



Bike Delaware

www.bikede.org

A coalition of like minded citizens and organizations that promote bicycling as a healthy alternative to driving and advocate safe provisions within our transportation system.

IMPROVING NONMOTORIZED SAFETY AND MOBILITY WITH INFRASTRUCTURE AT ARTERIAL ROAD SIGNALIZED INTERSECTIONS

Summary

In 2008, Delaware had the second highest number of pedestrians killed on its roads (normalized by population) in the country. If not for Florida's tragic record of unnecessary death that year, Delaware would have been the pedestrian fatality rate's "First State." To avoid this unwanted distinction in the future – and to avoid giving our state's motto a new and awful meaning – Delaware needs to invest in infrastructure that protects pedestrians from being killed on its roads. There are many infrastructure investments, for example, that have been shown to be effective at reducing collisions at intersections involving pedestrians while simultaneously improving the mobility of nonmotorized users of these intersections. Most of these countermeasures, however, (a) have already been adopted as a standard design element by DelDOT (pedestrian countdown signal), (b) are illegal in Delaware (radar speed camera), (c) are not permitted by the MUTCD (pedestrian hybrid beacon), (d) reduce motorized level-of-service on high ADT roads (road diet) or (e) are inordinately costly (bridge/underpass). Three other interventions, however, are not excluded by any disqualifying objections and have wide applicability at arterial road signalized intersections. These are (1) *lighting*, (2) the *median refuge island* and (3) *hot response pedestrian-actuated traffic signals*. Because of their proven effectiveness, DelDOT should adopt these interventions widely at arterial road signalized intersections wherever these intersections need to be used by pedestrians and bicyclists. Revising or creating the warrants that govern their installation or use should also be part of DelDOT's efforts to implement its new "Complete Streets" policy.

Delaware Statewide Pedestrian Action Plan and "Complete Streets" Policy

In 2004, Delaware had one of the highest pedestrian fatality rates in the nation. While the U.S. pedestrian fatality rate was 1.6 per 100,000 population, Delaware's rate was 1.9 per 100,000 population. Only seven other U.S. states had higher pedestrian fatality rates¹.

In March of 2006, Governor Ruth Ann Minner ordered that a Statewide Pedestrian Action Plan be developed to increase pedestrian safety in Delaware. Phase I of the Action Plan, which consisted of a "policy analysis document" was completed in July of 2007. The Phase I

document promised that a **Best Practice Guide** would be developed during Phase II of the Action Plan. This Best Practice Guide would "outline design standards for pedestrian facilities."² Only Phase I of the Statewide Pedestrian Action Plan, however, is available on the Delaware Department of Transportation ("DelDOT") web site³. No Best Practice Guide for pedestrian safety was completed.

Between 2004 and 2008, the U.S. as a whole reduced its pedestrian fatality rate from 1.6 to 1.4 fatalities per 100,000 population. Many of the most dangerous states reported fewer pedestrians killed. Delaware, however, actually saw its pedestrian fatality rate increase from 1.9 to 2.4 deaths per 100,000 population.⁴

On April 24, 2009, Governor Jack Markell ordered DelDOT to create a "Complete Streets" Policy that will promote safe access for all users, including pedestrians [and] bicyclists...[using] the latest and best design standards as they apply to bicycle [and] pedestrian...facilities..."⁵ DelDOT subsequently wrote a policy to "define and implement changes to the project development process that will value all transportation modes during the project scoping phase and enhance currently used design practices through updates to DelDOT design manuals, design memoranda, and policies."⁶

Delaware's "Complete Streets" policy establishes an admirable goal of a transportation system that is safe for nonmotorized users. Despite its strong language, however, it appears to represent a step backwards from the Delaware Statewide Pedestrian Action Plan, inasmuch as no commitment to introduce new design standards or infrastructure for DelDOT projects (*including retrofits*) has been made in response to the new policy.

