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ABSTRACT
Traffic accidents impose huge costs on individuals and society, so traffic safety is a major transport planning objective. Most conventional traffic safety programs focus on reducing distance-based crash rates, such as deaths and injuries per billion vehicle-kilometers. Measured in this way, increases in per capita vehicle travel are not significant risk factors and vehicle travel reductions are not recognized as potential traffic safety strategies. A new traffic safety paradigm measures crash rates per capita, as with other health risks, and so recognizes the safety benefits of transport policies which reduce per capita vehicle travel. Research described in this presentation indicates that vehicle-travel reduction strategies, such as improved public transit services, transport pricing reforms and smart growth development policies, can provide large traffic safety benefits: residents of more multi-modal communities have about a fifth the per capita traffic casualty rate as automobile-oriented communities, and many policies that encourage use of alternative modes also increase transport safety and security. However, these benefits are often overlooked in conventional traffic safety planning. This presentation identifies a new traffic safety agenda that includes demand management as a traffic safety strategy. It describes specific ways that individuals, transport planners, traffic safety experts and policy makers can take advantage of these opportunities to increase safety. It describes a comprehensive framework for comparing the full benefits of potential traffic safety strategies, including indirect costs and benefits. It discusses the implications of this new traffic safety agenda, and identifies transport policy and planning reforms that can help support is implementation.

Keywords
Traffic safety, Transportation Demand Management (TDM), comprehensive evaluation, new paradigm
1. INTRODUCTION

A paradigm shift (a fundamental change in the way problems are defined and potential solutions evaluated) is occurring in transport safety analysis (Litman 1999). The old paradigm assumes that automobile travel is overall a very safe activity, since most accidents are associated with special risks such as impaired driving, young or old drivers, or hazardous roadway conditions, and new technologies can further reduce crash injury risks. From this perspective, efforts to reduce overall vehicle travel to increase safety are inefficient and unfair because they “punish” all motorists for dangers created by a minority. As a result, the old paradigm emphasizes targeted safety programs intended to reduce high-risk driving activities, plus improve vehicle occupant protection to reduce injuries when crashes occur.

This paradigm is justified when risks are evaluated in some ways, but not others. For example, Figure 1 illustrates traffic fatality rates using two different denominators. Measured using distance-based units (per 100 million vehicle-miles or billion vehicle-kilometers), fatality rates declined more than two thirds during the last half century. From this perspective, traffic safety programs were successful and should be continued to further reduce road risk.

![Figure 1: U.S. Traffic Fatalities (BTS, Various Years)](image)

This figure illustrates traffic fatality trends over six decades. Per mile crash rates declined substantially, but per capita crash rates declined little despite significant traffic safety efforts. Both crash rates declined together after 2000 when per capita vehicle travel started to decline.

However, per capita vehicle travel more than doubled in the U.S. over that time period, offsetting much of the decline in per-mile fatality rates. When measured per capita (e.g., per 10,000 population), as with other health risks, there was little improvement during this period despite significant road and vehicle design improvements, increased use of safety devices, reduced drunk driving,
and better emergency response and medical care. Taking these factors into account, much greater casualty reductions are expected. For example, seat belt use increased from nearly 0% in 1960 to 75% in 2002, which by itself should reduce per capita traffic fatalities by about 33% (wearing a seat belt reduces the chances of dying in a car crash about 45%), yet, per capita traffic deaths declined only about 25%.

Similarly, per capita traffic fatality rates tend to increase with per capita vehicle travel, as illustrated in Figure 2. This shows that, despite major investments in safer vehicles and roadways, and various traffic safety programs, the United States has the highest per capita traffic fatality rate among peer countries (Luoma and Sivak 2012). From this perspective, traffic safety programs are ineffective at reducing traffic deaths and new approaches are justified.

