dataset*

As shown in Figure 2, I-95 and I-895 are two alternative routes that pass through the tunnels under the Baltimore Harbor and eventually rejoin at the East Baltimore. They split approximately five miles prior to the Baltimore City. The DMS device is installed prior to the split and is often used for displaying actual travel time, delay, and diversion messages regarding these two alternative routes (Hamedi et al. 2011). A number of Bluetooth sensors are deployed along these two routes to detect the actual travel time as well as the en-route diversion behavior (Haghani et al. 2010).
While enormous traffic-related ground truth information is collected during the two week Bluetooth sampling period, two real world en-route diversion scenarios are observed and extracted for the analysis. Scenario 1 is shown in Figure 2a. In this case, the DMS device posted travel time messages about the congestion on I-95 and suggested drivers to divert to I-895. Scenario 2 is shown in Figure 2b, where the DMS device reported major delay on I-895 and diverted drivers to I-95/I-695 corridor. The date, duration, and traffic diversion rate of these two scenarios are reported in Table 1.

To determine the baseline diversion rates, times when the DMS device displayed free-flow travel times are used. During the time periods when diversion messages were posted, the diversion behavior is significant (Masoud, et al., 2011). For instance, in Scenario 1, approximately 10% of I-95 usage decided to switch to I-895 corridor. And 95 effective Bluetooth samples are empirically observed in this case. Similarly, 212 effective samples are extracted in Scenario 2. Thus, in total, 307 testing examples are used in the following calibration process, with real-time travel time information collected by the Bluetooth detectors.

### RESULTS

For the calibration function of the class-conditional densities, a Gaussian and a generalized extreme value (GEV) are fit to each of the class conditional densities using the usual maximum likelihood estimates. The fits of these two functions represent a qualitative comparison between using symmetric distributions and using asymmetric distributions to approximate the class-conditional densities. Figure 2 shows the calibration function fits produced by these methods versus the testing behavior data. Performance measures are offered in the next subsection.

In general, the calibration results agree with the empirical observation. The average value for the naïve Bayes log-odds is approximately -0.5, which is consistent with the low diversion rates perceived from the testing dataset. In other word, the optimistic prediction estimated by the en-route diversion model is well captured and recalibrated by this Bayesian calibration process. For the diversion class (+), the test data curve plotted in Figure 6 skews towards the left side, as the en-route diversion model gives these observations higher

### TABLE 1: En-Route Diversion Percentage between I-95 and I-895

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>DMS and Date</th>
<th>DMS Duration</th>
<th>Average I-95 Percentage (%)</th>
<th>Average I-895 Percentage (%)</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4/6/2011</td>
<td></td>
<td>16:05–16:21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Base case</td>
<td>Free-Flow Travel</td>
<td>The same time periods as above of the other survey days</td>
<td>88.7</td>
<td>11.3</td>
<td>6.04</td>
</tr>
</tbody>
</table>
probability estimates to divert. And vice versa for the not-divert class (−).

**FIGURE 3: Estimated Class Conditional Score Densities versus the Actual Densities of the Testing Dataset (Source: Xiong and Zhang, 2013)**

![Figure 3](image)

### Performance Measures

The calibration function maps the estimated probabilities (i.e. log-odd scores) to the actually observed diversion rates. Now the evaluation of the calibration results is of concern. There are at least two types of performance measures that have been typically used in data mining to assess the quality of probability estimates: i.e. log-loss (Good 1952) and squared error (Brier 1950; DeGroot and Fienberg 1983). While actually meaning an overall improved prediction quality, a better score according to these rules sometimes has been loosely termed improving “calibration” (Bennett 2003).

This paper reports the average log-loss and mean squared error (MSE) for the performance measure of the calibration. The results are given in Table 2. Both calibration functions result in significant improvement for the model’s prediction accuracy, as the average log-loss statistic has been improved from -2.99 to -1.26 and -0.69 respectively and the MSE has been reduced from 0.19 to 0.13 and 0.09 respectively. And overall, asymmetric distributions (for instance, GEV in this case) tend to be empirically preferable and outperform symmetric distributions in terms of prediction accuracy.

<table>
<thead>
<tr>
<th></th>
<th>Average Log Loss</th>
<th>Mean Square Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Naïve Bayes</td>
<td>-2.9946</td>
<td>0.1897</td>
</tr>
<tr>
<td>Gauss</td>
<td>-1.2625</td>
<td>0.1311</td>
</tr>
<tr>
<td>GEV</td>
<td>-0.6861</td>
<td>0.0906</td>
</tr>
</tbody>
</table>

### CONCLUSIONS

Understanding en-route diversion responses of drivers under real-time information becomes a crucial issue in contemporary active traffic management to mitigate congestion. To achieve this goal, modeling effort and emerging data needs are discussed in this article. A Naïve Bayes model is developed for this binary en-route diversion decision (i.e. switch to the diverting route or stay on the normal route). Stated preference data collected from carefully designed driving simulator scenarios is employed in the model estimation. Due to the inherent bias from the simulator data, the prediction accuracy of the naïve Bayes model is shown by this paper to be over-optimistic. Then, this paper provides a Bayesian approach to calibrating the en-route diversion model using real-world en-route diversion data collected from Bluetooth sensors and Dynamic Message Signs.