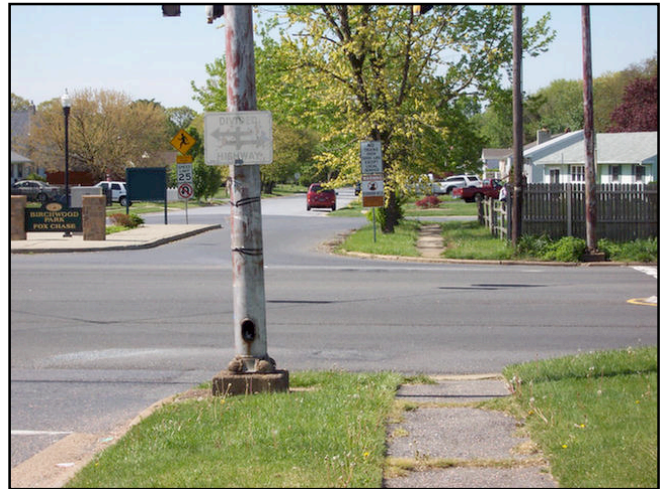
The Missing Piece

A policy commitment to improve safety and mobility for pedestrians, bicyclists and other nonmotorized users of Delaware's streets and roads has existed in Delaware at least since 2006 and across two consecutive Administrations. *The challenge is to turn this abstract policy commitment into infrastructure.* To meet this challenge, Bike Delaware believes that DelDOT should commit itself as an organization to specific design standards that have been proven to be effective and incorporate these designs as default standards into their warrants, design manuals, memoranda and policies. In the absence of such an organizational commitment, changes in DelDOT design practice are unlikely to be either widespread or consistent, will depend upon the initiative, discretion and education of individual engineers and will likely vary from project to project. Unless such reforms are part of Governor Markell's "Complete Streets" policy, the impact of this policy, like Governor Minner's Pedestrian Action Plan before it, is likely to be minimal.

Arterial Road Signalized Intersections

SR 273 is a 4 lane divided road and one of the busiest arterial roads in northern New Castle County. The section of SR 273 between I95 and SR 4 has an average daily traffic ("ADT") volume of over 40,000 vehicles⁷. At the signalized intersection of SR 273 and Brownleaf Road,

SR 273 is 82' wide from curb to curb. On April 6, 2010, at approximately 10PM, 16-year-old Michael Gropp was killed at this intersection while attempting to cross SR 273⁸. His death was an awful illustration of how dangerous intersections like SR 273 / Brownleaf are for pedestrians and other vulnerable road users who find themselves in an environment that has been optimized for motorized traffic and where investment in the safety of nonmotorized users has been neglected.



Crossing SR 273 at Brownleaf Road

Bike Delaware believes that SR 273 / Brownleaf and similar arterial road signalized intersections (“ARSIs”) should be designed using infrastructure that has been shown to increase the safety and mobility of nonmotorized users. There are many countermeasure investments that have been shown to be effective at reducing collisions at intersections involving pedestrians while simultaneously improving the mobility of nonmotorized users of these intersections. DeIDOT has already made an organizational commitment to one of these (the pedestrian countdown signal). Of the remaining possibilities, most unfortunately are disqualified for one reason or another in practice. But there are still three countermeasures that (a) have not been adopted by DeIDOT as a standard for ARSIs, (b) are legal in Delaware, (c) are not forbidden by the MUTCD, (d) do not reduce motorized level of service (“LOS”) and (e) are not inordinately costly. Two of these interventions have been proven to be effective in quantitative studies. The third has not been studied in the same way, but it is a negligible additional cost when a pedestrian triggered signal is already present or planned.

Signaling

Signals are the most common piece of infrastructure used to make intersections work for high traffic volume roads. Signals permit intersecting traffic (both motorized and nonmotorized) to share a finite space by separating the occupancy of that space sequentially in time. DeIDOT committed to using countdown pedestrian signals in both new and retrofit projects in 2009.

Both the pedestrian countdown signal and hybrid beacon (also known as a “HAWK” signal) have been shown to be effective at reducing collisions involving pedestrians. The pedestrian hybrid beacon is the less well known of the two, only being included in the most recent revision of the MUTCD. Unfortunately, in spite of its proven effectiveness, the draft MUTCD limits the deployability of the hybrid beacon to midblock locations. To be deployed at 273/Brownleaf would require departing from the MUTCD. There is no practical midblock location where it could be deployed near 273/Brownleaf. (Technically, under the MUTCD, it could be installed 100 feet away from 273/Brownleaf, but that would be inconvenient for pedestrians (and bicyclists) to access and so would not be used.)