**Figure 2**  Vehicle Travel and Traffic Fatality Rates (OECD Data)

![Graph showing the relationship between annual vehicle kilometers per capita and traffic fatalities per 100,000 population with a strong positive correlation.](image)

*Among economically developed countries there is a strong positive relationship between per capita vehicle travel and traffic deaths.*

There is other evidence that, all else being equal, per capita traffic crash rates increases with per capita vehicle travel, and that crash rated decline with successful implementation of vehicle travel reduction strategies (called *Transportation Demand Management* or TDM in this paper) and more compact, multimodal land use development (called *smart growth* in this paper) (Ewing and Dumbaugh 2009; Litman and Fitzroy 2014).

For example, several studies using a variety of analysis methods and data sets indicate that as per capita public transit travel increases in a community total per capita traffic casualty rates tend to decline (Duduta, et al. 2012; Karim, Wahba and Sayed 2012; Litman 2015; Stimpson, et al. 2014). Analyzing 29 years of traffic data for 100 U.S. cities, Stimpson, et al. (2014) found that a
10% increase in the portion of passenger-miles made by transit is associated with 1.5% reduction in total traffic deaths. Since only about 2% of total person-miles are currently by transit, this means that a 1% increase in transit mode share is associated with a 2.75% decrease in fatalities per 100,000 residents, which translates into a 5% decrease in total traffic fatalities in the 100 cities included in their study. Figure 3 illustrate this relationship.

**Figure 3**  Traffic Fatalities Versus Transit Trips (NHTSA Data)

This graph illustrates the relationship between per capita transit ridership and total (including pedestrian, cyclist, automobile occupant and transit passenger) traffic fatalities for 35 large North American cities. As transit travel increases, traffic fatalities tend to decline significantly. Cities with more than 50 annual transit trips per capita have about half the average traffic fatality rate as regions with less than 20 annual trips per capita.

Using sophisticated statistical analysis, Ewing and Hamidi (2014) found that more compact communities had significantly higher transit ridership, slightly higher total crash rates, but much lower fatal crash rates than sprawled communities: each 10% increase in their compact community index is associated with an 11.5% increase in transit commute mode share, a 0.4% increase in total crashes, and a 13.8% reduction in traffic fatalities.

Several factors help explain the large reductions in traffic fatalities in more compact, multimodal communities where residents drive less and rely more on walking, cycling and public transport (Dumbaugh and Rae 2009; Savage 2013). Such cities have less per capita automobile travel, lower traffic speeds, and drivers tend to be more cautious when they see more pedestrians and cyclists (Jacobson 2003). Improved transport options allow some households to reduce their vehicle ownership, for example, giving up a second car, which leverages additional vehicle travel reductions (Marshall and Garrick 2011). These factors
appear to be particularly effective at reducing driving by higher-risk groups including youths, seniors and alcohol drinkers. Figure 4 illustrates how youth traffic death rates decline with increased transit ridership, which indicates that many young people will reduce their driving if given suitable alternatives.

**Figure 4** Youth and Total Traffic Fatality Rates (CDC 2012)

Youths (15-25 years old) tend to have about twice the traffic fatality rates as the population average. Both youth and total traffic fatality rates decline significantly with increased transit travel. The statistical relationship between transit ridership and traffic safety is particularly strong for youths, suggesting that many young people are willing to reduce their higher-risk driving if given suitable alternatives.

Similarly, transit service improvements can reduce impaired driving (Mathis 2014). Residents often drive to parties, restaurants, and bars in automobile-oriented communities, but are more likely to walk, take transit or taxis in more multi-modal communities. Jackson and Owens (2009) and Broyles (2014) found that drunken driving rates declined after late-night transit service improvements. Public transit may also reduce distracted driving; many passengers report that they choose transit in part because they can use telephones, computers and portable movie players while traveling.

This and other evidence indicates that TDM and smart growth strategies can provide substantial reductions in traffic accidents. However, few conventional traffic safety programs recognize these impacts.

