High Speed Bicycling

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Abstract
This paper details the multiple problems bicyclists face due to side of the road operation, and provides a rationale for prohibiting bike lanes on roads with 2% downgrade or more where bicyclist speed of 20 mph or more is expected.

Introduction
In the consideration of on-road bicycling, virtually all design publications place great emphasis on the speed (and volume) of motor traffic. Scant attention has been paid to high bicyclist speed, principally generated on descents, and how it relates to bicycle operation and roadway design, and more specifically the provision of bicycle lanes (BLs). The 1999 AASHTO *Guide for the Development of Bicycle Facilities* does not address the issue. This is an unfathomable omission, as bicycle speed is a critical element in operating a bicycle, so should be considered in ancillary roadway design for bicycling. At least two publications have addressed the issue though.

Chapter 1000 of the California Department of Transportation (Caltrans) *Highway Design Manual*, http://www.dot.ca.gov/hq/oppd/hdm/hdmtoc.htm#hdm, pages 1000-18, notes that:

> "Bike lanes are not advisable on long, steep downgrades, where bicycle speeds greater than 50 km/h [31 mph] are expected. As grades increase, downhill bicycle speeds will increase, which increases the problem of riding near the edge of the roadway. In such situations, bicycle speeds can approach those of motor vehicles, and experienced bicyclists will generally move into the motor vehicle lanes to increase sight distance and maneuverability. If bike lanes are to be striped, additional width should be provided to accommodate higher bicycle speeds."

The *North Carolina Bicycle Facilities Planning And Design Guidelines* has almost identical wording, saying:

> "Bike lanes are not advisable on long, downgrades of 4 percent or more, where bicycle speeds greater than 48 km/h (30 mph) are expected. As grades increase, downhill bicycle speeds will increase, which increases the problem of riding near the edge of the roadway. In such situations, bicycle speeds can approach those of motor vehicles, and experienced bicyclists will generally move into the traffic lanes to increase sight distance and maneuverability. If bike lanes are to be striped, additional width should be provided to accommodate higher bicycle speeds."

The two State DOTs warn against BLs where bicyclist speed is about 30 mph (44 ft/s), though no rationale is given for this figure. Both guidelines acknowledge that riding near the edge is an inherent problem, and that high speed bicycling exacerbates the problem, but no further discussion is given. To fill this void, the multiple problems of riding near the edge will be examined in this paper beginning on page 4. In addition, the statement by both DOTs that "If bike lanes are to be striped, additional width should be provided to accommodate higher bicycle speeds." is questionable for three reasons:

Figure 1. Model behavior when descending at high speed. Extensive space is required.

- A slightly wider (1-2 ft) BL does not afford enough additional width to effect meaningful increases in sight triangles or leeway. The remark by both DOTs that "...experienced bicyclists will generally move into the traffic lanes..." exemplifies how much added room is consequential and needed. Bicyclists require the full lane width. (Figure 1 above)

- A BL by definition creates an additional lane, and thus increases the likelihood of sight line obstructions by left adjacent vehicles. Experienced bicyclists move farther into the travel lane as much to prevent overtaking vehicles from blocking their view, and blocking others' view of them, as to create added leeway (Figures 6 & 7 on page 4). A BL inhibits this precaution.

- An extra wide BL does not solve the debris problem inherent to BLs. A BL collects debris due to the natural sweeping action of motor vehicles which results in debris collecting to the right of the BL stripe. The gravel, sand, vegetative, and trash debris becomes much more dangerous at high speed (Figure 2).

Figure 2. A wide 5 foot BL filled with sand.

Discussion

Bicyclists' visibility and speed are important.
Poor visibility and high speed have been known predisposing and precipitating causes in two main types of bicycle-motor vehicle collisions for lawfully riding bicyclists — the Left Cross and Drive Out — since at least 1974 when Dr. Ken Cross performed the first large scale bicycling collision study. The following excerpts are illustrative:

- "...information obtained from participants of this type of accident [Left Cross; Figure 3] points to potential causal factors: poor bicycle visibility, an assumption by the bicyclist that he had been seen by the motorist, motorist underestimating bicycle speed, and uncertainty about which vehicle had-the right-of-way."

