IRF Examiner

Sharing Knowledge Across Borders

IRF STUDENT ESSAY LAUREATES

Volume 10, Summer 2016

"Better Roads. Better World."

IRF Examiner ISSN: 2411-3867

IRF Examiner

Volume 10, Summer 2016

"IRF Student Essay Laureates"

IRF EXAMINER: SUMMER 2016, IRF Student Essay Laureates

Articles edited for length by the IRF with the authors' permission.
The full papers form part of the proceedings of the 17th IRF World Meeting & Exhibition.

EDITOR

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Printed in the United States of America
IRF Examiner ISSN: 2411-3867

PREVIOUS EDITIONS

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 tenth 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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ENHACEMENT OF CURRENT ANTICORRUPTION PRACTICES TO IMPROVE TRAFFIC SAFETY

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INTRODUCTION

According to the World Health Organization (WHO) (2013), about 1.24 million people die and 20 to 50 million are injured in traffic crashes each year. Traffic is the eighth leading cause of death on a global scale, and is expected to reach the fifth position by 2030. Further, it is the primary cause for young people's deaths (aged 15-29 years) (WHO, 2013).

Investigation of events leading to traffic crashes is crucial in inhibiting the occurrence of crashes (U.S. Department of Transportation, 2008). Malfunction of vehicles, road condition and human factor are the main crash contributors (U.S. General Accounting Office, 2003).

The WHO (2004) defined major behavioral contributors to road crashes: alcohol or sleep deprivation combined with vehicle operations, inappropriate speed and non-use of protective equipment (e.g., seatbelts, child restraints, and helmets).

Education, engineering and enforcement help overcome these traffic safety impediments. Educating individuals on their responsibility and rights and making the roads and vehicles more forgiving through engineering, require legislation.

Effective enforcement of traffic safety policies is important for traffic fatalities reduction, but is often diminished by police corruption. Corruption is defined as misuse of authority for personal advance (The World Bank Group, 1997). Lindgren (1993) described most common acts of corruption in traffic police: bribery and extortion. These specific, usually overlapping actions, represent corrupt payment either given or taken, to influence officials' operation.

A typical case might involve traffic police halting a driver without explanation, and demanding bribes before letting him or her proceed. Processing unjustifiably demanded driver licenses and vehicle certificates is another example. Corrupt police bring inefficiency and unfairness. Further, genuine traffic policing is diluted by corruption when officers' efforts are diverted away from meaningful enforcement. Instead of time going to bribery, it should go to the impaired driver, speeding in an unsafe vehicle.

A BRIEF SUMMARY OF CORRUPTION ISSUES

Hors (2000) asserted that although evident in developed countries, corruption is especially wide spread in developing countries and is accepted. Hors expanded this statement by defining obstacles in corruption combat: economics and politics. Developing countries do not have the same means as developed countries to combat corruption. Also, politicians are generally not ready to take a stand against corruption, because it might lead to disciplinary sanctions. (Hors, 2000)

According to Ivkovic (2003), people of the State of Latvia consider their traffic police the most corrupt agency in the country, extracting bribes in every third encounter. Moreover, Cambodian traffic police extracts bribes in 4 out of 5 cases.

Neild (2007) reported that Nigerian and Mexican citizens expect to bribe police whenever they meet. Further, Ghanaians and Ugandans admit to bribing police in 92% and 63% of cases, respectively. Vehicle stops in Russia and Eastern Europe are associated with routine unlawful disbursements. (Neild, 2007)

CURRENT PRACTICES OF ANTICORRUPTION

Anticorruption measures can improve traffic safety. Strategies in Vietnam decreased number of traffic fatalities

in capital city by 10%. (Anbarci, Escaleras, & Register, 2006)

Countries around the world facing corruption in traffic use combinations of measures. Measures concerning police officers involve: added employment benefits, monitoring and control of their operation and increased sentence if involved in bribery/extortion. Further, education of both officers and public through media is a common approach. Finally, advancement of technology is extensively used for decrease of contact between officers and public, and for easier corruption detection.

Mexico, Georgia, Hong Kong and Singapore represent developing countries/regions according to United Nations (UN) classification. (Development Policy and Analysis Division, 2014)

Among these four nations, only Mexico has been unsuccessful in fighting traffic police corruption- over 70% of people still has little or none confidence into traffic police force. Comparison of Mexico's experience with other three nations' might be useful in anticorruption measure improvement. However, Mexico identified one successful measure: Mexico City introduced the deployment of purely woman-based police patrols. The rationale for this measure was based on the belief that women are naturally less corrupt and fairer than men. This unit issued over three times more tickets in comparison to their male co-workers. This accomplishment suggests that involving more women in traffic police departments might bring success in fighting corruption. But, Mexico's overall result demonstrates presence of shortages:

- Media involvement and public exposure were introduced in all of these nations, but the influence of discrediting in different cultures has to be noted. For example, a research conducted by Sznycer, et al. (2012) investigated the cultural influence on feeling of shame. The results revealed that Japanese subjects were more shame-prone than their British and American counterparts. Mexico might be also less sensitive to community dishonor.
- Mexico did not offer training on corruption to police officers. Singapore and Hong Kong did. The nation of Georgia used hotline for complaints and the readiness to report corruption increased. The number of non-anonymous reports in Georgia increased drastically because public there felt safer and more successful when whistleblowing than before. In contrast, Mexico did not involve public at all. Combat against corruption placed other officers and public only as observers, not as an active participants in discovering corruption. Mexican anticorruption fight relied solely on monitoring units and cameras, neglecting another excellent source of data.
- Mexico implemented negative motivation by introducing prison punishment. In contrast, Singapore's police are positively motivated with increased salaries and introduced benefits.

Additional effective measures conducted in the nation of Georgia involve use of technology: video cameras, payments only through bank accounts, and simplification of vehicle license and registration service process. Hong Kong emphasized importance of anticorruption education by offering seminars and establishing a website. Singapore highlighted a hiring process of police officers and their corruption training.

