

Reinhard Clever

# Can Lane Discipline Decrease the Sensitivity of Freeway Fatality Rates to Increases in Speed Limits?

Paper presented at the 50th Annual Transportation Research Forum in  
Portland, Oregon, March 16-18, 2009

Reinhard Clever, Ph.D., President, [thinkMetric.com](http://thinkMetric.com)  
25800 Industrial Blvd, No 1162, Hayward, CA 94545; phone: +1 (510) 610 – 3446;  
[Reinhard.Clever@thinkMetric.com](mailto:Reinhard.Clever@thinkMetric.com) <http://thinkMetric.com/home>

## ABSTRACT

While research in the United States has consistently shown that freeway fatality rates increase with higher speed limits, freeway fatality rates in Germany with no general speed limit on the autobahns are about the same as they are in the United States. The paper explores different contributing factors which might explain this mystery and which lessons of interest to US freeway operations might be learned. It surmises that a very strict separation of traffic by speed (lane discipline) in Germany as opposed to the US might be the main explanatory factor for the low sensitivity of fatality rates to changes in speed limits in Germany versus a very high sensitivity in the United States.

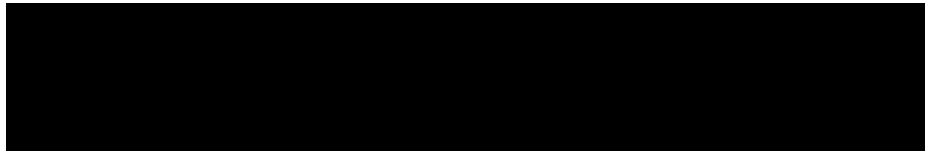
## BACKGROUND

### Comparison of International Road Accident Statistics

As late as the 1970's, accident rates in the United States were significantly lower than in the other industrialized countries (*OECD, 2007a*). However, since then, safety improvements have been more dramatic outside the United States, and in the first decade of the 21<sup>st</sup> century this country only takes an average rank (*OECD, 2007b*).

Pedestrian fatalities are a good example to demonstrate this point. TABLE 1 illustrates the remarkable success of pedestrian safety improvements in Germany (*BASt, 2008a and 2008b*). "Per kilometer and per trip walked, American pedestrians are roughly 3 times more likely to get killed than German pedestrians and over 6 times more likely than Dutch pedestrians." (*Pucher & Dijkstra, 2003*).

**TABLE 1 - Pedestrian Fatalities in Germany, 1970 – 2007, Source: *BASt (2008a and 2008b)***



### Comparison of Freeway Fatality Rates between Germany and the United States

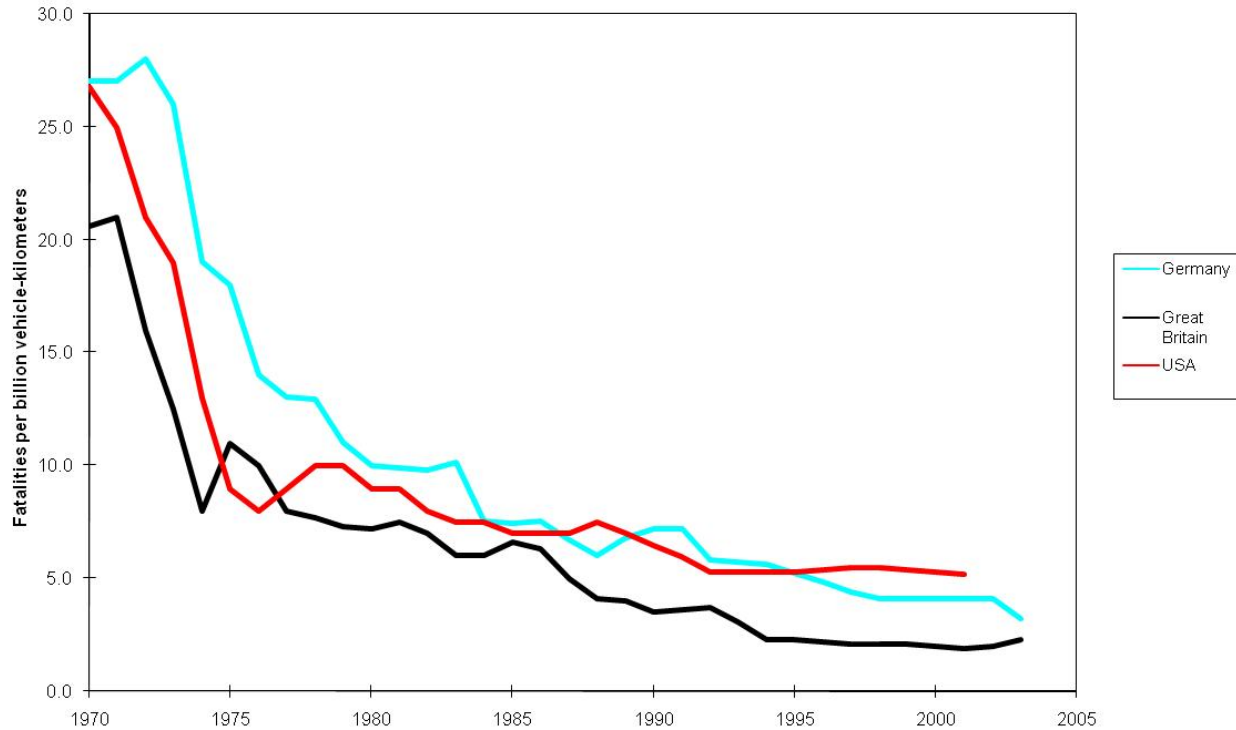
FIGURE 1 shows that the fatality rates per billion vehicle kilometers [Vkm] on U.S. freeways and German autobahns have been very similar for a long period of time (*OECD 2007c*). In 2001 the fatality rate was 5.1 in the United States and 4.2 in Germany. Some countries have considerably lower death rates, like Great Britain with 1.9 fatalities per billion vehicle kilometers (shown in FIGURE 1 for reference); other countries have considerably higher rates, like Austria with 8.3 fatalities in the same year.