The first contribution of the paper lies in the originality of the model. As an effective alternative to the typical discrete choice models that assume rationality and random utility maximization, the naïve Bayes classifier estimated by the paper takes a purely probabilistic perspective and predicts the posterior diversion rates based on the class priors. And the Bayesian approach to calibrating the naïve Bayes probability estimates provides a consistent and theoretically sound parametric method to transform the predicted diversion probabilities to the actually observed probabilities. This calibration approach is very flexible and the parameters can be easily estimated on a case-specific basis, which indicates a promising application potential.

This paper also remains a first research effort as an exploration of using Bluetooth based field data to evaluate and eventually calibrate an en-route diversion behavioral model. It bridges the gap between the real world en-route diversion situation and the simulated driving experiments and stated scenarios, which have been used for modeling for decades.

Given the ease of estimating the parameters of this model as well as the calibration functions, the model is operational, and ready to be integrated with traffic models (e.g. microscopic traffic simulators, dynamic traffic assignment models) or demand models (e.g. activity-based/micro-simulation models) for various transportation operations and planning applications that require en-route diversion analysis. The case study of I-95/I-895 diversion presented in this paper highlights the potential of applying this model to analyze en-route diversion behavior in congested commuting corridors, help evaluating DMS, ATIS, and other traffic operations strategies, and improve the aforementioned traffic/demand models’ sensitivity to real-time traffic information and en-route congestion.
REFERENCES


THE IMPACT OF HIGH OCCUPANCY VEHICLE POLICY ON TRAFFIC PERFORMANCE OF DR. DJUNDJUNAN STREET IN BANDUNG INDONESIA

Author:
Yohanes Samuel
Civil Engineering Department
Parahyangan Catholic University, Bandung, Indonesia

ABSTRACT

Dr. Djundjunan Street is an arterial road in Bandung and located after Pasteur Toll Gate. This street usually experiences the domino effect from the vehicular queue at Pasteur Toll Gate, especially during weekend periods. Traffic congestion on Dr. Djundjunan street cannot be avoided and therefore Bandung Municipality establish a high occupancy vehicle program named “4 in 1”. The impact of this policy is traffic congestion on Prof Dr. Surya Sumantri Street which is located parallel to Dr. Djundjunan Street. In order to provide solution of the problem, evaluation of this policy is crucial.

INTRODUCTION

Indonesia is a developing country with high population growth rate. Badan Kependudukan dan Keluarga Berencana Nasional (National Family Planning and Population) noted that the growth rate is increasing 1.49% per year (BKKBN, 2013). This condition triggers a rapid increase in the number of vehicles. Central Bureau of Statistics noted that in 2012, the number of vehicles has reached 94,373,324 units and the growth of number of vehicles has reached 10.25% (Central Bureau of Statistics, 2013).

Bandung the capital of West Java province is the fourth most populous city in Indonesia. It located near Jakarta the capital city of Republic of Indonesia, so that Bandung is a strategic location for economy, business, education, and culture activities. In the year 2013, vehicles growth rate in Bandung is 11% per year (Head of Traffic Police Corps of the Republic of Indonesia, 2014). For the distribution of transportation modes, users prefer to use their private vehicles, which are motorcycles (56%) and private cars (31%) rather than use public transports (13%). Bandung Transportation Agency (DisHub Bandung) had noted that last five years, the road network growth is just over 1%. The total scale of road networks area in 2011 was 3% of the total area in Bandung. Ideally, 10% to 30% of the total area in Bandung is supposed to be functioned as road networks (Bandung Transportation Agency, 2011).

During weekends, Bandung is always crowded by domestic tourists, especially from Jakarta. The tourists shop and attend family gathering in Bandung. Because of that, Pasteur Toll Gate, as one of inner gates to Bandung is usually busy. The number of vehicles that enter Bandung through Pasteur Toll Gate in 2013 was 14,128 unit vehicles per day during the week (Kurniawan, 2013) and increased up to 36,000 vehicles during long weekend (Mulyawati, 2012). Dr. Djundjunan street as an arterial road in Bandung and located after Pasteur Toll Gate usually experiences the domino effect from queue vehicles at Pasteur Toll Gate.