Anticorruption measures adopted by the developing countries are presented in Table 1.

Table 1: Anticorruption Measures in Developing Countries

Source:	Anticorruption measures:	Overall Result:
Mexico (Mexico City)		
(Anozie, Shinn, Skarlatos, & Urzua, 2004) and (Sabet, 2014)	Increased penalties for bribery and prison sentence is introduced	Almost 70% of public has little or none confidence into traffic police
	Monitoring unit is hired to control traffic patrols	
	Installment of standing cameras by the road	
	Media involvement in public naming and shaming of bribery partakers	
Georgia, Asia		
(The World Bank, 2012)	Entire traffic police force of 16,000 officers is fired in a day and replaced by new officers	First in the world in terms of relative reduction in the level of corruption in 2010.
	Undercover agents are used to control police officers	
	Fines are paid through bank accounts, not in cash	
	Video cameras are installed by roads	
	Introduced hotline for corruption complaints	
	Media campaigns are applied to affect people's attitudes towards traffic police	
	Technology implementation in vehicle license and registration service	
Hong Kong		
(Man-Wai, 2006)	Collaboration with media to publicize effective enforcement cases and for education	Increased readiness to report corruption (75% of complaints are non-anonymous)
	Websites for youth education and ethics development are established	
	Corruption prevention seminars are offered to police officers	
Singapore		
(Quah, 2006)	Increased salaries and benefits of traffic police officers	Corruption is very low
	Careful investigation of employee's backgrounds	
	Well-conceived training on corruption	
	Media involvement in public naming and shaming of bribery partakers	

Hungary, United Kingdom, Australia and the Czech Republic are "developed countries" through UN categorization (Development Policy and Analysis Division, 2014).

Two particular measures failed in Hungary. First, police officers used to be entitled to determine fines according to the offender's family status and income level, which

left the opportunity for corruption (Kosztolanyi, 1999). Second, strict policy established in 1999, increased fines by 500%. This had a negative effect. The number of fines fell by 20% (Pap, 1999). The high fines encouraged corruption.

Hungary offers immunity for one of the participants in a bribe, if reported on time. Whistleblower protection can increase the risk of bribing and decrease the risk of incrimination. United Kingdom took this approach, too. The example of the United Kingdom shows that even countries with low levels of corruption have to be persistent in this fight by finding new ways and establishing new policies to kill it. Australia uses cameras, GPS technology and background checks on officers thoroughly. The Czech Republic's efforts to diminish contact between officers and public through cameras at intersections and use of bank accounts exclusively for payments, gave positive outcomes.

Procedures used in developed countries to tackle corrupt behavior amongst traffic police are presented in Table 2.

Table 2: Anticorruption Measures in Developed Countries

Source:	Anticorruption measures:	Overall Result:
Hungary		
(Open Society Institute, 2002)	Provided corruption training programs to officers	Bribe-taking decreased
	Imunity offered to one party of a bribe if reported on time	
	Police officers are not allowed to accept any fines on the spot	
United Kingdom		
(Department for Business, Inovations & Skills, 2014)	Continuing fight against corruption	Corruption is not prevalent
	Protection of whistleblowers	
	Clearly defined core principles and high standards of behavior	
Australia		
(Porter & Prenzler, 2012)	Officers subjected to a range of integrity and suitability checks	Corruption is very low
	Cars equipped with cameras with video recording	
	Cars equipped with GPS allowing patrol vehicles to be tracked	
Czech Republic		
(Czech Republic - Corruption, 2013)	Using technology to automatically enforce traffic (cameras at intersections)	Corruption is decreasing
	Payments through bank accounts	

PROPOSED ENHANCEMENT OF ANTICORRUPTION MEASURES

The comprehensive review of anticorruption measures around the world shows that we need to improve. There follows a set of measures to contribute to addressing this.

1. Diagnose corruption and show that you care

   a. Use extensive online anonymous research. According to Ivkovic (2003), studying police corruption by surveying police officers and citizens usually encounters resistance. The reason is either "Code of silence" practiced by the officers or lack of motivation to reveal misconduct by citizens who were involved in it. Therefore, anonymous research will be more relevant. Also, online surveying format can substantially decrease the cost of research.

   b. Introductory surveys can be obligatory part of an electric bill payment. Later surveys should be mandatory with every vehicle registration. These reviews could examine if someone witnessed police misconduct or irregularity during vehicle registration or licensing and show the extent of it in the previous 12 months. This method would determine the trend of corruption change.

   c. Participants in surveys should be asked for their opinion on what are the reasons for traffic police corruption. This helps define weak spots in traffic department and provides ideas for future anticorruption measures. It also convinces public that the government is enthusiastic about fighting the corruption.

2. Education

   a. Mandatory seminars with topics on traffic safety and ethics need to be offered twice a year within department. The consequences of corrupt activities need to be emphasized. This should create higher awareness of police officers.

   b. Public needs to be informed on their rights and obligations not only through media (TV, radio, internet), but through formal education as well. Primary and high schools should have a workshop once a year about importance of traffic safety measures and proper enforcement. The result of this is early involvement of each citizen in fight against corruption.

3. Increase penalty for unethical behavior

   a. Police officer can abolish retirement benefits and possibility of getting a bonus after the first passing corruption complaint. He should be fired after the second violation.

   b. The bribe offerer can be protected if reports it in 24 hours. If he/she fails to do so, punishment should be monetary and license points should be reduced. If police officer declines the bribe, the driver will still be prosecuted for proposing it.

4. Establish interdepartmental control

   a. Random co-working officer will have to analyze audio and video recordings of the employee's encounters with public semiyearly, and write a report.

   b. Internal control, as a separate unit, should have access to all recordings and reports, too. If an internal

control discovers unreported corruption, both officers (corrupted officer and co-worker who has written the false report) will be equally punished. Maintaining ethics will become a team assignment for the entire department.