Detailed analyses of the statistics in FIGURE 1 are provided in *Elsner, Reichwein & Schepers (2000)*, *Schepers & Reichwein (2004)*, and *Schepers & Reichwein (2005)*.

For Germany with no general speed limit on the autobahns to have a lower freeway fatality rate than the United States seems counterintuitive. It may be better understood with an analogy of a 2-lane rural highway. Let us assume that the rules for 2-lane roads were 1) you may choose any one of the two lanes to travel in either direction, 2) you may pass either to the right or to the left. Let us also assume the speed limit was 25 mph. Now somebody suggested to increase the speed limit to 55 mph, but in

turn mandated lane discipline: 1) You must drive on the right side of the road, except for passing, and 2) you are only allowed to pass on the left. We could see that the higher speed limit, when combined with mandatory lane discipline, would probably save lives.

The impact of lane discipline on freeway fatality rates is the main topic of this paper.



**FIGURE 1 - Freeway Fatality Rates for Germany, Great Britain and the USA, Source: OECD (2007c)**

## Definition of Lane Discipline

Microsoft Encarta attempts to define the term, but unfortunately misses the main point (*Microsoft Corporation, 2008*). A UK press release clearly states that lane discipline is about (the American equivalent of) driving on the right and passing on the left (*Drive and Stay Alive, Inc., 2008*). Lane discipline can be important not just for freeways, but also for the operation of roundabouts as an online FHWA discussion illustrates (*US Federal Highway Administration, 2005*).

## CONTEXT AND HISTORY

### Repeal of the National Speed Limit in the United States

In 1995 the federally mandated 55 mph speed limit on all roads except rural interstates was abolished and states were given the authority to determine their own limits. In 1988 US Congress had already authorized an increase to 65 mph on rural interstates. Since 1989 many studies were done to compare

the number of accidents before and after the speed limit increase on rural freeways to 65 mph. Out of 21 studies between 1989 and 1995 evaluated by the author, 18 concluded that crash and fatality rates increased significantly after the speed limit was raised to 65 mph (*Clever, 1996*). Later studies assessed the effect of the repeal of the national maximum speed limit in 1995 and came to similar conclusions. *Grabowski & Morrissey (2007)* found that the repeal of the national speed limit resulted in a 36-37% increase in fatalities. They also found little support for the notion that a traffic shift to safer interstate highways had lowered the number of fatalities on alternate routes. Another study, comparing vehicle occupant deaths between 24 states which had raised the interstate speed limit with seven states that had not, concluded that fatality rates were 17% higher following the speed limit increases (*Farmer, Retting & Lund, 1999*).

The roughly 3.5% rise in fatality rates following the 10 mph speed limit increase on rural interstates in 1988 prompted economists to estimate the public's willingness to trade off wealth for a change in the probability of death. They found that about 125,000 hours were saved per lost life and, assuming time was saved at the average hourly rate, that the value of a statistical life might be in the neighborhood of \$ 1.5 million (*Ashenfelter & Greenstone, 2004*).

It is safe to conclude that fatality rates on US freeways are perceptibly sensitive to speed limit increases.

## German Experience

There was no statutory speed limit in Germany for roads outside of city limits until 1 October 1972, when a general maximum speed of 100 km/h (62 mph) was introduced on rural 2-lane highways as part of a large scale experiment (*Projektgruppe "Tempo 100," Keller, et. al., 1975*). This limit was extremely unpopular, but since it reduced accident rates significantly, it was there to stay and made permanent at the end of the trial period on 1 January 1976 (*Praxenthaler, 2000*). The experience with a statutory speed limit on autobahns was different. The same general limit of 100 km/h (62 mph) was introduced during the oil crisis. It saved on gasoline consumption and reduced green house gases, but the reduction in accident and fatality rates was not significant. After the oil crisis had subsided, the statutory speed limit was replaced by an advisory limit of 130 km/h (80 mph) on 1 November 1978 (*Praxenthaler, 2000*), which is still in effect today. It must be emphasized that a substantial portion of the German autobahn network has posted speed limits at various levels, but no general speed limit means that large sections of the network have no restrictions.