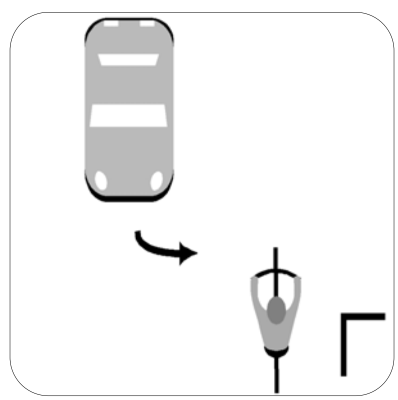

Figure 3. Left Cross.

- "Evidence obtained during interviews with motorists involved in this type of accident [Drive Out from stop sign; Figure 4] suggests that the motorist simply did not see the bicyclist."

- "Speed of the bicyclist was reportedly a factor in a few cases, but the cause of this accident [Drive Out from driveway; Figure 4] remains quite obscure."

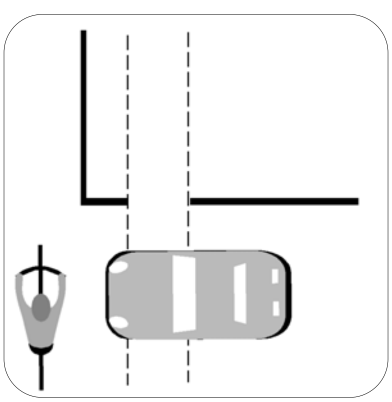

Figure 4. Drive Out.

Bicycle operation, especially high speed bicycling, has much in common with motorcycling.

In *Review of the Evidence for Motorcycle and Motorcar Daytime Lights* it notes:
"To consider, first, the natural conspicuity of motorcars and motorcycles, it may be observed that, in head-on view, on the one hand, the silhouette of the four-wheeled motorcar:

- Is typically 6 ft (1.8 m) wide;
- Has a clear-cut, sharp, 'contrasty,' regular outline;
- Features a simple, regular pattern of extensive, shiny or glazed surfaces.

By contrast, on the other hand, the silhouette of the two-wheeled motorcycle (and rider):

- Is typically 1½ ft (0.46 m) wide;
- Has a 'confused', irregular, outline;
- Features an irregular, often complex pattern of either predominantly dull, or mixed dull, shiny, and glazed, frequently non-extensive surfaces.

Thus whereas the motorcar possesses all of the features that naturally enhance conspicuity (and also assist the correct estimation of speed and distance), the motorcycle in stark contrast lacks all of them." The same can be said of bicycles.

The following excerpt from the National Agenda for Motorcycle Safety website hosted by the National Highway Traffic Safety Administration (NHTSA) similarly applies equally to bicyclists:

"Motorcyclists, who have significant room to maneuver while riding within a traffic lane, can use this margin to position themselves for maximum visibility to other motorists while maintaining safety and control of the traffic situation. The relatively narrow width of a motorcycle on the road allows its rider to employ many strategies not available to drivers of other vehicles.

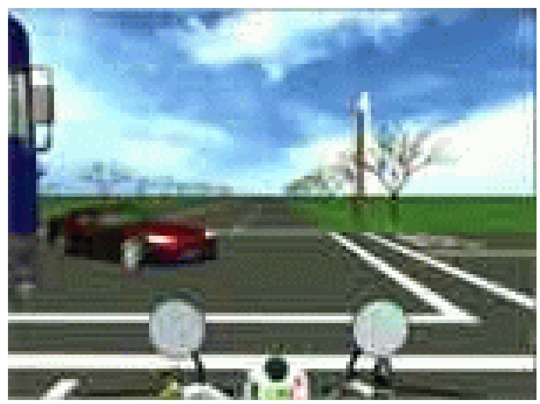

Figure 5. Both motorcyclists and bicyclists are at risk of the "Left Cross."
Source: Motorcycle Safety Foundation.