5. Technology incorporation

   a. Driver's examination centers and vehicles used for licensing drivers need to be equipped with cameras. Vehicle inspector needs to record his/her examination and the owner should submit the video with other registration paperwork.

   b. Registration and licensing process has to be simplified and majority of paperwork should be possible to submit online.

   c. Every patrol vehicle should have audio/video recorder. Also, small audio/video recorders can be attached to the officers' uniforms to record discussion with traffic violator. Officers should be obliged to communicate with public only while recorded.

   d. Public should be allowed to record encounters with police officers without prior announcement. This leads toward the increased possibility of getting caught.

   e. Payment of fines needs to be possible exclusively through the traffic department's website.

CONCLUSIONS

Incorporation of proposed improvements allows closing the circle of corruption control, so there is no room for potential misconduct. This is the main advantage of proposed approach. The practices around the world prove that any anticorruption system deficiency can be an opportunity for corrupt behavior. Use of education, technology and reward/punishment tactic can diminish these shortages.

Decrease of contact between police officers and drivers through online payments and document submission will decrease the probability of bribery/extortion. Emphasizing ethics importance and benefit of misconduct indication help to define scarcities through traffic department and to discourage misbehavior. If corrupt activity occurs anyway, there will be four levels to detect it:

- Audio/video cameras are mandatory in every encounter with public.
- Public is allowed to secretly record officers, so probability of detection is even higher.
- Whistleblowing of both officer's co-workers and public is stimulated.
- Internal control as an independent unit can discover and punish all of the participants: officers, their co-workers and public.

Consequences of discovered corrupt behavior are losing benefits or immediate departure from the department for the officer. On the other hand, offering a bribe, if repeated, can cause subtraction of driver's license. The risk for corrupt behavior involvement becomes very high for both traffic police and public.

All these steps need to be incorporated systematically and with regular evaluation of results. Strong governmental support through each stage is necessary. Carrying out the fight with corruption is both time and money-consuming process that eventually pays off. The result includes fewer fatalities and injured due to traffic. Also, revenues from additional fines can be used for further fight against corruption. Eventually, the traffic safety will not be decreased by the venomous corruption.

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COST EFFECTIVE DESIGNS TO IMPROVE HIGHWAY SAFETY

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INTRODUCTION

This paper discusses design safety improvement solutions that are reasonable and cost effective. Research studies for safety effects on design improvements and firsthand personal experience in projects are utilized to identify cost effective design improvements that are practical. Studies reviewed concentrated on the safety improvements related to design safety statistics and their effectiveness. The discussion also includes my firsthand experiences as a certified inspector over the years with these designs during the construction phases. The goal is to better understand the potential effectiveness of these design applications and provide the chance to review various case studies. Roadway design improvements are reviewed in addition to others found in the literature. Design features that are reviewed include: guardrail improvements, adding rumble strip, geometric corrections, and roadway widening.

ROADWAY DESIGN IMPROVEMENTS STUDIES

Studies by the US Department of Transportation (USDOT) provide data and insight on how (or if) these design changes make safety improvements [2, 3, 4, 5]. These studies show the functional safety characteristics of roadway rumble strip, roadway traction improvements and geometry widening. These improvements can reduce the number and severity of crashes that occur on the highways.

Adding rumble strip to roadways, according to FHWA evaluations, are cost effective and have a positive impact on safety for the traveling public [5]. In the study Safety Evaluation of Centerline Plus Shoulder Rumble Strips written by the USDOT gives the review that rumble strip is cost effective and improves safety function5. The study indicates a total of 20% reduction in crashes due to the addition of rumble strip.

Improving traction on roads is another safety improvement the study Gaining Traction on Roadway Safety published by the National Association of Professional Accident Reconstruction Specialists provides a focus on safety improvement design [1]. This study indicated that pavement surface treatments including Hot Mix Asphalt (HMA) overlays, open graded friction courses, chip seal, micro-surfacing, slurry seal, diamond grinding and ultra thin bonded wearing course benefit safety; the analyses considered crash statistics in seventeen States.

Roadway shoulder widening has been shown to benefit safety in three studies, from the USDOT, each varying on road types including Two Way Two Lane (rural) [2], Two Way Four Lane (rural) [3], and Two Way Four Lane (interstate) [4]. These three studies indicate that wider shoulder widths benefit safety and statistical data show a reduction in crashes with wider shoulders compared to a BASE of no shoulder roadway.

LOW COST SOLUTIONS

Some low-cost solutions, which can be incorporated into the designs of existing and new highways to improve safety, can include items such as guardrail improvements, adding rumble strip, geometric corrections, improving traction and roadway widening.

Guardrail improvements help update current requirement due to vehicles changing in design over time. Adding rumble strip help alert drivers if they are leaving the lane and allow them a warning to correct direction. Geometric corrections allow for safer driving on curves when roadway speeds have been increased. Improving traction helps drivers maintain better control even in wet weather conditions. Roadway widening in the form of adding or increasing the size of shoulder help drivers make recoveries if they leave the travel lane. As well these safety improvements can be funded through FHWA. States have the ability to use federal funding for certain highway safety improvements as well local counties and cities can utilize federal funding to improve the roadways. Particular funding included the Moving Ahead for Progress in the 21st Century Act (MAP-21) and after that the funding continued to the Highway Safety Improvement

Program (HSIP) as the core Federal-aid program. The objective of the HSIP program is to attain a reduction in traffic injuries and fatalities on roadways, including local government owned public roads and roadways in tribal lands. The HSIP needs an engineered, planned approach to improving roadway safety on all public roads that emphases on design performance not driver attitude such as drunk driving. Therefore designs meeting the FHWA criteria can be considered for this type of funding. This available funding allows agencies to implement designs at little or no cost depending on the projects and the design [6].

PERSONAL EXPERIENCE FROM PROJECT INSPECTION

Project inspection information of design improvements is discussed in this section to understand the construction process of the design applications. The experience attained from several safety improvement projects are based on certified inspections. The projects described include the addition of rumble strip, geometric correction, guardrail improvement and a widening project.