Variable speed limits on autobahns are becoming ever more popular. A variable speed limit (VSL) usually includes no speed limit as an option for ideal traffic and weather conditions. VSL is made operational with overhead gantries (FIGURE 2). A VSL system is most often installed to optimize traffic flow through bottlenecks. But it is also very effective under inclement weather conditions. For example during heavy fog it can prevent 150+ car "pile-ups," which are common on Interstate 5 in California's San Joaquin Valley. For more information on Variable Speed Limits on autobahns please see *Bertini, Boyce & Bogenberger, 2006* and *Boice, Bertini, Ahn & Bogenberger, 2006*.

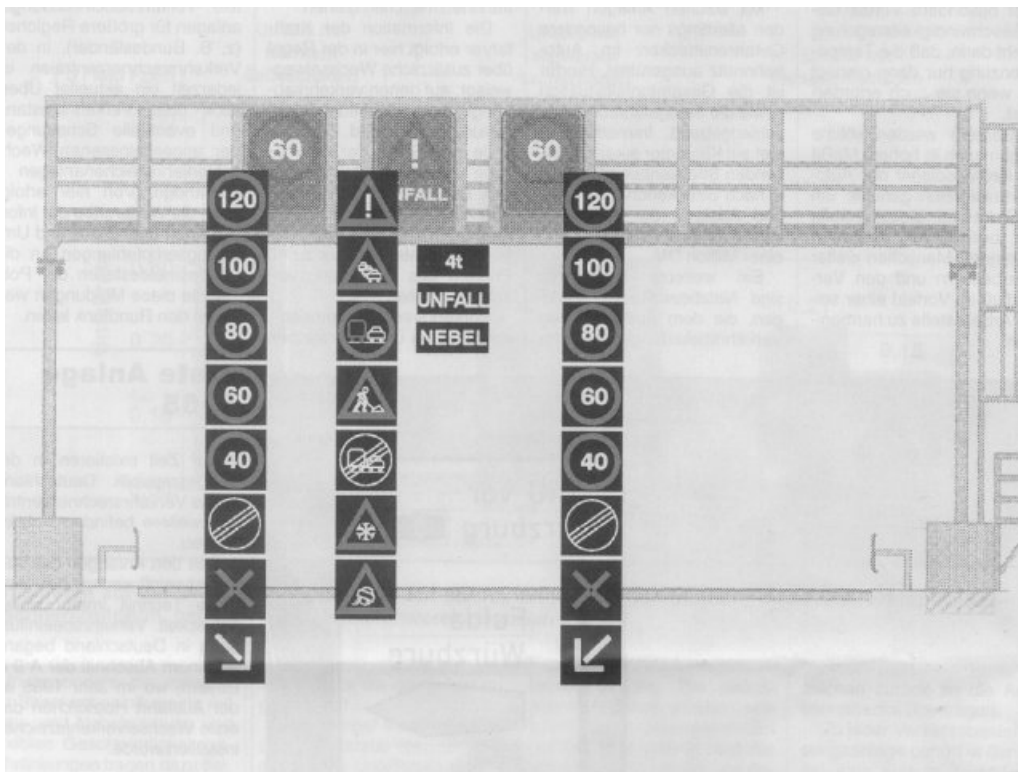
The imposition of a statutory speed limit on autobahns continues to be contentiously debated, but traffic safety arguments are rarely made. The emotional intensity of the discussion is reminiscent of the

gun control debate in the United States. In both cases the deeper issue is perceived to be the last stance of individual freedom against ever increasing authority of the state.

The next section of the paper looks at some of the differences between the United States and Germany which might explain the counterintuitive similarity in freeway death rates.



**FIGURE 2a - Variable Speed Limit Gantry - Source: Boice et. al., 2006**



**FIGURE 2b - Variable Speed Limit Options Menu – Source: Boice et. al., 2006**

## CONTRIBUTING FACTORS

### Drivers “At the Margin” due to a Zero Choice Transportation Environment

A “Zero Choice Transportation Environment” is characterized by the absence of alternative transportation, or by public transportation perceived as so inadequate by the trip maker that it is not considered in trip making decisions. That means the only practical alternative to using a private automobile is walking.

The direct consequence is that people too young, too old, too drunk, or too poor, who would use public transportation in other countries, are dependent on driving automobiles in the United States, regardless of their qualifications, and often no matter what the potential penalties are. A study examining the degrees to which Mexican immigrant families had access to cars pointed out that many were unable to get a driver’s license because of their legal immigration status. But driving without a license meant risking to have their car (or their friend’s car) seized and then not being able to retrieve it due to exorbitant fees. It also meant driving without insurance (*Lovejoy & Handy, 2008*). People are only willing to take these risks when they see no other alternatives.