Bandung Transportation Agency (DisHub Bandung) noted that during peak hours on the weekend, the number of vehicles enter Dr. Djundjunan street from Pasteur Toll Gate is 10,011 vehicles per hour which is greater than the capacity of Jalan Dr. Djundjunan (7,529 vehicles per hour). Bandung Transportation Agency (DisHub Bandung) implemented high occupancy vehicle named “4 in 1” every Saturday from 09:00 until 13:00 pm (Soedrajat, 2013) according to Bandung mayor’s actNo.551/Kep.582-DisHub/2013 about determination of area traffic control and liability of at least four persons in one private car on certain roads in the city.

The objective of the policy is to aim the reduction of number of vehicles that pass through Dr. Djundjunan Road but can increase the number of passengers. But many people think that this policy is ineffective.
and extends a negative effect for other adjacent roads especially on Prof. Dr. Surya Sumantri street (Baso, 2013). Therefore, evaluation of this policy is crucial. The research objectives are analyzing the traffic performance of Dr. Djundunan street due to the implementation of “4 in 1” policy and then evaluate the impact of the policy on Prof Dr. Surya Sumantri street as a parallel street to Dr. Djundunan street.

CONCEPT OF HIGH OCCUPANCY VEHICLE

In United States of America, the implementations of high occupancy vehicle (HOV) system concept have been proven to be flexible and cost effective alternatives in increasing the capability of congested urban transportation systems to move people. HOV facilities are an effective means of moving people; they encourage significant numbers of commuters to choose to ride a bus, vanpool, or carpool for reach their destination. The intent of HOV systems implementations is to help maximize the number of persons moved on a roadway by increasing the average number of persons per vehicle. In U.S., developing a high-occupancy vehicle project typically involves designating a special roadway or lane(s) that is reserved for exclusive use by high-occupancy vehicles during at least portions of the day. But in Indonesia, especially in Bandung, Bandung Municipality has a crucial issue with land use and creation of a new lane only for HOV lane is not realistic. Local government had already agreed that all of existing lanes leading into the city of Bandung at Dr. Djundjunan Road are applied with HOV

High-occupancy vehicles projects cannot be applicable everywhere. The reasons why high-occupancy vehicle system project is the right choice to be applied in Dr. Djundjunan Road are listed below.

• Increase the Average Number of Persons per Vehicle. High occupancy vehicle are designed to get single occupant drivers choose to use public transportation. HOV on Dr. Djundjunan Street provide to move more people in less vehicles, especially during the weekend.
• Preserve the Person-Movement Capacity of the Roadway. A single high occupancy vehicle lane assures that capacity will be available in the future to serve growth in person travel.
• Enhance Bus Transit Operations. Because of HOV, more commuters will prefer to use public transport, especially buses. But in Bandung, so far there isn’t any public transport that can be trusted or can be relied on because of challenges within Bandung’s public transport.
• Capital Costs. High occupancy vehicles facilities are relatively inexpensive, so this is the best choice for the city of Bandung limited funding.
• Public Operating Cost are Low. Because of the HOV policy, one car that passes through Dr. Djundjunan Road contains at least four persons. This car trips are served at a very low marginal public costs, because HOV policy makes the car operates more effective. As a result, total public operating cost per passenger on HOV facilities is low.
• When a decision is made by Bandung Municipality to apply HOV as a solution the congestion problem, other considerations that enhance high-occupancy vehicles success should also be considered. The considerations are listed below:
• High-occupancy vehicle lanes should be implemented as new lanes. Conceptually, an HOV lane can be created either by adding a new lane to a facility, which is then designated as an HOV lane, or by taking a lane away from general purpose traffic and designating it as an HOV lane. It was mentioned earlier that Bandung has a crucial issue about land use and creation of a new lane only for HOV lane is not realistic. Local government had already agreed that all of existing lanes leading into the city of Bandung at Dr. Djunjunan Road are applied with HOV
policy.

• High-occupancy vehicle lanes involve a system improvement. In addition to providing an exclusive lane for use by high occupancy vehicles, successful implementation of an HOV project generally involves providing a system of improvements. Some of these complementary system improvements involve construction of physical facilities; such as bus transfer centers, park-and-ride lots, and HOV bypass ramps. In Dr. Djundjunan Road, this action hasn’t been implemented. So great hope that local government can improve the HOV system with adding additional facilities that will help the HOV policy to obtain set goals. The success and acceptance of an HOV project can be highly dependent on pursuing the appropriate package of complementary actions and strategies. Simply constructing or designating a roadway lane as a priority HOV lane does not assure that the project will succeed.

• High-occupancy vehicle projects often involve multiple agencies. Transit agencies are frequently responsible for providing some of the support facilities and services that are needed to maximize HOV lane effectiveness. For example; because of Dr. Djundjunan Road applied “4 in 1” policy, personal commuters who need to travel through Dr. Djundjunan Road can use bus transit facility or another transit facilities, so they can pass through Dr. Djundjunan Road. If they bring their personal car, they can park their car at parking lots that other agencies provide. So in this case there are two additional agencies that are involved at this situation. These agencies are needed to make “4 in 1” policy a success. Unfortunately proper implementation by the local governments has been unsuccessful. Decisions have to be made regarding agency participation for funding of capital and operating costs.