Rumble strips

Adding rumble strip to rural two lane highways is a way to improve safety for the traveling public. During a project on a TWTL county road, new rumble strip installation had no major issues and proved to be a successful project. The existing pavement conditions provided a sufficient base for the installation of the new rumble strip and provided for a clean cut product. However on a rural freeway project the reinstallation of rumble strip did not have a sufficient base for a fully functional rumble strip. The shoulder called for a half inch lift of Asphalt Rubber Asphalt Concrete Friction Course (AR-ACFC) without milling. The existing rumbled strip remained and the reinstalled rumble strip was placed above after the ½" AR-ACFC lift was installed. The purpose of not milling was to save cost on the project. This preservation project resulted in a less functional product if it were milled because the existing asphalt surface was more worn and made for a less clean cut product [6].

Geometric corrections

One component to geometric corrections on projects is to update super-elevations to higher speed limits as per roadway design guidelines. These improvements can be implemented quite easily depending on the knowledge of the contractor in super-elevations and transitions from a crown to a super-elevation. Various projects have faced improper construction techniques for super-elevation corrections resulting in wrong super-elevation slopes and transitions. However, having an individual who understands the capabilities of equipment and the design of super elevations can lead to an effective product. It would seem to be beneficial to have a construction guideline for super elevation corrections to inform contractors on super-elevation designs and to provide an understanding to designers of the construction equipment capability for plans. The implementation of these geometric corrections are simple however if the know how is not available implementation can be very difficult for the contractors and will result in future projects having to make geometric corrections again.

Guardrail improvements

Guardrail improvements for roadways are important to provide safety with newer design vehicles and specification. Part of guardrail improvements currently taking place are up-to-date End Treatment installations and new guardrail height designs being implemented. These improved designs have had little general installation issues except in special cases. Installations where super-elevation corrections were made afterward in the same project have caused height issues. The guardrail runs did not meet specified height requirements due to the incorrect estimation of the newly geometrically corrected roadway alignment elevation near guardrail runs. These estimated top of roadway elevations were wrong after paving operations took place and left for an out of spec guardrail height because the guardrail was installed at the beginning of the project instead of afterward. Overall except for certain special cases guardrail installation has been a straightforward installation for contractors.

Shoulder widening

Roadway shoulder widening has had two minor challenges, which include proper construction next to the existing roadway and unforeseen existing drainage pipes. Gaining proper compaction and grade next to the existing roadway seemed to cause contractors challenges in construction compared to the other design safety improvements. However, this design application proves to be a very effective design improvement and reasonable to construct and is accomplishable. The second challenge is unforeseen drainage pipes that can cause a hindrance to the construction process. These pipes even if left in place and extended can obscure the structural section of the widening roadway mostly, the base structure of the road and must usually utilize a concrete cap above the pipe section. This concrete requirement can delay a project production for that section for a day in curing and install time.

CONCLUSION

This paper discussed design safety improvement solutions that are considered reasonable and cost effective. The literature review and federal programs evaluated identified several design improvements utilized to identify effective and safe designs. These safety improvements in designs were also re-visited based on firsthand personal experience in the State of Arizona. Findings were that these design improvements could reduce the number and severity of crashes that occur on highways. These safety improvements have been also studied, and are currently utilized to improve roadways using available federal funding; these programs are making these improvements more attractive and even more practical to implement.

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PUBLIC PRIVATE PARTNERSHIPS IN HIGHWAY CONSTRUCTION

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Essay Topic – Road Financing

Governments around the world are turning to Public-Private Partnerships (PPP's) as one solution to the challenge of funding road infrastructure. Provide an example of a PPP arrangement in a developed or developing country and what factors led to its success or failure? What lessons can be learned from this experience?

INTRODUCTION

Traditionally governments across the world have been the principal provider of infrastructure (in terms of both financing and constructing) within their respective countries. However, over the last few decades this position has begun to change. Aiming to reduce debts, yet at the same time to improve and expand upon existing infrastructure, governments have been experimenting with inviting private sector firms to enter into long term contractual agreements, which require the private firm to finance, construct, and/or manage a public sector infrastructure project on behalf of the government body. This type of arrangement is referred to as a Public-Private-Partnership (PPP) (Grimsey, D., & Lewis, M., 2000).

PPPs are effective at producing new infrastructure without a large upfront capital investment on the part of a government agency. However, PPPs are not without risks and are not always successful. The biggest potential downfall stems from the fact that public and private entities have very different interests. In the viewpoint of the public sector, the objective is to ensure that the money spent on infrastructure has been utilized economically and effectively, essentially getting a good "value-for-money" on their project. On the other hand, private sector participants wish to maximize the profits over the entire contact life of a PPP. Furthermore, private companies are much more wary about carrying risks than government agencies. Relating this to PPP projects, this means that private sector participants usually push for high premiums to accept risk, ultimately increasing the cost for the public sector partner. The goals of public and private partners in PPPs are conflicting, and this is the underlying problem of such arrangements (Hodge, G., 2004).

SELECTED CASE STUDIES

The projects selected for the focus of the essay have been limited to transportation projects, and more specifically highway construction and maintenance projects.

HIGHWAY 407 EXPRESS TOLL ROUTE (407 ETR): CANADA

The "Highway 407 Express Toll Route (ETR)" located in the province of Ontario, Canada is a 108 kilometre (67 miles) toll highway that runs across the north of Metropolitan Toronto. The highway construction project was a Public Private Partnership between the Province of Ontario and a private consortium. Originally, the consortium was to be responsible for design, construction, financing, and maintenance of the highway with a lease term of 99 years in which they are permitted to collect tolls from users of the roadway.

The request for proposals (RFP) for the highway was announced in 1993, at a time when the province was emerging for a recession and unable to finance such a large infrastructure project. Originally, the RFP detailed that the province would be responsible for land acquisition costs, while the private partner would provide financing, guarantee a maximum construction price, and operate the highway. The private partner would be compensated in the form of toll revenues, however traffic levels and toll revenues were not guaranteed by the government (Vining, A., & Boardman, A., 2008).