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1 Ironically, bars have among the highest parking requirements of any land use types, indicating that conventional transport planning assumes that it is normal for drinkers to drive, and encourages this practice.
2. TRAFFIC SAFETY PROGRAM REVIEW

This study evaluated the degree that various traffic safety programs recognize the safety benefits of TDM strategies.

<table>
<thead>
<tr>
<th>Program</th>
<th>Consideration of TDM</th>
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<tbody>
<tr>
<td>National Highway Traffic Safety Administration (<a href="http://www.nhtsa.gov">www.nhtsa.gov</a>)</td>
<td>The NHTSA is the lead U.S. traffic safety agency. It supports safety research and various programs, and is multi-modal to the degree that these programs include pedestrian, bicycle and school bus safety. As previously mentioned, its annual Traffic Safety Facts and various fact sheets tend to report crash statistics using distance-based rather than per capita units, which ignore the safety benefits of vehicle-travel-reduction strategies. The NHTSA report, Countermeasures That Work, describes and evaluates various traffic safety strategies but includes no information on TDM or smart growth strategies.</td>
</tr>
<tr>
<td>Toward Zero Deaths: A National Strategy on Highway Safety (<a href="http://www.towardzerodeaths.org">www.towardzerodeaths.org</a>)</td>
<td>Toward Zero Deaths is a coalition of government agencies and private organizations to promote traffic safety. It supports various types of safety strategies (safer drivers and passengers; safer vulnerable users; safer vehicles; safer infrastructure; enhanced emergency medical services; improved safety management) but includes no mention of transit, TDM or smart growth strategies. As with NHTSA, this program is also mandated to reduce highway crashes so its focus on targeted risk reduction strategies is understandable, but it may be amenable to some TDM and smart growth strategies if the organization’s leaders are presented with credible evidence that these are effective safety strategies that complement their current efforts.</td>
</tr>
<tr>
<td>The Injury Research Foundation (<a href="http://www.tirf.ca">www.tirf.ca</a>)</td>
<td>The Traffic Injury Research Foundation is a Canadian non-profit organization with public and private members that develops traffic safety information and programs. It has sponsored dozens of studies and programs targeting youths, seniors, impaired and distracted driving, but none that support TDM or smart growth.</td>
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### Mothers Against Drunk Driving (www.madd.org)

Mothers Against Drunk Driving advocates policies to stop drunk driving. It currently emphasizes three strategies: high-visibility law enforcement; require ignition interlock devices; and develop technology to determine automatically whether or not a driver exceeds the legal blood alcohol limit. Although it claims that these are “evidence-based,” the website provides no analysis of their effectiveness. MADD promotes “Safe Ride Programs” which encourages drinkers to use alternative modes, but provides no support for improving them.

### AASHTO Highway Safety Manual (www.highwaysafetymanual.org)

The HSM is intended to provide best available information and tools to facilitate roadway planning, design, operations, and maintenance decisions based on precise consideration of their safety consequences. The Manual is primarily concerned with highway design and operations; it includes no TDM or smart growth strategies.

### Global Road Safety Partnership (www.grsproadsafety.org)

The GRSP is an international partnership of private companies, government agencies and research organizations working to improve road safety in developing countries. Most of its documents emphasize targeted safety programs, such as motorcycle helmet encouragement and improved traffic law enforcement, but some, such as the *World Report on Road Traffic Injury Prevention* (WHO 2004) recommend demand management safety strategies. Their *Drinking And Driving: A Road Safety Manual For Decision-Makers And Practitioners* (GSP 2007) recommends that, “public transport must be easily accessible and available to deter people from driving after drinking” (p. 58).