To control for exposure differences among age groups a “paired-vehicle” analysis including 2,516 freeway accidents in which one older driver (66+) and one younger driver (31-45) were involved found that older drivers were cited twice as often as younger drivers for all accidents, and five times as often for accidents involving lane change maneuvers (*US Federal Highway Administration, 1996*).

Young drivers have a higher propensity to take risks, often imprudently, due to their limited experience. The minimum license age is generally 18 years in Europe, versus 16 in the United States. The risks associated with drunk driving are well documented and not further discussed.

Since increasing penalties for illegal driving without providing viable alternatives to the use of the private automobile can only have a limited effect, one could reasonably argue that re-creating a balanced transportation system in the United States may significantly reduce accident rates. In a balanced system all modes, each one having its unique set of advantages and disadvantages, are able to do what they do best. Frequent short haul feeder flights within a metropolitan area, as e.g. between Burbank and Los Angeles International Airport, made necessary by the slow and unreliable uni-modal ground transportation system, would indicate the opposite – an unbalanced transportation system. Airplanes are required to fulfill a transportation function that is handled more efficiently elsewhere by rail.

At the end of World War II the United States had one of the best public transportation systems in the world. It was systematically destroyed by National City Lines after the war, and is now being rebuilt, as a shadow of its former self, at a tremendous cost. Furthermore, land use patterns adopted in the last 50 years have made the deployment of public transportation very difficult.

Limiting “drivers at the margin” by adopting stiffer penalties is probably not very effective, and doing so by providing alternate means of transportation is definitely very expensive. Neither option appears to be a very fruitful avenue to pursue.

## Automobile Safety Inspections

While the safety risk of marginal drivers is well established, the safety risk of marginal vehicles is not. For example, Norway had to introduce periodic automobile safety inspections in 1995 as a condition of access to the European common market. Christensen and Elvik found that this had little effect on overall traffic safety (*Christensen & Elvik, 2007*). The authors speculate that car owners may have been able to adapt their driving behavior to the technical condition of their car.

Mandating automobile safety inspections to limit the use of marginal vehicles would be considerably easier than re-creating a balanced transportation system to entice marginal drivers not to use automobiles, but the overall effect on traffic safety may be very limited.

## Truck Speed Limits

Due to their weight, trucks have a much greater braking distance than cars and considerably less maneuverability. This causes truck speed limits to be usually lower than those for cars. The maximum speed for trucks in the European Community is 80 km/h (50 mph), and that, of course, includes German autobahns.

Ten states in the US have adopted a general speed limit of 120 km/h (75 mph) for rural interstates without setting lower speed limits for trucks (*Insurance Institute for Highway Safety, 2008*). In those states the truck speed limit on freeways is 50% higher than in the European Community. It is interesting to note that the United States may have the highest truck speed limits in the industrialized world.

## Lane Discipline

### Germany and The United States – Two Extreme Cases

The most striking difference which drivers who are familiar with both German autobahns and US freeways notice is the dissimilar level of attention given to lane discipline. Interesting lessons might be learned from this for US freeway operations, since it does not involve re-creating an alternative transportation network nor taking on the powerful lobby of the American Trucking Association.

The principle of separation of traffic by speed is only a subcategory of the larger principle of *mode separation*. The idea that the better the mode separation the lower the accident rate is very old and self-evident. At grade versus grade separated railroad crossings are a good example. It also explains why accident rates of freeways are consistently lower than those of surface streets, even though speeds are higher on freeways than on surface streets. Since the principle of separation of traffic by speed works so well between surface streets and freeways, the question arises why not to apply it to freeways themselves. This principle is systematically implemented and strictly followed by most drivers on European freeways.

However German drivers take this to an extreme. A clear distinction is made for example between the “haves” and the “have-nots,” those who have the right of way when merging onto a freeway and those who do not. This makes it possible for freeway traffic to operate at very high speeds without the threat of having to brake abruptly for merging traffic. But it also necessitates very long acceleration lanes. In spite of these long lanes it occasionally happens that a vehicle attempting to merge is not able to

accelerate fast enough before reaching the end of the acceleration lane. It is then forced to come to a very quick stop. These are called “starving vehicles,” because they have to wait so long before a large enough gap in the traffic flow allows them to move onto the main freeway lanes. They basically find themselves in the same situation as cars that had to pull over to the shoulder.

“Starving vehicle” incidents happen very infrequently, but the mere fact that a word exists to describe this condition is indicative of the excessive attention given to lane discipline. Impatient drivers tailgating slower vehicles is another example.

It is an interesting exercise to juxtapose the German extreme with the North American one.