The MUTCD restriction on the hybrid beacon is both misguided and unfortunate. It is particularly unfortunate because the hybrid beacon effectively addresses the non-compliance

problem, which is the most important weakness of signaling with respect to pedestrian safety. As researchers at the Federal Highway Administration note, “[t]he public is often baffled by pedestrian signal timing and pushbuttons; such pedestrian features seem to vary not only from jurisdiction to jurisdiction, but also from intersection to intersection... At many intersections that do have pushbuttons, the DON’T WALK phase is so long that pedestrians feel their pushbutton request has not been recognized by the signal system. ...[T]hese problems encourage disrespect for pedestrian signals .”⁹

SR 273 is a busy arterial designed to accommodate high levels of rush-hour traffic without congestion. At off-peak hours, however, the road is “over-designed” with little traffic. This situation tempts pedestrians to signal non-compliance. The published report of the collision that killed Michael Gropp does not say whether he was crossing SR 273 while SR 273 traffic had a green light. It is certainly possible, however, that - crossing late at night when SR 273 has little traffic - he decided to not wait for the SR 273 green light to change and that that decision was a contributing factor in his death.

The pedestrian hybrid beacon is designed to reduce pedestrian non-compliance. As seen in a video of a pedestrian hybrid beacon installation in Tucson¹⁰, as soon as the pedestrian pushes the pushbutton trigger, a yellow light begins to flash. The pedestrian is thus re-assured that the signal is working and his desire to cross has been recognized. As a result, the pedestrian is empowered and is more likely to comply with the signal.¹¹ The pedestrian favorable timing in this video should also be noted. It appears that the pedestrian hybrid beacon has been programmed with a wait-time-to-cross of about 10 seconds. This short wait time is another factor that encourages pedestrian compliance and so increases the effectiveness of the beacon.

As an alternative to the pedestrian hybrid beacon, Bike Delaware recommends a wide implementation of a hot response²⁴ for pedestrian-actuated traffic controls during off peak hours. This is a simple programming change (e.g. in a pedestrian countdown signal) so that there is an instant response to a pedestrian request to cross. As soon as a pedestrian trigger stimulus is detected, the traffic signal should turn yellow for motorized traffic. Without a “hot response”, pedestrians tend not to wait for a legal signal to cross. They look for “gaps” in traffic and attempt to cross when they think they have identified a sufficiently large gap¹². Signal non-compliance is common.

Hot response pedestrian signals have been implemented by a number of state Departments of Transportation including, for example, the Oregon Department of Transportation (ODOT). ODOT writes in their Bicycle and Pedestrian Plan:

“A pedestrian-activated signal may be warranted where the expected number of people needing to cross a roadway at a particular location is significant and/or if it difficult for pedestrians to find an adequate gap...Wherever possible, the response for pedestrians should be “hot.” The signal should turn yellow then red for traffic as soon as a pedestrian pushes the button. This will encourage pedestrian to comply with the signal. If there is a substantially delayed response after a pedestrian pushes the button, the pedestrian will often seek a gap and cross against the light. Then when the light does turn red for motorists, the pedestrian is gone, increasing motorist frustration, as they don’t understand why they were required to stop.”¹³

One possible, but unfounded, objection to hot response pedestrian-actuated traffic control is that it could have some affect on the driver decision 'dilemma zone', where a driver has to make a decision about stopping abruptly or speeding thru an intersection. In fact, the dilemma zone is an inevitable problem. It can be helped by programming appropriate yellow "clearance" times, but is wholly unaffected by whether the yellow signal is triggered by a computer or by a pedestrian. Another concern, with more merit, is that hot response pedestrian signal control is inconsistent with coordinated signals across multiple intersections. We acknowledge this objection, which is why we advocate that hot response control should only be programmed during *off-peak hours* when signal coordination is unnecessary because traffic volume is low. (These off-peak hours, however, are dangerous to pedestrians because low traffic volumes tempt pedestrians to signal non-compliance.)

We are unaware of any official DeIDOT policy with regard to hot response pedestrian-actuated traffic control during non-peak hours but there is at least one example, at the intersection of Harvey and Orleans roads in Arden, where it has been implemented, without incident or complaint as far as we are aware.

As a bicycle advocacy organization, Bike Delaware would also suggest that signal pushbuttons also face outwards toward Brownleaf Road so bicyclists as well as pedestrians may easily trigger them.

Lighting

Studies have shown 43%¹⁹ and 62%¹⁸ reductions in nighttime crashes involving pedestrians due to the installation of crossway illumination. Improving visibility at ARSIs protects bicyclists and other nonmotorized users as well.