DATA COLLECTION

Primary data and secondary data were collected in this study. Primary data is carried out several times on Dr. Djundjunan street and Prof. Dr. Surya Sumantri street at the same time in Bandung during 09:00 until 13:00 in 18th and 25th of October, 1st and 8th of November 2014. The field data are traffic volume per hour and vehicle speed per hour. Secondary data was obtained from Bandung Transportation Agency (DisHub Bandung). The secondary data are vehicle speed per hour and traffic volume per hour on Dr. Djundjunan street and Prof. Dr. Surya Sumantri street in 2011 when the “4 in 1” policy had not been established by Bandung Transportation Agency (DisHub Bandung).

DATA ANALYSIS

Comparing the primary data and the secondary data about vehicle speed per hour and traffic volume per hour at Jalan Dr. Djundjunan and at Jalan Prof. Dr. Surya Sumantri using a statistical hypothesis test, it can be called as “t test”. This test is used for finding the best acceptable conclusion about whether “4 in 1” policy is the right decision to answer the congestion problem. If the answer is no, another option must be made so the problem can be solved. From the primary data and the secondary data, degree of saturation value can be calculated. The degree of saturation value calculated can be compared using a statistical hypothesis test.

\[
\text{To calculate degree of saturation:} \\
\text{DS} = \frac{Q}{C}
\]

With:

\[
\text{DS} = \text{Degree of saturation} \\
Q = \text{Traffic flow} \\
C = \text{Road capacity}
\]


\[
\text{Pooled Standard Deviation:} \\
SP = \sqrt{\frac{(n_1 - 1) \times S_1^2 + (n_2 - 1) \times S_2^2}{n_1 + n_2 - 2}}
\]

With:

\[
SP = \text{Pooled standard deviation} \\
n_1 = \text{Total data from the first sample} \\
n_2 = \text{Total data from the second sample} \\
S_1 = \text{Standard deviation of first sample} \\
S_2 = \text{Standard deviation of second sample}
\]

\[
\text{Statistical Test:} \\
t = \frac{(\bar{y}_1 - \bar{y}_2)}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}}
\]

With:

\[
\bar{y}_1 = \text{Mean of first sample}
\]
CONCLUSIONS

Many drivers passing through Dr. Djundjunan Road from Pasteur Toll Gate and several local government parties think that this policy is ineffective; even give a negative effect for other roads adjacent especially Prof. Dr. Surya Sumantri Road. If the implementation of HOV projects in Jalan Dr. Djundjunan isn’t on a right target, we can agree with the negative thoughts about that policy. The analysis of this policy must be done to produce the best solutions. Many advantages in the implementation of HOV projects can move large numbers of people with fewer vehicles and the system is inexpensive so this policy is the right answer for Bandung because of Bandung’s limited funding, increasing the number of persons per vehicle and reduces the rate increase in vehicle-miles of travel, which lessens transportation energy consumption. But the implementation of this project can create congestion on Prof Dr. Surya Sumantri Street running parallel to Dr. Djundunan Street.

Implementation of this policy is still not perfect. Much work must be done by Bandung Municipality so the policy can achieve its goal and can bring the best result. If Bandung Municipality wants to improve the performance of “4 in 1” policy, than first thing Bandung Municipality should do is improving the public transportation facilities especially on Dr. Djundjunan street. With the policy move along with the good public transportation facilities, it can be confirmed that the traffic volume on Dr. Djundjunan Street will decrease.

REFERENCES


THE KILLER TREE PROBLEM

Author: Bradley J. Winkelbauer, E.I.T.
Civil Engineering
University of Nebraska-Lincoln

RESPONDING TO THE FOLLOWING PROMPT
What steps need to be taken to place road safety at the same priority level that the environmentalists have on a road project? No road projects can be started without an environmental study. Why not require the same for a road safety audit? Why is it that a killer tree that is located close to the road and has killed errant motorists cannot be removed because of environmental concerns? Who is responsible the next time this killer tree kills another motorist causing a needless death?

BACKGROUND
For over 40 years, impacts with roadside trees have been one of the most common, and deadly, crash types. Vehicle-tree crashes are responsible for more fixed-object crashes annually than any other fixed object on the roadside, and result in over 3,000 fatalities annually in the United States, accounting for 28% of crashes with fixed objects [1]. Moreover, many state DOTs and municipalities have limited reaction to these tree deaths because of social and political pressure to retain the trees. However, removing killer trees from the roadside would result in significant safety and economic benefits. Yet, environmentalists continue to get priority when it comes to tree placement, despite several glaring safety problems with roadside trees located near streets and highways.