- Motorcyclists can choose their position within their lane to avoid road surface hazards, other vehicles, pedestrians or other mobile hazards, intrusions, or potential intrusions into their right-of-way.
- Motorcyclists may seek positions where they are in view of other drivers and pedestrians.
- Motorcyclists may select a position that maximizes their view of the road and traffic ahead.

All motorcyclists should be aware of the value of lane positioning to maximize their visibility to other motorists and better manage traffic situations."

As with motorcycles, it is well established that motorists do not notice bicycles as well as motor vehicles. Motorists are poor at judging bicyclist distance and closing speed due to bicyclists' narrow profile and poor contrast. Because bicycles are usually, but not always, relatively slow at 14 mph typical (Taylor, 1993), motorists have this low speed expectation. Bicyclists' usual side of the road position exacerbates these motorist failings and the negative safety consequences.

Five problems bicyclists face due to operating near the side of the road.

Problem 1. Increased hazard from oncoming Left Cross motorists.
Problem 2. Increased hazard from Drive Out motorists.
Problem 3. Increased hazard from Overtaking and Right Hook motorists.
Problem 4. Left turns are more complicated and difficult.
Problem 5. The roadside is more likely to have debris and other surface hazards.

Each of these problems is discussed in detail below.

Problem 1. Increased hazard from oncoming Left Cross motorists.

- The closer to the side a bicyclist operates, the greater the likelihood of being overtaken and obscured by left adjacent motor vehicles (gray and green cars) in the line of sight to the Left Cross motorist.

- Riding near the side exacerbates narrow bicyclists' general visibility deficit by placing the bicyclist out of the main viewing area of oncoming Left Cross motorists who are more likely to be searching the center of the lane(s). Moreover, near the side bicyclists are more likely to visually blend with roadside elements such as parked vehicles, signs and other fixed objects, pedestrians, and shadows.

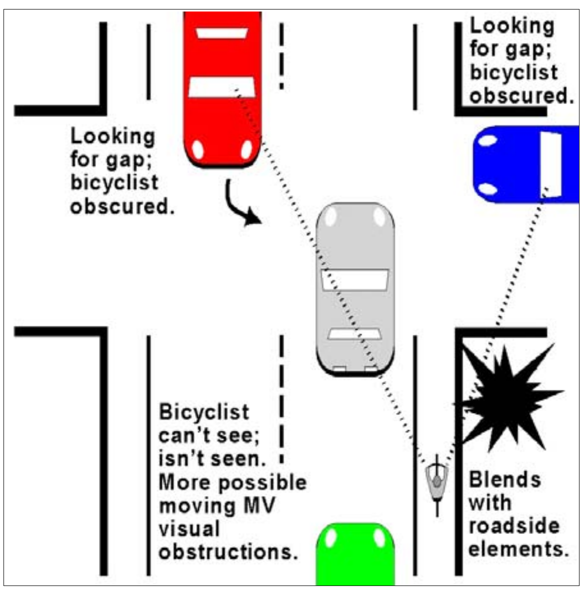

Figure 6. Poor lateral position operating near side of road. In this case, a BL directs that position.

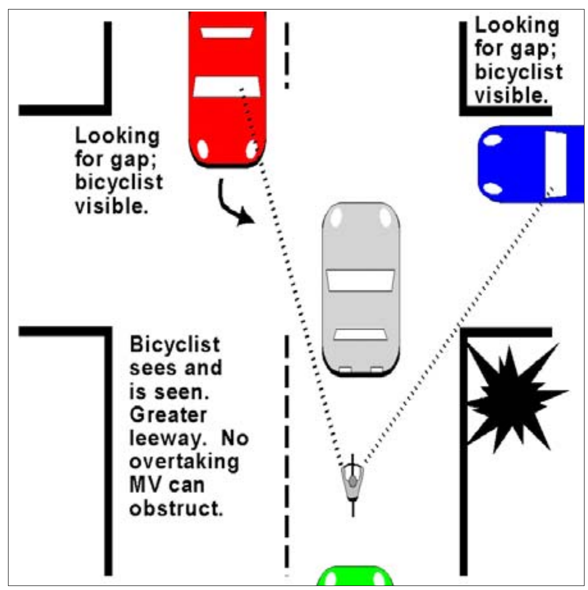

Figure 7. Optimum lateral position is enabled by absence of a BL. Here, pavement width is the same as in Figure 6.