A DeIDOT "warrant" controls the installation of lighting. The current warrant for lighting appears to be wholly focused on factors relating to motorized traffic. The only guideline that clearly applies to an intersection like SR 273 / Brownleaf states that "lighting **may** be installed ... [a]t residential development entrances where there are at least 100 homes,"¹⁴ leaving the installation of lighting to the discretion of engineers. In the case of SR 273 / Brownleaf, that discretion resulted in a decision to leave the intersection unlighted.

Michael Gropp was killed at 10PM at one of just 3 entrances to his subdivision. In order to walk to the subdivision where his girlfriend lived, he had to cross an unlighted, 82' wide road with four lanes of high-speed traffic (plus one turning lane). Bike Delaware believes that this is a fundamentally dangerous situation for pedestrians and bicyclists. Where an intersection *must* be used because it is one of only a handful of entrances to a subdivision and where this intersection is with a high-volume, multi-lane road like SR 273, we further believe that leaving a decision to light the crossway wholly within the discretion of individual engineers is misguided at best. Giving better guidance in DeIDOT's lighting warrant would (and should) reduce engineering discretion.

Intersection Geometry

DelDOT's current Bicycle Policy, dating to December of 2000, states that "[o]ver and under crossings should be considered for roadway crossings with a high number of nonmotorized users, high speed and high volumes of motorized traffic or specific safety concerns."¹⁵ Where an arterial is already at a different grade, bridges and underpasses are the gold standard for nonmotorized safety at intersections. The high cost of this intervention, however, combined with other practical problems, will limit its applicability to special situations. It is probably not, for example, a practical option for 273 / Brownleaf.

Road diets have also been shown to be effective at improving nonmotorized safety. There are no examples in the literature, however, of applying road diets to roads with ADT > 25,000. Applying a road diet to 273 between SR 4 and I 95 would result in traffic congestion, traffic diversion or traffic reduction, or some combination of these three. Bike Delaware acknowledges that implementing a road diet on SR 273, reducing the motorized level of service and potentially increasing congestion, would generate extraordinary opposition. It is, therefore, probably also not a practical option for 273 / Brownleaf.

Evidence exists in the literature that narrowing lanes and constructing curb extensions reduces the speed of vehicles at intersections, but we have not been able to find any carefully controlled studies that show a clear reduction in nonmotorized user fatalities and injuries, which leaves these two types of infrastructure in the 'Tried' category for now.

Median refuge islands, on the other hand, reduce pedestrian-vehicle collisions by 50% or more²⁰ and are a proven and effective countermeasure that improves pedestrian safety and mobility. They are particularly suited for wide, multi-lane roads like SR 273 at Brownleaf Road.

At the 273 / Brownleaf intersection, there are already 4' wide raised medians adjacent to the turning lanes. There is an additional 1' of space on each side of the medians before the turning lane stripe. The medians only need to be extended further into the intersection in order to be able to serve as refuges for pedestrians and bicyclists crossing SR 273. A median refuge could also be widened beyond 6', if desired, without securing any additional right-of-way by the simple expedient of narrowing the travel lanes or by taking space from the 8' shoulders. There is plenty of right of right-of-way for a median refuge that is 10' wide, or even greater, though the Federal Highway Administration says narrower refuges are also acceptable:



Median Refuge Island

“Guidance Statement/Application: Raised medians (or refuge areas) should be considered in curbed sections of multi-lane roadways in urban and suburban areas, particularly in areas where there are mixtures of a significant number of pedestrians, high volumes of traffic (more than 12,000 ADT) and intermediate or high travel speeds.

Medians/refuge islands should be at least 4 feet wide (preferably 8 feet wide for accommodation of pedestrian comfort and safety) and of adequate length to allow the anticipated number of pedestrians to stand and wait for gaps in traffic before crossing the second half of the street.”¹⁶

A “Complete Streets” Design Standard for Arterial Road Signalized Intersections

Michael Gropp was killed at 10PM at night when there is typically little traffic on SR 273. Any of the three interventions we are recommending could have saved his life.

If there had been a hot response pedestrian triggered signal, Michael Gropp could have triggered a red light for SR 273 traffic, which would have alerted the driver of the car that hit him as the driver approached Brownleaf.