### Road Safety Foundation (www.roadwaysafety.org)

The Roadway Safety Foundation (www.roadwaysafety.org) is a non-profit organization created by automobile and allied industries to coordinate highway safety activities. It receives support from the Federal Highway Administration to promote traffic safety programs, including distribution of their, *Roadway Safety Guide: A Primer for Community Leaders*. This Guide describes various roadway engineering strategies and traffic safety programs which can increase traffic safety, but includes no mention of transit, TDM or smart growth strategies.
The Transportation Planner’s Safety Desk Reference (NCHRP 2010) discusses planner’s role in transportation safety. It includes 22 emphasis areas, each with an overview of the problem, descriptions of appropriate safety strategies, crash modification factors that can be used to predict the crash reductions from specific safety improvements, additional resources, and best practices.

Although it focuses on targeted safety programs, it does recommend vehicle travel reduction strategies. The Introduction states, “By providing mobility alternatives to the auto, transit reduces vehicle miles traveled (VMT), resulting in fewer traffic incidents, injuries, and fatalities.”

Governors Highway Safety Association ([www.ghsa.org](http://www.ghsa.org))

This organization provides information on state traffic safety programs. All the programs identified in its Highway Safety Program Guidelines are targeted strategies; none include TDM or smart growth strategies, or any discussion of reducing crashes by reducing vehicle travel. This organization may be amenable to new approaches if presented with credible evidence of their effectiveness, and acceptable by other traffic safety organizations.

Desktop Reference for Crash Reduction Factors, Institute of Transportation Engineers ([www.ite.org](http://www.ite.org))

This report documents estimates of the crash reduction that might be expected if specific countermeasures are implemented in a specific situation. These estimates are known as Crash Reduction Factors (CRFs). The strategies considered are all roadway physical design (including signs and marking) strategies, plus increased traffic law enforcement. The ITE includes a diverse range of members, including some that support multi-modalism, TDM and smart growth.

Motor Vehicle PICCS ([www.cdc.gov/motorvehiclesafety/calculator](http://www.cdc.gov/motorvehiclesafety/calculator))

The Motor Vehicle PICCS (Prioritizing Interventions and Cost Calculator for States) identifies a dozen possible state-level traffic safety strategies and the casualties that could be prevented by their implementation. It includes a fact sheet for each intervention, a final report and user guide. None of the strategies considered involve transportation demand management or smart growth.
In summary, most current traffic safety programs focus on targeted strategies intended to reduce specific risks. Only two programs evaluated here (the *Global Road Safety Partnership* and the *Transportation Planner’s Safety Desk Reference*) mention TDM as a possible way to increase traffic safety, and they provide only minimal information about those strategies, with little guidance on how to predict their impacts or evaluate their full benefits (including co-benefits). They generally assume that TDM can only provide modest safety benefits, reflecting ignorance about TDM impacts. This tends to reflect these organizations’ ideologies; most were established to support highway safety, so they consider their primary clients to be motorists and their primary goal to facilitate mobility. From this perspective, vehicle travel reduction efforts may be considered harmful to their clients and contradictory to their goals. Transport professionals, including traffic safety experts, are now starting to apply more comprehensive and multi-modal analysis.

Traffic safety experts may appreciate one specific justification to incorporate pro-transit policies in traffic safety programs: many existing traffic safety strategies involve reducing higher-risk driving; such strategies tend to be more effective and acceptable if targeted populations (youths, seniors, drinkers and texters) have appropriate alternatives to driving. This suggests that there are opportunities to encourage traffic safety experts and organizations to consider and support pro-transit policies in their work.

### 3. COMPREHENSIVE EVALUATION

Many transport safety strategies only help achieve a few planning objectives. For example, grade-separated highways reduce intersection crashes but by increasing traffic speeds they tend to increase crash severity, and to the degree that they induce additional vehicle travel and sprawl, they may increase per capita crash casualties. Similarly, increasing vehicle crash protection (e.g., seatbelts, air bags, larger vehicle size, etc.) tends to result in more *intensive* driving (incrementally high speeds and less shy distance, and more total vehicle travel, called *risk compensation*). By improving travel options and reducing total vehicle travel, TDM and smart growth strategies tend to provide a much broader range of benefits, many of which are overlooked or undervalued by conventional traffic safety planning, as indicated in Table 2.