Responses to the RFP revealed that private partners were very reluctant to assume financing risks as well as

construction and operating risks, especially considering that no toll revenue guarantees were being offered. Due to the lack of interest from the private sector, the province assumed financing of the project, and also retained the operational risks during the first eighteen months (Vining, A., & Boardman, A., 2008).

Eventually the operating rights for the highway were sold to a Canadian-Spanish-Australian consortium for $3.1 billion in 1999 on a ninety-nine year lease term. The contract set a maximum toll rate for the first year of operation. Initially, a base traffic flow was set based on the peak-hour traffic volume and it was assumed this would grow by one to three per cent a year. If traffic volumes exceeded the growth assumption, tolls could be raised without restriction; however if volumes were lower than predicted and tolls were still raised, the province could impose a penalty. As of 2008, tolls have been raised six times, and the consortium has recently announced it intends to raise tolls again. These toll increases have dampened the Highway 407 volumes, resulting in increased congestion levels on the adjacent roadway network (Vining, A., & Boardman, A., 2008).

In 2004, the Province of Ontario filed a lawsuit against the consortium claiming that it had breached its contract by raising tolls without the permission from the government. The court sided with the consortium and even an independent arbitrator agreed that the consortium had to right to raise tolls without authorization from the province. However, in 2005, Ontario and the consortium came to an agreement where the consortium agreed to implement a "customer benefit program" which reduced tolls by up to fifteen per cent for 100,000 frequent users over the next four years and provided discounts for truck drivers during evenings and weekends. As a concession, the province agreed to withdraw its court case and demands for a toll rate reduction. The agreement allowed the consortium to further increase tolls, after the customer benefit program had been implemented for frequent users (Vining, A., & Boardman, A., 2008).

The Highway 407 was constructed in a timely fashion and without major cost overruns and currently generates about 350,000 daily vehicular trips. Land acquisition and construction costs were reduced by utilizing innovative design features, such as shorter entrances and narrow radius ramps, and the conversion of dual exit lanes to a single exit lane and the use of asphalt paving rather than concrete. In the early stages of design there were concerns that these changes could result in a lower safety rating for the highway, however there has been little evidence of this in practice (Vining, A., & Boardman, A, 2008).

The main downfall of the Highway 407 project as a PPP was the failure of the government body to effectively transfer financing risks to the private partner. The construction phase became a conventional highway construction project with the private partner building a fixed-price construction project. Over the course of the highways lifetime, it has become apparent that the consortium operating the highway is more concerned in maximizing profits rather that easing congestion levels in the Metropolitan Toronto area; which was the main driving force for the highways construction.

HIGHWAY A2 AND A4: POLAND

In the early 1990's Poland's highway network consisted of only 199 km and not a single four lane highway existed in the entire country. The country's inadequate road network was recognized as a key factor limiting its economic development and the government was placing a high emphasis on the rapid development of its highway system. In 1993, the government produced a plan to build 2,600 km of highways by 2005, and it was assumed that this could be accomplished through the use of PPP's (Brenck, et al., 2005).

The first PPP highway project undertaken in Poland was the A4, which was to link two major cities in southern Poland, Krakow and Katowice. The first phase of the project consisted of an extensive rehabilitation of the existing highway and its operation and maintenance. The contract for the project was signed in 1997 and put into operation in 2001. The financial incentive for the private partner was solely based on the collection of toll revenues. The second stage of the project, which consisted of rehabilitating a major bridge, turned out to be more difficult, mainly because of lower than projected traffic volumes and difficulties in raising the finance for this phase of the project. Overall, the commercial success of the A4 is still doubtful (Brenck, et al., 2005).

Another PPP highway project in Poland is the A2, linking Warsaw to Poznan and the German border at Slubice. With an estimated construction cost of $870 million (Euros) the A2 is the largest Public-Private-Partnership transportation project in Poland. Construction for a 150 km portion of the A2 was awarded in 2000; the contract is for a 40 year lease term and includes the right for the private partner to charge tolls. Construction commenced in 2001, and is now operational. However, the trouble is that the highway experiences very low traffic volumes. Only a small number of private users are willing to pay the high toll fees. It is estimated that 60-80% of truck drivers bypass the tolled stretch of the highway to avoid the tolls. Currently, the government and private partner are in the process of negotiating compensation payments due to the lack of toll revenues being generated. This has put doubt on the completion of the remaining portion of the A2 highway. Potential private partners are extremely warry to

invest the large capital required when it appears they will receive minimal toll revenues (Brenck, et al., 2005).

The most significant problem encountered during the PPP highway project undertaken in Poland was the lack of toll revenues generated. Lower than expected traffic volumes lead to extremely disappointing toll revenues making private partners warry to continue to be involved in highway construction projects in which their returns were not guaranteed.

CONCLUSIONS

Public Private Partnerships are alternative public agencies can utilize to construct large transportation infrastructure projects when they lack the capital themselves. However, as seen in the case studies mentioned previously, these types of arrangements do not come without risks. As seen in the Highway 407 project in Canada, the reluctance of the private partners to take on substantial risk and their drive to maximize profits had a negative impact on congestion levels in the greater Toronto area, which was the main goal of the project. In Poland, low toll revenues from low traffic volumes made private partners warry of continuing PPP projects, leaving the future of the country's highway network in jeopardy of being completed.

The largest problem that PPP projects face is the fact that public and private entities have very different interests. In the viewpoint of the public sector, the objective is to ensure that the money spent on infrastructure has been used effectively. On the other hand, private sector participants wish to maximize the profits. Furthermore, private companies are much more wary about carrying risks than government agencies. The goals of public and private partners in PPPs are conflicting, and this is the underlying problem of such arrangements.