Bicyclists should operate further from the side to place themselves where motorists more readily search, reduce visual blending, and lessen or fully negate the possibility of being obscured by left adjacent vehicles. An assertive lateral position may also send the message to potential Left Cross drivers that the bicyclist is moving faster. The problem of increased hazard from oncoming Left Cross motorists is greatly exacerbated by high bicyclist speed.

Problem 2. Increased hazard from Drive Out motorists. (See also Figures 6 and 7 above).

- When near the side a bicyclist is more likely to be obscured by roadside obstructions in the line of site to Drive Out motorists. The farther from the side the bicyclist operates, the sooner both parties can see each other.

- Riding near the side results in little lateral clearance between the bicyclist and the emerging vehicle, and short stopping sight distances for both bicyclist and motorist.

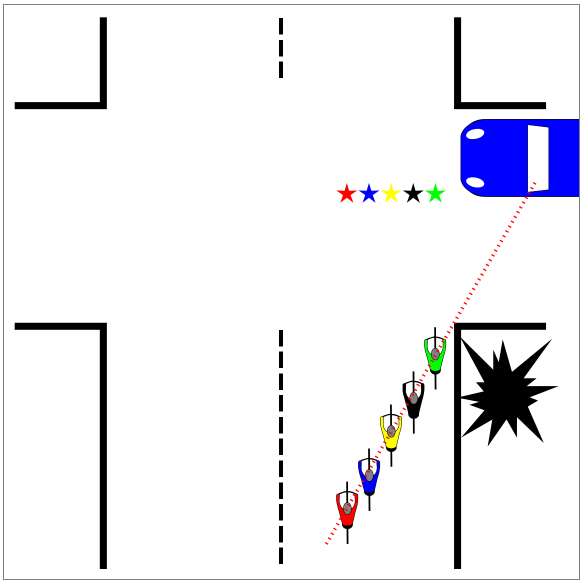

Figure 8. Sight line and impact points.

In Figure 8, each bicyclist 2 ft more left is 3.5 ft farther from the junction curb line when she first sees and is seen by the Drive Out motorist. The red bicyclist at 10 ft from the edge is 8 ft farther left than the green bicyclist, and has 14 ft more stopping distance. At 20 mph (29 ft/s) this provides nearly ½ second additional reaction time. Moreover, the potential impact point is 8 ft farther from the emerging Drive Out motor vehicle, affording added stopping distance and reaction time for the motorist. Higher bicyclist speed reduces reaction time and increases stopping distance, increasing the hazard from Drive Out motorists.

Note that a typical 4-wheel motor vehicle driver would be seated at about the lateral position of the red bicyclist. All countries have adopted this motorist position closer to the centerline (rather than closer to the curb or edge line) for the safety advantages afforded by improved sight lines at junctions. Motorcyclists typically track on the left side of the lane for the same reason.

Problem 3. Increased hazard from **Overtaking** and **Right Hook** motorists.

- Motorists sometimes **Overtake** when road and traffic conditions make the pass risky. The farther from the side a bicyclist operates, the more likely the motorist is compelled to be cautious, reducing speed (to as low as bicycle speed) and moving laterally left.

- Motorists sometimes pass bicyclists and then turn right in front of them. The farther from the side a bicyclist operates, the less likely the motorist will be able to execute the pass and perform the errant **Right Hook**.