The frequency and severity of tree crashes are strongly related to the tree’s location and proximity to the road. A study [2] in 2005 on Massachusetts roadways found that fatal tree crashes are most prevalent on local rural roads, followed by major rural collectors, and other roads, with 90% of all fatal tree crashes occurring on two-lane roads. A summary of the distribution of fatal tree crashes per functional class is shown in Figure 1. More accidents occur between 0 to 12 feet from the travel lane, with significantly less between 12 to 30 feet. Additionally, more than 60% of the tree collisions involved drivers that had been drinking and over 60% of the fatalities were under the age of 35 [3]. Trees are addressed in the Strategic Highway Safety Plan [2], but recommendations were limited to clear zone treatments. Tree crash prevention is not currently well defined in design policies; therefore, mandatory safety measures are not in place to reduce the frequency and number of fatalities.

Road Safety Audits
Environmental studies are completed before any road project can be started. Unfortunately, road safety
audits are not often required. The road safety audit is a systematic procedure that brings traffic safety knowledge into the road planning and design process to prevent traffic crashes [4]. The purpose is to assess the current conditions of the roadway and make suggestions to minimize death and serious injury. These audits can be completed for new construction, as well as for rehabilitation projects on existing roadways. The audit will work toward lowering the number of needless fatalities associated with vehicle-tree crashes. Road safety audits will also allow changes to be made to the road design before installation and could reduce possible litigation costs. Audits are very common around the world, but they have not yet become standard practice in the United States.

A road safety audit can greatly help place road safety at a similar priority level to that associated with environmental concerns, such as clean water and clean air. The results of each of these studies must be considered in conjunction so there are no conflicts. In one such instance [5], $12,000 was spent to conduct a road safety audit in which the following suggestions were made: install curve warning and chevron signs; paint thicker edgelines; and remove trees along the roadway. These safety improvements totaled $23,000, reduced the crash rate by 3.5% and resulted in a benefit-to-cost ratio of 20:1. This is a dramatic example of the safety and economic benefits that road safety audits can provide. These need to be as commonplace as environmental audits, because the safety of the road users is believed to be as important as most environmental concerns.

Causes of Needless Deaths

Some factors that may contribute to vehicle-tree crashes include presence of horizontal and/or vertical curves, excessive speed, inadequate clear zone, and high tree density. Of these, it was found in the Massachusetts study [6] that speed limit, clear zone, and tree density have the greatest impact on the number of fatal tree collisions. Crashes with trees are far more dangerous than crashes with other vehicles, because the consequences are often greater when the object involved in the collision is rigid, narrow, and lacks energy absorption. Although crashes with vehicles are far more common, head-on crashes with fixed objects are far more injurious than vehicle-to-vehicle crashes. Based on the increased risks for vehicle-tree crashes, a road safety audit should be performed along with an environmental audit to identify critical road safety concerns.

Despite the need to remove trees from within the clear zone, there is major public resistance to eliminating, reducing, or relocating roadside trees due to their aesthetic appeal and perceived environmental road benefits. Trees collect stormwater runoff that would otherwise drain into local streams. However, falling leaves and branches can clog sewer drains and make the stormwater runoff problem significantly worse. Trees may help to reduce erosion and can even reduce the surface temperature of the pavement by providing shade. However, shade can also prevent chemical treatments from reaching an activation temperature to properly melt snow and ice on the roadway. Further, trees may not like to be close to nearby road salts and other de-icing chemicals as well as petroleum-based products that splash onto nearby soils. Trees can also be used to screen out commercial areas that may be displeasing to drivers. Sound walls can also provide the same benefits and have the added benefit of being crashworthy. In all, it is important to realize that the efficiency and safety of streets are more important than placing trees near the road and other environmentalists’ concerns.

Benefits of Removing Trees

The first major benefit of removing or relocating trees that are close to the roadway would be increased motorist safety with the elimination of rigid, discrete hazards. The best way to obtain this benefit is to adopt the clear zone concept. A clear zone is defined as the distance adjacent to the road edge that is free and clear of fixed objects, which could damage a vehicle and harm occupants upon impact [7]. By clearing the area of rigid hazards, a driver can safely return to the road or bring the vehicle to a safe stop before encountering additional harmful consequences. A 30-ft clear zone is often recommended for high-speed, rural roads, while a 10-ft clear zone is often noted for low-speed roads [2]. Figure 2 depicts trees within the clear zone, which can cause crash and sight distance concerns. As noted above, a reduction in the number of vehicle-tree crashes can be achieved with the use of a clear zone.