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ASPHALT CONCRETE USED TO COMBACT CLIMATE CHANGE

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INTRODUCTION

According to the Intergovernmental Panel on Climate Change (IPCC), the earth's annual temperature has increased by approximately 1.3oF over the 20th century. The National Science and Technology Center reports an average 0.58oF increase in temperature per decade within the past few decades in the United States (US). Along with the increase in temperature, many regions (particularly the eastern United States) have seen an increase in the total average annual precipitation. Warming has also contributed to glacier mass loss and ocean thermal expansion, increasing sea levels and increasing the risk of road erosion from storm surges and waves further inland. [1]

Since most roadways in the United States are designed to withstand local weather and climate, the unpredictability of weather conditions due to climate change make pavement design a bit more challenging. Projected increases in frequency and intensity of extreme weather conditions bring an increase of potential problems for roadways. High temperatures may result in softening and expansion of pavements leading to increased rutting and potholes, while heavy rains can weaken or wash out the subsoil and shorten the life expectancy of the asphalt. Increased asphalt degradation not only increases replacement cycles, but also leads to limited access, congestion, and higher costs. [2]

Despite the potential effects of extreme weather on asphalt pavements, asphalt concrete (specifically hot mix asphalt) is still the most common paving material used in the United States. Some of the many advantages contributing to asphalt concretes high popularity are its low initial and low maintenance costs, its flexibility and speed of construction, and its ability to handle heavy loads. Asphalt pavements also reduce noise and improve ride quality. [3] By altering the mix design, asphalt pavements can be designed to withstand most all weather conditions. Several mix types, including open graded friction course and stone matrix asphalt, exist to combat the effects of extreme weather on a pavement's performance and life expectancy.

ASPHALT CEMENTS USE IN EXTREME WEATHER CONDITIONS

Hot mix asphalt (HMA), the most frequently used surfacing material in the US, accounts for 96% of America's roads and can be designed to meet most any specifications and construction uses. [4] Hot mix asphalt surfaces such as stone matrix asphalt (SMA), designed using the Superpave method, and open graded friction courses (OGFG) work well in many climates. Stone Matrix Asphalt's high coarse aggregate content, high asphalt content and high filler content result in a mix with excellent stone-on-stone content that is very resistant to rutting. Open graded HMA designed with a layer having a large volume of air voids, helps improve drainage, increase skid resistance and reduce splash and spray. [4] Although SMA and OGFC pavements exhibit many advantages, there may be higher costs associated with the binder and asphalt content along with additional time and effort to produce the mix. Furthermore, open graded mixtures typically require additional de-icing applications in cold regions and SMA mixtures require extra cooling time to prevent early flushing of the binder. [5]

Porous Asphalt

Porous asphalt incorporates the use of OGFC placed over a filter course on top of a reservoir of large single sized aggregate. It is designed to reduce runoff from roads and parking lots that would otherwise drain back into creeks and rivers. Porous asphalt became increasingly accepted in the United States in 2012 after west central Oregon experienced a major winter storm, which caused millions of dollars of flood damage to the area, with the exception of one community. Pringle Creek in Salem, Oregon had a storm water control scheme consisting of roads and

parking lots made with porous asphalt. As a result, Pringle creek only experienced a few puddles. [6]

That summer dozens of porous asphalt projects were installed around the country. In New York, Lake George's Beach Road became the heaviest traveled road in the state to incorporate porous asphalt and solved a huge environmental problem for the lake, where storm water was the number one contributor of contaminants. Downstate, porous asphalt was used to solve flooding problems in the city borough of Queens. [6]

Along with its ability to improve drainage, porous asphalt also has the ability to reduce the urban heat island effect and also requires less salt for snow and ice removal than conventional pavements. Because of its ability to clog, a filter fabric is typically placed at the bottom to prevent fines from migrating to the top. Sand should be avoided for snow and ice removal; however, the pavement can be vacuumed, jet washed or flushed to maintain its porosity.

Asphalt Rubber

Another mix that has proven successful in a variety of climates is asphalt rubber (AR). In Arizona's climatically diverse regions, rubberized asphalt has been used for over 25 years to resurface highway and city streets. Two types of AR used by the Arizona Department of Transportation (ADOT) are Asphalt-Rubber, Asphalt Concrete Friction Course (AR-ACFC), also known as an open graded friction course, and Asphalt-Rubber, Asphalt Concrete (AR-AC) that is a gap graded mix. Both types have been used over Portland cement concrete pavements (PCCP) and asphalt concrete (AC) pavements. Over 3000 miles of asphalt rubber overlays, most commonly consisting of 80% hot paving grade asphalt and 20% ground tire rubber, have been constructed by ADOT since 1988. [7]

In 2002, a series of projects were evaluated throughout the state. Each project consisted of an AR-ACFC placed over existing PCCP constructed between 1988 and 1995. The locations varied from the desert regions of Tucson and Phoenix, where temperatures range from 20oF to 120oF, to the alpine region of Flagstaff, where temperatures range from -30oF to 90oF. After evaluation, all the pavements, differing in age from 7 to 14 years, showed considerable resistance to aging. The Flagstaff pavement, although still serving well, was nearing the end of its life. [7]

Other states such as California, Florida, and Texas have experienced success with AR pavements as well. Although asphalt rubber pavements provide the advantage of a smoother and quieter ride, they cannot be applied in very hot or cold weather. To adhere properly, the underlying pavement surface must be between 85oF and 145oF which becomes difficult in cooler climates, especially when night paving, where pavement temperatures often drop below 85oF.