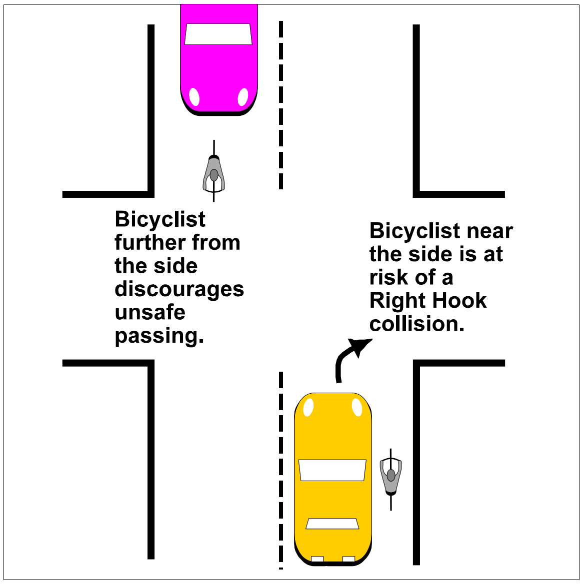

Figure 9. A bicycle driver should Use More Lane for its many operational advantages.

Problem 4. Left turns are more complicated and difficult.

- A bicyclist operating at the right side of a lane can expect motorists to overtake on the left within the lane, partially or wholly, depending upon lane width. To make a left turn, the bicyclist must yield to this added line of overtaking traffic before moving laterally to the left side of the lane prior to executing the turn (when in the leftmost lane). In contrast, a bicyclist fully using the normal lane has only the same left turning constraints as any other driver.

- Like other drivers, a bicyclist turning left in heavy traffic may have to merge left well in advance of the turn. When a BL is present, some motorists take offense to a bicyclist who is not in the BL. Normal lanes (narrow, normal, wide) are not subject to such misinterpretation.

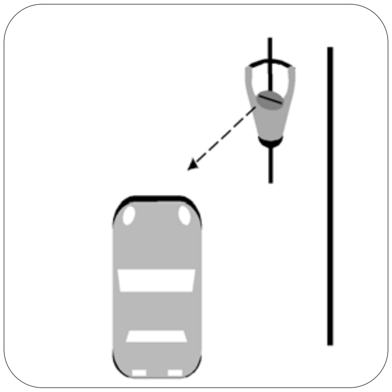

Figure 10. Bicycle drivers wishing to turn left from the right side of the lane first have an additional line of traffic to yield to.

Problem 5. The roadside is more likely to have debris and other surface and lateral hazards.

- Motor vehicle wind and tire blast propels vegetative, gravel, and trash debris to the side. If a BL (or shoulder stripe) exists, debris is pushed across the stripe into the BL space and accumulates. A narrow, standard, or wide (14-16 ft) normal lane is less likely to harbor debris because motor vehicles' typical position (in the absence of bicyclists) is closer to the edge than if a BL was present, and some motorists will track right at the edge. This results in debris being continuously swept far right and out of bicyclists' traveled way.

Figure 11.Vegetative debris in BL.

Figure 12. Same road without BL is clear.

- Surface hazards such as potholes, utility covers, sunken drainage grates, longitudinal slots, wet metal and painted surfaces, drainage problems, and assorted irregularities are also more likely to be at the side of the road. Parked vehicles present a "Dooring" hazard to unwary bicyclists who operate with insufficient clearance to them.

- Debris and hazards are a greater danger at high speed when avoidance is more difficult, braking on a clean surface is crucial, and the loss-of-control consequences of a front wheel slip, deflection, puncture, or blowout from a cut sidewall are potentially severe.

High speed operation at the side of the road is contraindicated.
High speed bicycling, on a descent or otherwise, exacerbates three of the five inherent problems of operating near the side of the road: **Problem 1.** Increased hazard from oncoming Left Cross motorists; **Problem 2.** Increased hazard from Drive Out motorists; and **Problem 5.** The roadside is more likely to have debris and other surface and lateral hazards. To reduce the hazards, bicyclists should operate further left and use more of the lane, as much as the full lane width.

Figure 13. A high speed bicyclist, on a descent or otherwise, can be as fast or faster than motor vehicles, and requires unrestricted use of the full lane width.