FIGURE 2: Median Trees Near Traveled Way (Lincoln, Nebraska)
of trees having a negative impact aside from fatalities is the economic strain they place on municipalities. Most noticeably, sidewalk maintenance due to tree root growth has become a recent issue in numerous cities across the country. In the city of Lincoln, Nebraska, over $6.5 million has been allotted in the past two years for the repair of over 1,550 sidewalks [8]. Although trees are not the only cause for requiring sidewalk replacement, they have caused excessive damage and cost cities like Lincoln a significant amount of money. Sidewalk repairs can cause municipalities to greatly increase budgets for general tree maintenance. Further, trees have caused damage to other city infrastructure, such as roads, curbs, and sewers. This finding fortifies the fact that urban roadside trees may be causing more harm than good when placed close to the traveled way.

**Potential Solutions**

In order to bring road safety and environmentalists’ concerns to the same level, a few concepts can be used. Initially, not all trees may need to be removed or relocated, as high-risk locations should be treated first, such as near curves along roads with speeds of 30 mph or greater. Streets can still remain aesthetic and livable with trees located outside the clear zone. Planting guidelines must be put into place and require minimum lateral distances to edge of traveled way for tree placement based on the posted speed limit of the roadway. Initial placement criteria may be based on the 10 ft and 30 ft suggested clear zones for low and high speed roads, respectively.

The concept of layering trees can also prove beneficial and allow trees in regions to enhance aesthetics. Layering involves placing small shrubs and bushes closer to the road, with small diameter, less injurious, mature trees placed farther behind the shrubs. Larger trees can be used when located farther outside the clear zone. By placing differing levels of foliage before the large trees, some limited energy can be dissipated before the vehicle reaches the most harmful object with additional lateral space for errant vehicles to recover. Layering may be the most important in urban roadway medians, such as in Figure 3, where small diameter trees are placed within the clear zone. When considering layering and tree sizes, it is important to remember that trees expand in size over time. It has been suggested to limit roadside and median trees to 4 in. diameter or less to reduce crash severity. However, it is important to note that a 4-in. diameter tree may grow into a 10-in. diameter tree in 10 to 15 years. Layering with small diameter trees would still allow the foliage to be in place along the roadside, but it would reduce the risk of killer trees due to an increased lateral offset to the traveled way combined with a small diameter, mature trunk.

**CONCLUSION**

Street trees, as they are currently being used, are dangerous and expensive to maintain. A decision to move trees farther away from the traveled way can save lives in the long term. By removing trees from within the clear zone and/or relocating trees beyond the clear zone, both roadway designers and environmentalists could be satisfied. Layering, when the median is wide enough, can also provide a safe approach and keep large trees outside of the clear zone. Efficiency and safety of roadways needs to become the focal point of roadside design. The epidemic level of roadside tree fatalities is a growing concern, yet with collaboration between competing arguments, less people will die as a result of vehicle-tree collisions. Collaboration will follow when greater responsibility and liability is doled out to the roadway engineer, environmentalist, and road authority. In this case, the safest design option will be chosen and less needless deaths will occur.
REFERENCES


THE MINIMUM SAFETY SERVICE STANDARD ON PADALARANG - CILEUNYI TOLL ROAD

Author:
Dessy Dwi Ros Aninda
Civil Engineering Department
Parahyangan Catholic University
Bandung, Indonesia

ABSTRACT
Padalarang - Cileunyi toll road is one of the toll roads in West Java, Indonesia. It crosses Bandung City, Bandung Regency, West Bandung Regency, and Cimahi City. Padalarang - Cileunyi toll road accommodates high traffic and as an alternative way to decrease traffic congestion. In order to minimize traffic problems, Padalarang - Cileunyi toll road is required to fulfill minimum service standards. The substance of toll road safety service indicators are traffic sign, road markings, guide posts, stakes km per 1km, right of way, and handling of accidents. The purpose of this study is to evaluate the performance of Padalarang-Cileunyi toll road towards fulfillment of minimum service standards of toll road in order to maintain operational effectiveness. This study will be beneficial for other toll road in Indonesia to fulfill the minimum safety standard.

INTRODUCTION
Indonesia is a developing country that is still developing aspects such as economy, education, politic, social, culture and infrastructure. West Java Province is one of the 34 provinces in Indonesia with high population growth and rapid development in infrastructure, including transportation facilities. Transportation is the movement of goods and people from the origin to destination. It provides benefits to the community in terms of economical, social and political factors.

From the economic point of view, transportation helps move goods from the production sector in order to fulfill society’s needs. In terms of politics, transportation plays an important role for an archipelago country like Indonesia. It creates national unity between its people, making them grow stronger, as well as develops community services more evenly on every part of the Indonesian territory.

ACT NO. 38 IN 2004 IN INDONESIA
According to the Act No. 38 in 2004 in Indonesia, the road is the land transportation infrastructure that includes all parts of the road, including complementary buildings and equipment intended for traffic, which is at ground level, above ground, below ground and/or water, as well as on the water surface, except railroad, lorry road, and the cable.

The road parts include the road benefits space, road area and supervision of road space. The road benefit space covers the road, the curb line, and the safety threshold. Road area covers space and the benefits of certain downstream land beyond the benefits of the road while the supervision of the road space is a certain space outside the road area that is under the control of the organizers.