#### Table 2 Comparing Strategies (Litman 2005)

<table>
<thead>
<tr>
<th>Planning Objective</th>
<th>Grade Separation</th>
<th>Vehicle Crash Protection</th>
<th>TDM Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase traffic safety</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Congestion reduction</td>
<td>✓</td>
<td></td>
<td></td>
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<tr>
<td>Roadway cost savings</td>
<td></td>
<td>✓</td>
<td></td>
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<tr>
<td>Parking cost savings</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Consumer cost savings</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Improved mobility options</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy conservation</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Pollution reduction</td>
<td></td>
<td>✓</td>
<td></td>
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<tr>
<td>Physical fitness and health</td>
<td></td>
<td></td>
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<tr>
<td>Land use objectives</td>
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</tbody>
</table>
4. A NEW TRAFFIC SAFETY PARADIGM

A new safety paradigm recognizes that all vehicle travel incurs risks, that high-risk and low-risk driving are complements, and that TDM and smart growth policies can provide substantial reductions in per capita traffic crash casualty rates, in addition to other economic, social and environmental benefits (EMBARQ 2012; May, Tranter and Warn 2011; Pirdavani, et al. 2013).

The new safety paradigm it is slowly gaining accepted. For example, the Federal Highway Administration 2010 Transportation Planner's Safety Desk Reference (FHWA 2012) recognizes that, “By providing mobility alternatives to the auto, transit reduces vehicle miles traveled (VMT), resulting in fewer traffic incidents, injuries, and fatalities. Transit ridership can be encouraged among the groups with the highest crash rates, such as young and older drivers, to reduce the potential for crashes.” That is a major step toward recognizing TDM as a traffic safety strategy. However, it is an exception – most traffic safety guidance documents ignore TDM strategies, and the Safety Desk Reference provides no guidance on how to calculate TDM safety benefits or incorporate mobility management into traffic safety programs.

The new paradigm supports more integrated and beneficial planning. Most conventional safety strategies impose significant costs and provide few other benefits. For example, driver impairment reduction strategies require restrictive drinking policies and increased policing, improved vehicle crash protection adds equipment costs and vehicle weight, and reducing roadside hazards often involves more costly roadway engineering and loss of roadside trees. In contrast, most mobility management strategies provide significant co-benefits including congestion reduction, road and parking facility cost savings, consumer savings, energy conservation and emission reductions, and improved mobility for non-drivers, and improved public fitness and health, in addition to increased safety.

5. IMPLEMENTING THE NEW SAFETY AGENDA

Paradigm shifts are challenging but exciting because they involve fundamental changes in the way problems are defined and potential solutions evaluated. They require practitioners to rethink the terms used to describe a problem, the methods used to measure impacts, possible responses to problems, and potential partnerships. Below are some ways that practitioners can help implement the new traffic safety agenda.

- Shift from distance-based to per capita indicators of accident risk. Distance-based indicators, such as crashes per billion vehicle-kilometers or million passenger-trips, fail to account for the incremental crashes that result from increases in per capita travel, and the safety benefits that result from vehicle travel reductions. Measuring crash risk per capita, as with other health risks, accounts for exposure (the amount of travel people engage in.
Learn about the full variety of transportation demand management (Table 1) and smart growth strategies. Most people are familiar with some of these strategies, but the field is rapidly expanding and improving as new technologies and methods develop.