A Bike Lane guides and constrains bicyclists to ride curbside, reducing bicyclists' operating space and guaranteeing that bicyclists will be overtaken and obscured by left adjacent motor vehicles, blend with roadside elements, have less visibility and stopping distance with emerging vehicle drivers, be vulnerable to right turning motor vehicles, have greater difficulty making a left turn, and operate in a space with greater likelihood of debris and other surface irregularities. A bicyclist may choose to ride curbside on a normal, non-BL road (narrow, standard, or wide outside lane), but is not directed to do so by a pavement line as with a BL. In a normal lane of any width, a bicyclist can choose with impunity how much of the lane to use based on speed, destination, and other operational context then existing.

Skeptics may argue that bicyclists can simply leave the BL and use the adjacent travel lane whenever they choose. While moving out of the BL is possible, laws (specific or implicit), and the stay-right mis-education that the stripe conveys to bicyclists and motorists alike, makes using the adjacent defacto "motor vehicle lane" less appealing and less likely.

20 mph and negative 2% slope are the upper limits for bike lanes.
The approximately 30 mph and negative 4% slope specified by Caltrans and the NCDOT as the speed and slope at which BLs are contraindicated is far too liberal and is not supported by any rationale. 20 mph (29 ft/s) and negative 2% are the appropriate specifications given:

- the above five problems associated with riding near the side of the road, which are assured when BLs are placed. At 20 mph or more, bicyclists require more operating room for leeway and improved sight triangles than BLs afford, and must have a debris-free surface. The design criteria for the safety of 10-16 ft narrow, standard, or wide "normal" lanes used by vehicles as a general class, including bicycles, are superior to the design standards of substandard width 4-5 ft lanes located at the right side of the road intended for bicycles as a specific class;

- that typical level bicyclist cruising speed is just 14 mph (Taylor, 1993), which is less than half of the unjustified 30 mph specification;

- that BLs are intended to attract inexperienced bicyclists who by definition are ill prepared to cope with high speed operation at the side of the road;

- that at bicyclist speeds of 20 mph or more, speed differentials between bicycles and motor vehicles are usually sufficiently reduced that any alleged potential positive operational benefit of BL segregation from overtaking motor traffic is negated;

- that under wet conditions, bicycle braking capability is greatly reduced, and operating space requirement is increased even further.

Figure 14. DO NOT PASS BICYCLES sign on high speed descent.

Additional supporting evidence.

- Speed Analysis.

Figure 15 below was derived using the *Bicycle Speed and Power Calculator* found at http://www.kreuzotter.de/english/espeed.htm. Bicyclists on mountain (Mt) and road (Rd) bicycles weighing 110 lbs at 64 inches tall, 150 lbs at 69 inches, and 180 lbs at 72 inches were specified, with bicyclist power output a modest 100 watts. Bicycle weight was input at 25 lbs. Temperature was set at 68 degrees at an altitude of 450 ft (typical altitude of Chapel Hill, NC).