Traffic signs are some of the equipment that can be either symbols, letters, numbers, sentences or a combination of them that serves as a warning, ban, orders or instructions to road users. As a means to control traffic, especially to improve the safety and smoothness of the road system, the bullet made / installed markings and traffic signs that can deliver information (orders, prohibitions, warnings, and instructions) to road user, and can affect road users.

In order for a sign / markings to be effective, it must meet the following requirements:

- Specific needed
- Seen clearly
- Full of attention
- Clear and simple purpose
- Syntax fully respected and adhered to by the road user
- Provide sufficient time to respond

In order to have clear view for road users to see the sign, sign letter should contrast with the background, no obstructions such as plants or other overlap signs, located
at an adequate distance regarding speed limit, and is visible in the dark.

**TOLL ROAD**

According to the function, the network consists of public roads and special roads. Public road is a road reserved for common traffic, while the special is the roads built by the agency, individual enterprises, or community groups for their own interests. The government has authority to hold the road. Implementation of the road, as one part of the organizations of the transportation infrastructure, involved elements from society and government.

In order to provide optimum service, integrated road sectors including government, society, and business have to work together. Indonesia government build national road with status of toll roads wherein road users are required to pay a toll (Government Regulation of the Republic of Indonesia, 2005). This specification is intended to accommodate the potential for high traffic and alternative way to decrease traffic congestion. The toll road is expected to accelerate economic growth and improve the welfare of people’s lives in order to move more quickly, easily and safely.

A toll road is built with a consideration of the safety, security, and convenience of road users. The security factor can be realized with the release of a design area of criminal acts. Safety factors can be realized by the standard design of highway required including road geometric design, road furniture design, and road pavement design. Furthermore, comparison between the level of customer satisfaction and level of service quality is needed.

**PADALARANG - CILEUNYI TOLL ROAD**

Padalarang - Cileunyi toll road is one of the toll roads in West Java that crosses Bandung City, Bandung Regency, West Bandung Regency, and Cimahi City. The Padalarang – Cileunyi toll road operated in 1991 with a length of 58.5 km and is managed by PT Jasa Marga (Persero) Tbk. The environment around the toll road is mostly farming area, residential area, and industrial area.

Padalarang-Cileunyi toll road is expected to have capacity and level of service better than non-toll roads. Padalarang – Cileunyi toll road have eight toll gates with a range of booths from two to 13.

The availability of Norms, Standards, Guidelines, and Manuals related to the operation of toll road, are important references for good service infrastructure quality and toll roads facilities. There are minimum services standards consisting of measurement in the implementation of toll road management.

Government Regulation no. 14/2004, Article 8 controlled substance service includes four things (i.e. the condition of the toll road, average travel speed, accessibility, mobility and safety). While the Government Regulation No. 392/2005, added the substance regarding service unit for help/rescue and relief services.

In order to implement the rules and indicators values contained in the Minimum Service Terms (MST) the toll road still requires monitoring system that includes policies and procedures for monitoring the toll road concession in accordance with the MST. The implementation of this monitoring requires additional tools such as toll road operation mapping tool, which is equipped with available facilities, as well as a variety of operations, which covers traffic characteristics, traffic accidents, or road environment that is intended to support the monitoring system.

According to regulation of the Minister of Public Works No. 392/PRT/M/2005 regarding the Minimum Service Standards of Toll Road, routine and intensive monitoring system on Padalarang - Cileunyi toll road section is needed in order to provide the service. Traffic accidents are a major indicator of the road safety level. Traffic accidents cause much greater loss in terms of lives and money. Traffic accidents can be caused by several factors including human factors, vehicle factors, road geometrics, incorrect installation of traffic signs and road pavement factors. Accident rates are a quantitative measure or scale to describe safety condition of a road segment.

According to Minister of Public Works Act No. 392/PRT/M/2005 this study evaluates the performance of the Padalarang - Cileunyi toll roads, by examining toll road safety indicators comprised of signs, traffic regulation, road markings and right of way.

For all toll roads in operation, the indicators of minimum service standards for ruggedness is a maximum or five years to fulfill, and right of way fence indicator is a maximum period of three years with the implementation done in stages (Minister of Public Works No. 392 Section 8, 2005).

**CONCLUSIONS**

The purpose of this study is to determine the suitability of safety services towards fulfillment of the Toll Road Minimum Service Standards in order to maintain an effective operation of the toll road. Padalarang - Cileunyi toll road in West Java Province in Indonesia is the case study. Road safety service indicators used are traffic sign, road markings, guide posts, stakes km per 1km, right of way, and handling accidents. Related regulations, standards, manuals, and research reports regarding
safety of toll roads in Indonesia used as references. This study will be beneficial to other toll roads in Indonesia or other toll roads in developing country with similar traffic and geometric conditions.