If there had been crossway lighting, Michael Gropp and his girlfriend might have been more visible to the driver of the car that hit him and the driver might have been able to take earlier evasive action.

If there had been a median refuge island, Michael Gropp might have been able to take refuge there and might have been able to evade the car that hit him.

Because the objectives of these three interventions are different, and because each type addresses different possible accident scenarios, the interventions are complementary. One aims to improve nonmotorized signal compliance. One aims to increase the nighttime visibility of crossing pedestrians and bicyclists. And one aims to reduce nonmotorized exposure to vehicular traffic. Bike Delaware proposes that DeIDOT adopt all three of these countermeasures:

- (1) hot response pedestrian-actuated traffic control at off peak hours
- (2) crossway lighting and
- (3) refuge islands

as part of a “Complete Streets” compliant design standard package for arterial road signalized intersections. We further urge that the applicable warrants should be revised, or created, so that engineering guidelines give greater weight to nonmotorized safety and mobility and are no longer exclusively focused on motorized traffic.

A Proactive Approach to “Complete Streets”

Bike Delaware also urges a proactive, rather than reactive, approach to implementing DeIDOT’s “Complete Streets” policy. Something like a ‘Complete Streets Best Practice Guide’ consisting of recommended infrastructure and design practices for nonmotorized safety and mobility – as originally planned under the Pedestrian Action Plan – should be developed and shared with the public. In addition, even though the “Complete Streets” policy only explicitly applies to new road projects, better designs will only be implemented if engineers understand what the problems

are. And that in turn requires a commitment under “Complete Streets” to identify what the most dangerous part of the transportation system for nonmotorized users are.

Even if there are no dedicated funds for systematically and rationally improving surface transportation for nonmotorized users, there should at least be a commitment under “Complete Streets” to identifying and understanding what the most important issues for pedestrians and bicyclists are and how best to address these issues with better design and better infrastructure. At least, then, when road projects do come up that present opportunities for improvement, engineers will be ready to deploy solutions that can help prevent more tragedies like the death of Michael Gropp, while simultaneously improving mobility for pedestrians and bicyclists.

Infrastructure Category	Infrastructure	Objective	Evidence For Effectiveness
*** Proven and Adopted By DeIDOT***			
Signaling	Countdown Signal	Change nonmotorized behavior: reduce nonmotorized exposure to vehicular traffic	• Markowitz et al. ¹⁷
*** Proven ***			
Lighting	Crossway Illumination	Improve sight distance / visibility	• Pergrum ¹⁸ • Polus and Katz ¹⁹
Intersection Geometry	Median Refuge Island	Reduce nonmotorized exposure to vehicular traffic	• Garder ²⁰ • Bowman and Vecellio ²¹
*** Proven but Illegal in Delaware***			
Cameras	Radar Speed Camera	Change driver behavior: reduce vehicle speed	• National Safety Camera Program ²² • Pilkington ²³
*** Proven but MUTCD Currently Forbids Deployment at Intersections***			
Signaling	Pedestrian Hybrid Beacon	Reduce nonmotorized exposure to vehicular traffic	
*** Proven but Reduces Motorized LOS***			
Intersection Geometry	Road Diet	Reduce nonmotorized exposure to vehicular traffic	
*** Proven but Costly To Do Right***			
Intersection Geometry	Bridge/Underpass	Reduce nonmotorized exposure to vehicular traffic	
*** Tried ***			
Signaling	Hot Response ²⁴ Pedestrian Signal	Change nonmotorized behavior: reduce nonmotorized exposure to vehicular traffic	
Intersection Geometry	Lane Narrowing	Change driver behavior: reduce vehicle speed	
	Curb Extensions	Change driver behavior: reduce vehicle speed	

Infrastructure for Improving Nonmotorized Safety at Arterial Road Signalized Intersections