There are countries where people drive on the right side of the street, e.g. in Continental Europe. There are other countries where people drive on the left side of the street. Britain, Australia, and Japan are examples of that. But there is also one country where people drive on the left side of the right side of the street, the United States. In a very telling anecdote a German driver failed his US driving test for driving on the right side of the right side of the street. He was supposed to drive on the left side of the right side of the street. The right side of the right side of the street was for parked and right turning vehicles only. This rule is deeply embedded in US traffic engineering. People are supposed to drive on the left side and only in exceptional cases on the right, the exact opposite of the European rule.

Passing lanes are usually striped in a fashion that seems to indicate that the passing lane is on the right, not the left. Some people use it this way, passing on the right, but slow traffic also moves to the right resulting in an unholy combination of the fastest and the slowest traffic in a single lane, the auxiliary lane (FIGURE 3).

The result of slow moving traffic being almost equally distributed over all freeway lanes is that passing cars have to zigzag around them. At the relatively forgiving speed of 55 mph this is a nuisance but it is not likely to have a major safety impact. At higher, less forgiving, speeds however, it is not acceptable anymore when passing traffic is forced to zigzag. This may be the leading cause of the high sensitivity of freeway fatality rates to increases in speed limits in the United States.



**FIGURE 3 - Passing Lane on the Right**

### **Australian Experience**

On 1 March 1988 previously advisory “Keep Left Unless Overtaking” (KLUO) signs (FIGURE 4) were made regulatory. *Zutshi & Cavallo (1989)* found that making the previously advisory “Keep Left Unless Overtaking” (KLUO) signs regulatory resulted in a significant increase in the number of cars travelling in the left lane.



**FIGURE 4 - Australian Road Signs – Source: *Government of Victoria (1999)***

A statutory “Keep Left Unless Overtaking” rule applies to all multi-lane roads (freeways or surface, urban or rural) with a speed limit of more than 80 km/h (50 mph). In addition, drivers must stay out of the right lane where “Keep Left Unless Overtaking” signs are posted. Exceptions are allowed for drivers turning right or making a U-turn (*Royal Automobile Club of Victoria, 2007*).

The rule in Australia applies only to the far right lane. By contrast, the British Highway Code specifically includes the center lanes in the “Keep Left Unless Overtaking” regulations (*Drive and Stay Alive, Inc., 2008*).

It is very noteworthy that *Zutshi & Cavallo(1989)* even found a larger increase in the percentage of vehicles using the left lane in zones where KLUO rules did not apply, compared to those sections where KLUO signs had just become regulatory. This indicates that the 1988 “Keep Left Unless Overtaking” regulations had caused a fundamental shift in driving behavior.

For an example of the exact wording of the law in Australia see *Government of Victoria (1999)*. *Government of New South Wales (2000)* is a technical description of how the road signs are used, and *Sanderson & Corrigan (1987)* evaluate their effect on lane utilization and lane speed. “Keep Left Unless Overtaking” signs have also been introduced in New Zealand (*King, 1993*).

### Michigan Experience

Unlike the above mentioned Australian study, which found that making the previously advisory “Keep Left Unless Overtaking” (KLUO) signs regulatory resulted in a significant increase in the number of cars travelling in the left lane, a Michigan study (*Dion & Liang, 2007*) not only indicated that a change in the law to prohibit unlawful left lane usage on non congested two lane rural freeways in Michigan had no effect, but also concluded that changing the “Slower Traffic Keep Right” signs to “Keep Right Pass Left – It’s the Law” (FIGURE 5) would not affect driver behavior without concurrent enforcement.

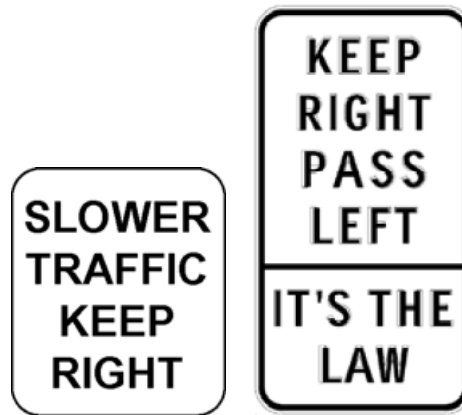


FIGURE 5 - Michigan Rural Freeway Signs - Source: *Dion & Liang (2007)*

### The Concept of Unenforced Laws

Just passing a law does not appear to be enough to change people’s behavior in the United States. The public also needs to be convinced that the new law is actually going to be enforced. When the government fails to take this critical second step, the new regulation is simply ignored, as is the case with Michigan’s “Keep Right – Pass Left” law.

The concept of unenforced regulations is another point of distinction between the United States and Germany.