Stone Matrix Asphalt

Stone matrix asphalt was developed in Europe and has been used in the United States since 1991. The stone-on-stone contacts, as well as the high binder content, provide its strength and increased resistance to rutting. States such as Wisconsin, Georgia, Michigan and Missouri were among the first to use the mix. By 2002, an estimated 15 million tons of SMA was placed in over 250 projects in the US. [8]

In 1992, following Europe's SMA success, the Maryland State Highway Administration (MDSHA) started specifying SMA on its major highways and has since constructed over 85 SMA projects on highways with traffic counts averaging more than 20,000 daily. With a total of over 1,300 lane miles of paving, the typical Maryland mix designs have high asphalt binder contents classified using the Superpave Performance Grading (PG) system. Most Maryland SMA projects have used either modified PG 70-22 or modified PG 76-22 binders. Mineral fillers and binders are typically used as well to provide adequate binder consistency and prevent binder drain-down during transport and paving. The most common nominal aggregate sizes used in Maryland SMA mixes are 12.5 mm and 19 mm. Maryland pavements, which were evaluated after ten years, showed little to no rutting nor increase in roughness, and little decrease in friction. Cumulative rut depth averaged 0.14 in. for the 12.5 mm mixes and 0.13 in. for the 19 mm mixes, and cumulative International Roughness Index (IRI) values averaged 75.7 in. per mi. for the 12.5 mm mixes and 97.1 per mi. for the 19 mm mixes. [9]

In addition to the increased rutting resistance, SMA also provides reduced tire splash and reduced tire noise. Although SMA mixes typically cost 20 to 50 percent more than conventional dense-graded asphalt mixes, (10 to 30 percent for MDSHA), the increase in pavement life (25 to 40 percent) due to reduced rutting and increased durability usually outweighs the increased cost. [9]

CONCLUSION

Despite the potential effects of extreme weather on asphalt pavements, asphalt concrete is still the most common paving material used in the United States. Some of the many factors contributing to its wide acceptance are its low initial cost, its flexibility and speed of construction and its complete recyclability.

To address the effect of increased precipitation, asphalt pavements such as porous open graded friction courses, are designed to allow drainage through the surface

layer, and are able to minimize hydroplaning and reduce splash and spray. States such as Oregon and New York have used porous asphalt to mitigate flood damage and reduce environmental issues resulting from storm water contamination of lakes and rivers. Porous asphalt also has the potential to reduce the urban heat island, but because of its ability to clog, sand for snow and ice removal is not recommended.

To combat the effects of increased temperatures, stone matrix asphalt provides a durable mix with high resistance to rutting and has been used in the United States since 1991 by states such as Wisconsin, Georgia, Michigan, Missouri and Maryland. The state of Maryland, who has specified SMA for use on its major highways since 1992, conducted a ten year evaluation, which showed little to no rutting in the pavements. Although SMA mixes typically cost more than conventional dense-graded asphalt mixes, the increased pavement life typically outweighs the cost.

Other pavement types, such as asphalt rubber, have shown success in a diverse range of climates, and have proven to reduce noise and improve ride quality. In Arizona, asphalt rubber has been used successfully in its desert and alpine regions for over 25 years. Other states such as California, Florida, and Texas have experienced success with AR pavements as well. Although asphalt rubber pavements cannot be applied in very hot or cold weather, they provide an economical highway rehabilitation solution and also help reduce the amount of scrap tires discarded in landfills.

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RETHINKING THE FUEL TAX IN THE AGE OF INCREASED FUEL ECONOMY

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INTRODUCTION

Increased fuel economy and alternative fuel technology vehicles are gaining momentum in the passenger car market lately (1) due to their promise of decreased life-cycle operational costs (2) The automobile market is constantly evolving with the introduction of innovative technologies that lead to reduced fuel consumption. Major vehicle manufacturers have introduced hybrid, plug-in hybrid and battery electric vehicles in order to comply with the corporate average fuel economy (CAFE) standards in the United States, improve fuel efficiency of their production and reduce tailpipe emissions (3). The light-duty vehicle market is undergoing rapid changes; however, government regulations do not seem to keep up with this fast production pace.

The Federal Highway Trust Fund (HTF) is partially financed by motor fuel taxes, tires, trucks and trailer sales and heavy-duty vehicle usage (4). The fuel tax is not collected directly from the consumer; instead, the tax is collected from the importer or the producer of the taxable fuel product (4). Federal Highway Administration reports the tax rates for main passenger car fuels: 18.4 cents per gallon for gasoline and 24.4 cents per gallon for diesel (4). In the long run, revenue shortfalls are expected, assuming the structure and collection remains the same, due to inflation. What is more, the average fuel economy of the passenger vehicle mix is expected to increase significantly due to the aforementioned Department of Energy CAFE mandates (5). CAFE standards for passenger cars require a production vehicle mix of 36.2 mpg in average for 2015, which should reach 54.9 mpg by 2025 (6). Thus, changes are needed for the fuel tax mechanism or else the financing of the Highway Trust Fund could be at stake. In Table 1 the 2011 and 2015 revenue from the gas tax collection is estimated using average historical data and projections for the vehicle market and assuming current travel patterns. The revenue is calculated based on Equation 1 for the forthcoming 2025 year and compared to a past year for which data is available, 2011. The historical data for 2011 come from (6), the alternative vehicle population and registration data projections for 2015 come from (7) and the vehicle miles traveled (VMT) projections from (5). It is assumed that all the non-alternative fuel vehicles are gasoline ones; so the total revenue from the fuel tax may be underestimated in this case.

$$R = VMT \cdot \left(\frac{1}{MPG} \right) \cdot C \cdot N \qquad (1)$$

Where R is the revenue in $, MPG is the fuel economy in miles per gallon, C is the fuel tax in $ per gallon per vehicle, and N is the number of the conventional, non-alternative fuel vehicle registrations.

Table 1: Revenue from Fuel Tax Due to Increased Fuel Economy, Based on Avg. Values

Year	2011	2025
Alt. fuel vehicle population (thousands)	1,191.786	15,000
Total vehicle registrations (thousands)	125,657	270,000
Average population mpg (mpg)	24.4	54.9
Average annual VMT (miles)	11,601	12,700
Revenue from fuel tax ($)	1.089 1010	1.085 1010

Using average values, in Table 1 we show that the fuel tax revenue of 2011 could be decreased by 0.37% in 2025.
This essay aims at showcasing the caveats of the current fuel tax structure and proposing alternative methods to collect VMT based fees that will fund the Highway Trust Fund in the near future and account for its financial sustainability. Last, this study presents the advantages and disadvantages of alternative fees and concludes with recommendations on future research needed to address the issues raised.