Notes

- ¹ “Traffic Safety Facts, 2004 Data”, NHTSA’s National Center for Statistics and Analysis. Retrieved on April 20, 2010, from <http://www-nrd.nhtsa.dot.gov/Pubs/809913.PDF>.
- ² “Delaware Statewide Pedestrian Action Plan, Phase I: Policy Analysis Document”. Retrieved on April 20, 2010, from http://deldot.gov/information/projects/bike_and_ped/delaware_ped/pdfs/DE_Ped_Action_Plan.pdf.
- ³ Delaware Statewide Pedestrian Action Plan. Retrieved April 20, 2010, from http://deldot.gov/information/projects/bike_and_ped/delaware_ped/pages/ped_action_plan.shtml. Retrieved on April 20, 2010.
- ⁴ “Traffic Safety Facts, 2008 Data”, NHTSA’s National Center for Statistics and Analysis. Retrieved on April 20, 2010, from <http://www-nrd.nhtsa.dot.gov/Pubs/811163.PDF>.
- ⁵ “Executive Order Number Six - Creating a “Complete Streets” policy“. Retrieved on April 18, 2010 from http://governor.delaware.gov/orders/exec_order_6.shtml.
- ⁶ Retrieved from http://www.bikede.org/cs_draft_091709.pdf.
- ⁷ “DeIDOT 2008 Average Daily Traffic”. Retrieved on April 18, 2010 from http://deldot.gov/information/pubs_forms/manuals/traffic_counts/2008/aadt_maps/AADT_2008_B1.pdf.
- ⁸ “Delaware crime: Boy killed by driver in race, police say”, Delaware Online. Retrieved on April 18, 2010 from <http://www.delawareonline.com/article/20100408/NEWS01/4080343/Boy-killed-by-driver-in-race-police-say>.
- ⁹ < <http://www.tfsrc.gov/safety/pedbike/pubs/05085/chapt11.htm> >.
- ¹⁰ Retrieved on April 27, 2010 from <http://www.youtube.com/watch?v=ReNk2T5ay1c>.
- ¹¹ R. Van Houten et al., “Pedestrian Push-Button Confirmation Increases Call Button Usage and Compliance”, *Transportation Research Record: Journal of the Transportation Research Board*, 1982, 99-103 (2006).
- ¹² G. Tiwari et al., “Survival Analysis: Pedestrian risk exposure at signalized intersections”, *Transportation Research Part F* 10 (2007), 77-89.
- ¹³ Oregon Bicycle and Pedestrian Plan, Oregon Department of Transportation. Retrieved on June 1, 2010 from http://www.oregon.gov/ODOT/HWY/BIKEPED/docs/OBP_Plan/Chapter_5_crossings.pdf.
- ¹⁴ “State of Delaware Department of Transportation Lighting Design Guidelines, August 2009”, at http://deldot.gov/information/pubs_forms/manuals/lighting/lighting_guidelines_2010-01-08.pdf
- ¹⁵ “Bicycle Policy”. Retrieved on April 25, 2010 from http://www.deldot.gov/information/community_programs_and_services/bike/biking_in_delaware/deldot_policy.shtml
- ¹⁶ Retrieved on July 21, 2010 from http://safety.fhwa.dot.gov/policy/memo071008/#ped_refuge
- ¹⁷ F. Markowitz et al., *ITE Journal*. “Pedestrian Countdown Signals: Experience with an Extensive Pilot Installation”. Retrieved on April 27, 2020 from <http://www.oaklandnet.com/government/ceda/revised/planningzoning/MajorProjectsSection/attachmentE/Oak%20to%20Ninth%20EIR%20Addendum%20No1%20-%20Appendix%20C10.pdf>.
- ¹⁸ B.V. Pegrum, The application of certain traffic management techniques and their effect on road safety, *National Road Safety Symposium* Canberra, Australian Department of Transport, (1972).
- ¹⁹ Abishai Polus, Allan Katz, An analysis of nighttime pedestrian accidents at specially illuminated crosswalks, *Accident Analysis & Prevention*, 10, 223-228 (1978).
- ²⁰ Garder, P., “Pedestrian safety at traffic signals”, *Accid Anal Prev* 1989; 21:435-444

²¹ Bowman, B. and Vecellio, R., "Effect of Urban and Suburban Median Types on Both Vehicular and Pedestrian Safety", *Transportation Research Record*, Transportation Research Board, Issue 1445 (1994), p 169-179.

²² "The national safety camera programme, Three-year report". Retrieved on April 18, 2010 at http://eprints.ucl.ac.uk/1338/1/2004_31.pdf.

²³ P. Pilkington and S. Kinra, "Effectiveness of speed cameras in preventing road traffic collisions and related casualties: systematic review", *BMJ: British Medical Journal*, 330, No. 7487, 331-334 (2005).

²⁴ Retrieved on May 30, 2010 from <http://www.fhwa.dot.gov/environment/sidewalks/appb.htm>