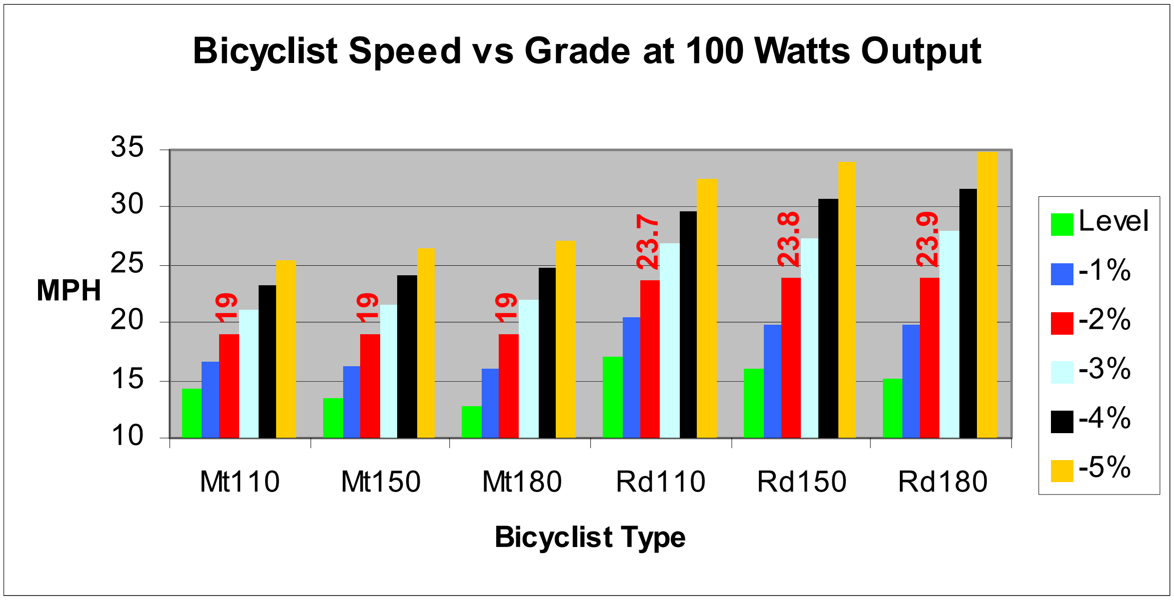

Figure 15. Bicyclist Speed vs. Grade at 100 Watts Output.

The graph shows that at 100 watts effort on level ground (green bars), bicyclists travel between 12.8 mph (Mt180) and 17.1 mph (Rd110), which is consistent with Taylor's measured value of 14.1 mph. On a descent of 2% (red bars), bicyclists achieve between 19 and 23.9 mph at this same low level of effort. Greater pedaling effort would result in higher speed.

A tailwind, motor-vehicle wind push, and motor-vehicle slipstream effect can all greatly increase bicyclist speed. In many places wind patterns are very predictable and reliable, and typical bicyclists easily exceed 20 mph with tail wind assist. Figure 15 shows that a 150 lb bicyclist on a road bicycle pedaling at 100 watts output travels at 15.9 mph on level ground. With a tailwind of just 10 mph the speed would be 22.1 mph.

John Allen notes that "Strong bicyclists may achieve sustained speeds up to 25 mph on level ground. Streamlined recumbents push this speed even higher. Bicycles with electric motors to assist muscle power are becoming more popular. A facility that attempts to draw a sharp line between bicycles on the one hand, and motor vehicles on the other, will inevitably draw that line in the wrong place for at least some in both categories."

John Forester has developed a standard motion simulation calculator that determines the movement and acceleration of a bicyclist on descents for successive short intervals of time for the conditions of each segment of a route (Appendix A).

- Braking Performance.

According to AASHTO's "Green Book,"*A Policy on Geometric Design of Highways and Streets*, in roadway design, braking and sight distance calculations for all vehicles, including bicycles, are figured using a deceleration rate of 3.4 m/s^2 (11.2 ft/s^2), which is 0.35 g.

Four-wheeled motor vehicles have much better emergency braking capabilities than bicycles, approximately 0.6 - 0.7 g (some cars can achieve more than 0.9 g), affording motorists a great margin for error beyond AASHTO's roadway design specification. In contrast, a typical bicyclist can be expected to decelerate at 0.35 g on clean, dry, level pavement which, coincidentally, is AASHTO's figure for roadway design purposes as previously noted. A conventional bicycle's theoretical maximum deceleration is limited to about 0.6 g on level pavement by weight transfer, which can cause pitch-over. However, only a highly skilled bicyclist using optimal technique may be able to achieve this 0.6 g; most will be far lower at about 0.35 g.

For non-level roads the grade is added (+ or -) to this deceleration rate in gees. This means that on a 5% descent, for example, braking effort equivalent to 0.05 g is used to counteract the effect of gravity, leaving typical bicyclists only 0.35 - 0.05 = 0.30 g for deceleration.