REFERENCES
2015 IRF CALENDAR OF EVENTS

IRF Board of Directors & General Assembly
February 23–24, 2015
Paris, France

Certified Training: Asphalt Pavements
March 15–17, 2015
Riyadh, Saudi Arabia

Certified Training: Safer Roads By Design™: Across Six Continents
March 15–25, 2015
Kuala Lumpur, Malaysia

Executive Workshop Series: Proper Installation of Safety Devices
March 25, 2015
Sao Paulo, Brazil (During BRE)

Executive Workshop Series: Pavement Maintenance
March 26, 2015
Sao Paulo, Brazil (During BRE)

4th IRF Caribbean Regional Congress
May 4–8, 2015
Montego Bay, Jamaica

Certified Training: Safer Roads by Design™ Building Engineering Capacity
May 10–12, 2015
Riyadh, Saudi Arabia

Certified Training: Performance-Based Contracts
May 17–27, 2015
Kuala Lumpur, Malaysia

IRF International Pavements Congress
May 26–28, 2015
Santiago, Chile

Executive Workshop Series: Performance-Based Contracts
August 6–8, 2015
Toronto, Canada

Executive Workshop Series: Meeting the UN Decade of Action Challenge
August 31 – September 2, 2015
Panama City, Panama

Executive Workshop Series: Meeting the UN Decade of Action Challenge
September 22–25, 2015
Santiago, Chile

Certified Training: ITS from Concept to Reality
October 12–15
Riyadh, Saudi Arabia

Certified Training: Public Private Partnerships
November 8–18, 2015
Kuala Lumpur, Malaysia

Bridge Maintenance & Inspection
November 22–24
Riyadh, Saudi Arabia

2nd IRF Africa Regional Congress
December 1–3, 2015
Nairobi, Kenya

Certified Training: Safer Roads By Design™: Across Six Continents
December 6–16, 2015
Orlando, Florida USA

2015 IRF WEBINARS

The IRF continues its initiative to provide world-class training content through web based media. Below is the 2015 schedule of IRF e-Learning Webinars. Webinars are complementary for IRF Members and can be viewed by non-members for US $129.

January 5: Bridge Inspection & Maintenance
January 28, 2015: Vulnerable Road Users
February 25, 2015: Work Zone Congestion Mitigation
March 25, 2015: Rural Road Maintenance
April 29, 2015: Pedestrian Safety in the Work Zone
May 27, 2015: The Traffic Police Integrity Challenge

June 24, 2015: Emergency & Incident Management (pt 2)
July 29, 2015: Tunnel Safety
August 26, 2015: Climate Change & Building Resilient Roads
September 30, 2015: ITS Applications for Road Safety
October 28, 2015: Funding Long-term Road Maintenance
November 18, 2015: Managing Mega Projects

This document is current as of May 14, 2015.
**WHO YOU NEED TO KNOW**

The International Road Federation has a major role to play in all aspects of road policy and development worldwide:

- For governments and financial institutions, we provide a wide base of expertise for planning road development strategy and policy.
- For the private sector, we are business network, a link to multilateral institutions, and a platform to access government officials and decision makers.
- For the community of road professionals, we provide an invaluable advocacy and knowledge sharing platform.

**IRF MEMBERSHIP**

With a presence in 116 countries, membership in the IRF is a compelling value proposition that confers the prestige of belonging to the best-recognized global advocate for better roads.

“Since 1948, the IRF’s mission has been to encourage and promote the development and maintenance of better, safer and more sustainable roads. Today, there has never been a better time to be part of the global network of IRF Members.”

Eng. Abdullah Al-Mogbel
IRF Chairman

**MEMBER SERVICES**

How IRF members are utilizing their membership to advance their goals

*based on member survey - % may exceed 100%*

- **USE IRF KNOWLEDGE SERVICES TO MAKE BUSINESS DECISIONS** 63%
- **NETWORK AT IRF CONGRESSES** 41%
- **ATTEND CERTIFIED TRAINING & WEBINARS** 32%
- **USE IRF ADVISORY SERVICES** 27%

For more details, please contact arafiq@IRFnews.org or visit [www.IRFnews.org](http://www.IRFnews.org)
IRF EXECUTIVE COMMITTEE

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Ministry of Transport, Kingdom of Saudi Arabia

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* Denotes Ex-Officio Member
The INTERNATIONAL ROAD FEDERATION is a full-service membership organization founded in Washington, D.C. in 1948. The IRF is a non-governmental, not-for-profit organization with the mission to encourage and promote development and maintenance of better, safer and more sustainable roads and road networks around the world. Working together with its members and associates, the IRF promotes social and economic benefits that flow from well-planned and environmentally sound road transport networks and advocates for technological solutions and management practices that provide maximum economic and social returns from national road investments.