The “gap” between what the law demands and how people act seems to be much larger in the United States compared to not only Germany but also with respect to many other European countries. Part of the reason may be the nature of some of the laws. A case in point are right of way regulations. The basic rule in Europe is that unless there is a posted sign that specifically grants the right of way, one has to yield to traffic coming from the right. The rule in the United States is almost the exact opposite. Theoretically nobody has the right of way, but in practice it means that people assume they have the right of way, unless they see a sign to the contrary, like a yield or a stop sign. Since the basic rule in America is inherently much more dangerous than the fundamental European rule, stop signs are used as speed bumps to compensate for the greater danger. This causes people to “roll” through stops rather than doing what the sign says: stop. When yielding to the right, one is not obliged to come to a complete stop, thus Europeans are not breaking the law as routinely as American drivers do.

There are many more examples. California law requires motorists to yield to pedestrians not only at marked, but also at unmarked crosswalks. *Mitman and Ragland (2007)* found that only a small percentage of the driver population even knows about this law.

This has important consequences for any scientific evaluation of the degree to which greater lane discipline in the United States could decrease the sensitivity of fatality rates to speed limit increases. Without strict enforcement and especially good education before and after studies would be pointless.

## **SUGGESTED RESEARCH: LANE DISCIPLINE EFFECTS BEFORE AND AFTER STUDY**

Since a “Keep Right – Pass Left” law is already in effect in Michigan, performing a Lane Discipline Effects Before and After Study there would be most sensible. However, because the concept of driving on the right and passing on the left is so anathema to American drivers, the changes, whose effects are the subject of the study, cannot be limited to stepped up enforcement, but have to include educating drivers about the apparent advantages of this regulation. People who have never been outside of the United States cannot be expected to recognize the potential benefits without the dissemination of pertinent information. Likewise, highway patrol officers will probably not give the enforcement of the “Keep Right – Pass Left” law a high priority without clearly understanding the background and motivation behind it.

The limitation of the Michigan law to uncongested rural two-lane interstates would be of great benefit to this study. It makes the unintended side effect of increased conflicts in merging zones less likely, and does not necessitate the lengthening of acceleration lanes and concurrent implementation of new right of way rules, which would give through traffic priority over merging traffic.

## **CLOSING REMARKS**

It was previously mentioned that the separation of traffic by speed is a special case of *mode separation*.

North America's road infrastructure and regulatory framework was optimized for a uniform, uni-modal traffic flow. European countries, in part due to their high population densities, never had the option of having all their mobility needs met by the most convenient of all modes, the private automobile. Integrating the divergent needs of a multiplicity of transportation options into a coherent transportation environment had always been a high priority. In the process sophisticated mode separation schemes were developed which minimized intermodal conflicts and optimized the transportation network as a whole.

As America adapts both its infrastructure and regulations to a more multi-modal environment, which lacks the characteristic of a uniform traffic flow, it has the benefit of drawing on the experience of other countries. FIGURES 6 and 7 are good illustrations of this adaptation process.

FIGURE 6 shows an intersection where particular care was taken to separate conflicting movements of disparate modes. Drivers making right turns on red are able to see pedestrians coming from either direction by default. They do not need to remember to also look for pedestrians, who are crossing the intersection on a green light and are coming from the right.



**FIGURE 6 - Safe Intersection for Right Turns on Red**

FIGURE 7 demonstrates lane discipline on the part of the traffic engineer.



**FIGURE 7 – Passing Lane on the Left**

## BACK REFERENCES

*All electronic sources were last accessed on 2009-03-17 unless otherwise noted.*

Ashenfelter, O; Greenstone, M (2004). Using Mandated Speed Limits to Measure the Value of a Statistical Life. *Journal of Political Economy*, 112 (1), 226-267. Abstract accessible online at: <http://www.journals.uchicago.edu/doi/abs/10.1086/379932>.

BAST – Bundesanstalt für Straßenwesen – German Federal Highway Administration (2008a). Traffic Accidents in Germany. Accessible online at: [http://www.bast.de/cIn\\_005/nn\\_76770/EN/e-Statistik/e-Unfalldaten/downloads/e-strassenverkehrsunfaelle,templateId=raw,property=publicationFile.pdf/e-strassenverkehrsunfaelle.pdf](http://www.bast.de/cIn_005/nn_76770/EN/e-Statistik/e-Unfalldaten/downloads/e-strassenverkehrsunfaelle,templateId=raw,property=publicationFile.pdf/e-strassenverkehrsunfaelle.pdf)

BAST – Bundesanstalt für Straßenwesen – German Federal Highway Administration (2008b). International Traffic and Accident Data - Fatalities by Traffic Participation. Accessible online at: [http://www.bast.de/cIn\\_005/nn\\_76770/EN/e-Statistik/e-Unfalldaten/downloads/e-getoetete-verkehrsbeteiligung,templateId=raw,property=publicationFile.pdf/e-getoetete-verkehrsbeteiligung.pdf](http://www.bast.de/cIn_005/nn_76770/EN/e-Statistik/e-Unfalldaten/downloads/e-getoetete-verkehrsbeteiligung,templateId=raw,property=publicationFile.pdf/e-getoetete-verkehrsbeteiligung.pdf)