FUEL TAX VERSUS MILEAGE BASED USER FEES

Fuel Tax: Issues and Recommendations

Can federal fuel tax keep up with those vehicle fuel economy changes? Weatherford supports that if Congress decides to regularly increase fuel tax, the system in place will be able to keep on generating revenue for the HTF (8). Not only those political decisions are hard to coordinate and reach consensus in the first place but also HTF would be at risk every other year if the taxes to be charged were not optimized. Apart from the legislative issues, federal fuel tax has been extensively criticized in the literature, as in many cases it is found inequitable. For example, West uncovers that low-income households, due to financial constraints, tend to own older and lower fuel economy vehicles and are disproportionally charged compared to wealthier drivers (9). Also, as it is reported by the Congressional Budget Office (CBO), the federal fuel tax is not equitable for rural households, because in rural areas distances between activities are greater and fuel consumption is inherently higher (10). As CBO proposes regarding an optimal taxation structure, on top of the fuel tax users of the highway network should be charged a combination of taxes, following the concept of the full marginal cost pricing.

Despite the current system's disadvantages, there is an important reason for its prevalence. The collection system is simple and efficient, as it is not directly collected from the consumers but from the producers of the fuel. The implementation cost of the tax collection is small and the procedure is simple.

Literature also supports that modifications of the current fuel tax structure can be a short-term solution for the problems that we have identified previously. As reported by Wachs, projections of fuel prices in the future show increasing trends. If federal tax was a fix percentage of the fuel price, this mechanism would produce growing revenue streams in the future (11). Another approach proposed by the Financing Commission is an increase of the gasoline tax by 10 cents per gallon, which could effectively generate approximately 50% more revenue, as well as reduce the VMT by approximately 2% (12).

User Based Fees: Substitute or Trouble?

User-based fees per mile and tolls for the users of the road network have been identified as alternatives to the traditional fuel tax system. Those fees would account for the heterogeneity of the network users, as those could adhere to a "pay-as-you-drive" concept (11). Wireless communications, GPS trackers and on-board device readers could be effectively used in order to collect the mileage information needed to impose such a fee. Thus, the collection of user-based fees is possible in the recent years due to such technological advances. Baker and Goodin evaluate VMT fees, mileage-based user fees and time/distance/place financing options that could substitute the current fuel tax (13). Hanley and Kuhl conduct a national level experiment for the evaluation of drivers mileage-based fees (14). Hereinafter, research analyses findings on the aforementioned fee mechanisms are presented.

The VMT fee is the most prevalent alternative in the literature. Rufolo and Bertini note that VMT fees can be flat or vary based on time of day and/or location (15). VMT fees are believed to contribute towards reducing congestion by providing an incentive to reduce VMT (13). An effective VMT fee charge can, thus, achieve the stability of the revenue much needed for the HTF in the long run, since it is not impacted by the fuel economy of the vehicles. However, a question arises: does this fee structure, similarly to the fuel tax, impose a greater burden for households with certain characteristics, ending up being inequitable? Based on 2001 National Household Travel Survey data analysis, Weatherford finds that for "87% of the population the driving cost per mile will increase by maximum 5%", under the assumption that the VMT fee imposed is revenue-neutral. Their research shows that such a VMT fee leaves low-income population and population of rural areas better off but imposes larger charges to those driving vehicles with increased fuel economy and households with a greater number of children. Robitaille et al. also conduct analysis with 2001 NHTS data and find that both fuel tax and VMT fee are inequitable and disproportionally impact different areas, income and race groups (16). Sorensen et al. suggest that VMT fees could be set so that impose higher charges for fuel-inefficient vehicles in order to penalize their increased emissions (17).

Overall, literature is inconclusive regarding the effects of the VMT fee on the social welfare and equity. However, the greatest barrier of imposing such a fee is the high implementation cost and the data handling of sensitive public location information. In order to effectively measure the annual VMT of a household, large investments need to be made so as every vehicle to be equipped with tracking devices. Those devices need to be regularly tested to provide accurate VMT information. Tracking X and Y household vehicle coordinates would be essential for spatial differentiated fees, but this could be considered as an invasion of privacy. Alternatives for accurate measurement of the annual VMT per household need to be proposed in order to guarantee privacy and fair charging. On the other hand, Sorensen et al. suggest that the investment for the tracking devices and the collection of anonymous data could be also used to improve operations and achieve effective management of the transportation network (14).

Last, VMT measurement and fee payment enforcement should become publicly accepted before implemented. Hanley and Kuhl national level user fee experiment reveals that approximately 70% of the participants are favorable to the mileage-based fee system (14). Still, substantial research efforts should be put so as to provide concrete evidence of the advantages of this fee structure and work towards building public consensus. Across the literature, experts pinpoint that perhaps more than one system should be in place, i.e., increased flat fuel tax and VMT fee, in order to provide options to the public and address their concerns.

CONCLUSION

The impacts of a mileage-based fee are still questionable. The aforementioned literature emphasizes on the advantages of a VMT fee over the fuel tax that is currently in effect but also identifies the barriers that should be broken down to proceed with such an implementation.

It is clear that part of the Highway Trust Fund revenue is at stake if the current tax measure is not effectively revised in order to avoid shortfalls. Researchers need to provide ways to equitably impose user charges and ensure the financial sustainability of the Highway Trust Fund.

Public acceptance is another crucial component of the success of the proposed fees application. It is of great importance to engage stakeholders into the tax system's planning, allow jurisdictions to collaborate and jointly raise awareness on this structure, provide different ways to measure annual VMT and reassure the privacy of the sensitive spatial datasets. Research could involve pilot programs in every state that could be conducted through cooperation with universities and intelligent technology system vendors, which could also support research efforts by providing innovative equipment and data handling platforms.

Given all the evidence, it is now time to rethink the fuel tax and start planning for the proper system improvements or substitutes. Those should guarantee the funding mechanism's sustainability, maximize social welfare and account for environmental externalities.

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