**Table 1**  
Transportation Demand Management Strategies

<table>
<thead>
<tr>
<th>Improve Transport Options</th>
<th>Pricing Incentives</th>
<th>Land Use Management</th>
<th>Implementation Programs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transit improvements</td>
<td>Congestion pricing</td>
<td>Smart growth</td>
<td>Commute trip reduction programs</td>
</tr>
<tr>
<td>Walking and cycling</td>
<td>Distance-based fees</td>
<td>New urbanism</td>
<td>School and campus</td>
</tr>
<tr>
<td>improvements</td>
<td>Parking cash out</td>
<td>Parking management</td>
<td>transport management</td>
</tr>
<tr>
<td>Rideshare programs</td>
<td>Parking pricing</td>
<td>Transit oriented development</td>
<td>Freight transport</td>
</tr>
<tr>
<td>Flextime</td>
<td>Pay-as-you-drive vehicle insurance</td>
<td>Car-free planning</td>
<td>management</td>
</tr>
<tr>
<td>Telework</td>
<td>Fuel tax increases</td>
<td>Traffic calming</td>
<td>Tourist transport</td>
</tr>
<tr>
<td>Carsharing</td>
<td></td>
<td></td>
<td>management</td>
</tr>
<tr>
<td>Guaranteed ride home</td>
<td></td>
<td></td>
<td>Marketing programs</td>
</tr>
</tbody>
</table>

- Continue research concerning the safety benefits of TDM and smart growth strategies, and develop models for predicting these impacts.
- Encourage practitioners including traffic safety professionals, transportation planners and engineers, urban planners, public health officials, transit agencies, municipal governments, campus managers, and public officials to learn about TDM and smart growth traffic safety benefits.
- Learn about the full economic, social and environmental benefits of TDM and smart growth strategies and use this information when evaluating their cost efficiency compared with other traffic safety strategies. For example, many TDM strategies help reduce traffic and parking congestion, infrastructure costs, consumer costs and pollution emissions, as well as increasing public fitness and health, and improving mobility options for non-drivers; all of these benefits should be considered.
- Build coalitions. Because TDM and smart growth provide diverse benefits, they offer an opportunity to build broad coalitions to support implementation. For example, people and organizations concerned with economic development, traffic and parking congestion reduction, affordability, public fitness and pollution reductions have reasons to support these strategies.
- Implement TDM and smart growth strategies as integrated programs, since they tend to be more effective and politically acceptable if implemented together. For example, public transit improvements tend to be most effective if implemented in conjunction with walking and cycling improvements, efficient road and parking pricing, and commute trip reduction programs.
6. CONCLUSIONS

Traffic accidents impose major costs on society. There are many possible ways to reduce crashes; which strategies are considered most effective and cost effective depends on how they are evaluated. When measured using distance-based indicators, conventional traffic safety programs seem effective and justified. However, if traffic risk is measured per capita, conventional safety programs appear much less effective and new approaches, including transportation demand management and smart growth strategies, are justified.

TDM and smart growth can provide large safety benefits. Virtually all areas with very low traffic casualty rates, below five annual traffic deaths per 100,000 residents, are compact, multimodal communities, while most sprawled, automobile-dependent communities have four or five time higher rates, and credible research indicates that strategies such as efficient road and parking pricing, public transit improvements, and complete streets programs reduce traffic casualty rates.

Conventional traffic safety programs tend to focus on targeted strategies which reduce special risks, such as youth, impaired and senior driving; they generally ignore TDM and smart growth as potential safety strategies. However, a new traffic safety paradigm recognizes the incremental crashes that result from increases in per capita vehicle travel and the safety benefits of TDM and smart growth strategies. Because they provide significant co-benefits, these strategies are often cost effective, when all impacts are considered, and offer opportunities to build diverse coalitions for supporting such strategies.

Many obstacles must be overcome for TDM and smart growth safety programs to be implemented to the degree justified. Many transportation agencies continue to apply a highway agency perspective: they assume that their goal is to facilitate automobile travel and are disinclined to apply strategies that reduce mobility, and many have little understanding of how to implement TDM and smart growth, and how to evaluate benefits. Practitioners will need to change the way they think about and measure risk, and learn about TDM and smart growth strategies, and build political and institutional relationships to support them.

7. ACKNOWLEDGEMENTS

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