Bertini, R.; Boice, S.; Bogenberger, K. (2006). Comparison of Key Freeway Capacity Parameters on North American Freeways with German Autobahns Equipped with a Variable Speed Limit System. Proceedings of the 5th International Symposium on Highway Capacity and Quality of Service in Yokohama, Japan; edited by Hideki Nakamura and Takashi Oguchi; Tokyo: Japan Society of Traffic Engineers, pp. 279-287. Abstract accessible online at: <http://ntlsearch.bts.gov/tris/search.do?b1=1&f1=0&t1=ti%3Acomparision+ti%3Aakey+ti%3Afreeway+ti%3Acapacity+ti%3Aparameters+ti%3Anorth+ti%3Aamerican+ti%3Afreeways+ti%3Agerman+ti%3Autobahns+ti%3Aequipped+ti%3Avariable+ti%3Aspeed+ti%3Alimit+ti%3Asystem&r=1&d=tr&p=0&z=1&s=yr&o=1&new=n>. Full text accessible online at: [http://web.pdx.edu/~bertini/papers/ISHC\\_Final\\_April\\_2006.pdf](http://web.pdx.edu/~bertini/papers/ISHC_Final_April_2006.pdf).

Boice, S.; Bertini, R.; Ahn, S.; Bogenberger, K. (2006). Dynamics of Variable Speed Limit System Surrounding Bottleneck on German Autobahn. *Transportation Research Record: Journal of the Transportation Research Board*, Vol. 1978, pp 149-159. Abstract accessible online at: <http://trb.metapress.com/content/r730500498041327/>.

Christensen, P.; Elvik, R. (2007). Effects on Accidents of Periodic Motor Vehicle Inspection in Norway. *Accident Analysis & Prevention*, 39 (1), 47-52.

Clever, R. (1996). Summary of Research on the Safety Effect of the Speed Limit Increase on Rural Interstates to 65 mph. Accessible online at: <http://thinkMetric.com/pubs/autobahn/1996.html> .

Dion, F.; Liang, Z. (2007). Assessment of the Effectiveness of Proposed “Keep Right Pass Left – It’s the Law” Signs on Two-Lane Rural Freeways. University of Michigan Transportation Research Institute; Michigan Department of Transportation; Report No. UMTRI-2007-45. Abstract accessible online at: <http://hdl.handle.net/2027.42/57737>.

Drive and Stay Alive, Inc. (2008). Keep Left unless Overtaking and Don’t Hog the Middle Lane. UK Department of Transport, Highways Agency, Press Release, 11 October 2004. Accessible online at: [http://www.driveandstayalive.com/info%20section/news/individual%20news%20articles/x\\_041011\\_uk\\_keep-left-unless-overtaking.htm](http://www.driveandstayalive.com/info%20section/news/individual%20news%20articles/x_041011_uk_keep-left-unless-overtaking.htm)

Elsner, E., Reichwein, S. & Schepers, A. (2000). Traffic Safety on European Motorways – in German. Straßenverkehrstechnik, 44 (1), 5-10.

Farmer CM, Retting RA, Lund AK (1999). Changes in motor vehicle occupant fatalities after repeal of the national maximum speed limit. Accident Analysis & Prevention, 31 (5), 537-543. Abstract accessible online at: <http://www.ncbi.nlm.nih.gov/pubmed/10440551>.

Government of New South Wales (2000). Use of Keep Left Unless Overtaking Signs. Roads and Traffic Authority, Road Safety and Traffic Management Directorate, New South Wales, Authority, Technical Direction No. 2000/3. Accessible online at: [http://www.rta.nsw.gov.au/trafficinformation/downloads/00\\_03.pdf](http://www.rta.nsw.gov.au/trafficinformation/downloads/00_03.pdf).

Government of Victoria (1999). Road Rules – Victoria. Victoria Government Gazette, 28 October 1999. Accessible online at: [http://www.vicroads.vic.gov.au/NR/rdonlyres/363A6DB7-86A0-4411-AD67-D8974A20832D/0/part\\_11.pdf](http://www.vicroads.vic.gov.au/NR/rdonlyres/363A6DB7-86A0-4411-AD67-D8974A20832D/0/part_11.pdf)

Grabowski, D C; Morrissey, M A (2007). Systemwide Implications of the Repeal of the National Maximum Speed Limit. Accident Analysis & Prevention, 39 (1), 180-189. Abstract accessible online at: <http://ntlsearch.bts.gov/tris/search.do?b1=1&f1=0&t1=kw%3Asystemwide+kw%3Aimplications+kw%3Arepeat+kw%3Anational+kw%3Amaximum+kw%3Aspeed+kw%3Alimit&r=1&d=all&p=0&z=1&s=yr&o=1&new=n>.

Insurance Institute for Highway Safety, Highway Loss Data Institute (2008). Maximum posted speed limits, July 2008. Accessible online at: <http://www.iihs.org/laws/speedlimits.aspx>.

King, B. (1993). Introduction of Keep Left Unless Overtaking signs on four-lane highways in Wellington. University of Auckland, Department of Civil Engineering, Auckland, New Zealand.

Lovejoy, K.; Handy, S. (2008). A Case for Measuring Individuals' Access to Private-Vehicle Travel as a Matter of Degrees: Lessons from Focus Groups with Mexican Immigrants in California. 87<sup>th</sup> Annual Meeting of the Transportation Research Board.

Microsoft Corporation (2008). Lane Discipline. MSN Encarta. Accessible online at: [http://encarta.msn.com/dictionary\\_561510709/lane\\_discipline.html](http://encarta.msn.com/dictionary_561510709/lane_discipline.html).

Mitman, M. F.; Ragland, D. R. (2007). Crosswalk Confusion: More Evidence Why Pedestrian and Driver Knowledge of the Vehicle Code Should Not Be Assumed. Transportation Research Record: Journal of the Transportation Research Board, No. 2002, pp.55-63. Abstract accessible online at: <http://trb.metapress.com/content/b1kn25n427865535/>

OECD (2007a) – International Road Accident Database (IRTAD). Trellis Graph of Traffic deaths per 1 billion vehicle kilometers in individual representations since 1970. Accessible online at: <http://www.internationaltransportforum.org/irtad/pdf/p128.pdf>.

OECD (2007b) – International Road Accident Database (IRTAD). Bar Graph of Road deaths per billion vehicle kilometres in 2006, selected countries. Accessible online at: <http://www.internationaltransportforum.org/irtad/pdf/p141.pdf>.

OECD (2007c) – International Road Accident Database (IRTAD): Line Graph of Death rates on Motorways since 1970 - selected countries. Accessible online at: <http://www.internationaltransportforum.org/irtad/pdf/p130.pdf>.

Praxenthaler, H. (2000). Initiativen und Maßnahmen, Unfallverlauf und Erfolgsbilanz. Straßenverkehrstechnik, 44 (3), 137-142.

Projektgruppe "Tempo 100" – Keller, H., et. al. (1975). Effects of the 100 km/h speed limit on traffic flow and traffic safety – in German. Bundesanstalt für Straßenwesen, Cologne, June 1975.

Pucher, J., & Dijkstra, L. (2003). Promoting Safe Walking and Cycling to Improve Public Health: Lessons from The Netherlands and Germany. American Journal of Public Health, 93 (9), 1509-1516. Accessible online at: <http://policy.rutgers.edu/faculty/pucher/AJPHfromJacobsen.pdf>

Royal Automobile Club of Victoria (RACV) (2007). Keep Left unless Overtaking. Accessible online at: <http://www.racv.com.au/wps/wcm/connect/Internet/Primary/road+safety/roads+&+traffic/road+rules/common+road+rules/keep+left+unless+overtaking>.

Sanderson, J.T.; Corrigan, J. McM. (1987). Lane Utilization and Lane Speed Characteristics Related to Keep Left Unless Overtaking legislation. Melbourne: Royal Automobile Club of Victoria (RACV).

Schepers, A. & Reichwein, S. (2004). Traffic Safety on European Motorways – in German. Straßenverkehrstechnik, 48 (3), 101-105.

Schepers, A. & Reichwein, S. (2005). Traffic Safety on European Motorways – in German. Straße und Autobahn, 56 (12), 5-10.

US Federal Highway Administration (1996). Analysis of Older Drivers on Freeways. HSIS Summary Report, Report No. FHWA-RD-96-035. Full text accessible online at: <http://ntl.bts.gov/DOCS/rd96-035/rd96-035.htm>.

US Federal Highway Administration (2005). Roundabouts: Good Alternative? , Office of Operations - Knowledge Communities Discussion Topic, "Nick," 01/10/2005." <http://knowledge.fhwa.dot.gov>. Last accessed 2008-08-01.

Zutshi, I.; Cavallo, A. (1989). Evaluation of the "Keep Left Unless Overtaking" Regulation. Victoria Road Safety & Traffic Authority, Australia, Report No. GR 89-2; HS-040 597. Abstract accessible online at:

<http://ntlsearch.bts.gov/tris/search.do?b1=1&f1=0&t1=kw%3ADriving+kw%3Apassing+kw%3Afreeways&r=1&d=tr&p=3&z=1&s=yr&o=1&new=n>.

## **FORWARD REFERENCES**

To obtain a list of papers, theses, or books which cite this paper, please go to:

<http://thinkMetric.com/pubs/autobahn/index.html#fwd>.

If you have cited this paper, please send a brief email to the author, so your publication can be added to the Forward References section: [Reinhard.Clever@thinkMetric.com](mailto:Reinhard.Clever@thinkMetric.com) .