Further, unlike motor vehicle braking which is not markedly affected in wet conditions, the braking capability of some bicycles is greatly reduced due to the diminished friction between the brake shoes and a wet rim. According to John Forester [personal communication, 12/22/04]

> "Bicycle braking under wet conditions needs to be considered in two phases. The first phase is wiping the rims clean, the second phase is actual braking. For aluminum rims, one can consider three rotations of the wheel to wipe the rim reasonably dry. That is about 21 feet for typical wheel sizes. Subsequent braking, given good brakes to start with, is then typical of dry, unless the road surface is so slippery that it will not produce a 0.67 coefficient of friction. The situation with chrome-plated steel rims is worse; they don't wipe dry."

At 20 mph (29 ft/s), 21 feet of nearly non-existent braking adds about 0.7 seconds to braking time. Thus, instead of taking 2.6 seconds to come to a complete stop, it would take 3.3 seconds on level ground when wet, amounting to an average deceleration of 0.28 g. Heavy rain or road splash at high speed could result in continuously wet rims, further drastically reducing braking capacity.

Figure 16. Braking from high speed on a descent takes considerable distance.

For sight-triangle and other operational calculations, bicycle deceleration rate in wet conditions should be considered to be slightly more than half that under dry conditions; 0.20 g. Moreover, BL stripes are very slippery when wet, adding an unnecessary longitudinal hazard. These concerns amplify the argument that BLs are counter-indicated, especially on high speed descents.

Conclusions and Recommendations

The motorcar possesses all of the features that enhance conspicuousness and assist in the correct estimation of speed and distance by other road users. By design, motor vehicle drivers are placed nearer the centerline for improved sight lines and their demonstrated safety advantages.

Bicyclists have an inherent lack of conspicuousness which is worsened by side-of-the-road operation that results in atypical and sub-optimal lane position, obscuration, and visual blending. Bicycle operation at the side of the road greatly increases the risk of Left Cross, Drive Out, and Right Hook collisions, risky Overtaking, and debris and other surface and lateral hazards. Left turns are more complicated and difficult. Bicyclists are usually, but not always, relatively slow, giving motorists a low speed expectation.

High speed bicycling exacerbates most of the problems associated with lack of conspicuousness and roadside utilization. At high speed, bicyclists require considerable operating space — more than BLs afford — for added conspicuousness, leeway, stopping distance, and ultimately safety.

BLs should not be placed on descents of 2% or more where speeds of 20 mph or more are likely. Such high speed bicycling, however achieved, obviates the need for providing additional road width for enhanced motorist overtaking. However, if additional width is to be provided, the appropriate treatment is to leave the added space un-striped in the form of a wide outside lane (WOL). The design criteria for the safety of 10-16 ft wide normal lanes used by vehicles as a general class, including bicycles, are superior to much narrower BLs at the side of the road intended for bicycles as a specific class. The W7-5 sign with supplemental placard can be used to inform bicyclists and motorists and to add legitimacy to bicyclists' full use of the lane should they choose that option (Figure 17).

Figure 17. W7-5 sign with supplemental placard.

BLs constrain bicyclists in a substandard width lane at what is known to be the more hazardous side of the road. They entice bicyclists to filter forward on the right, a proven risky maneuver made riskier by high speed. When a BL is placed, bicyclists suffer a loss of freedom, by law or by motorist coercion, to use the remainder of the road, which has then become the defacto "Motor Vehicle Lane(s)." Normal roads do not suffer such artificially induced mis-education and discrimination.

Normal roads (narrow, standard, or wide outside lanes) without BLs are the vast majority of the road network, and it will always be this way. Striping an inherently spotty system of BLs is a poor strategy inconsistent with the expectations of all road users. When BLs are an element of the road system, bicyclists have a schizophrenic lateral position; sometimes within the travel lane and to the left of an edge line, sometimes to the right of a BL stripe. Without BLs, bicyclists would have a 10-15 ft lane in front of them from which to chose their optimal lateral position based on context, and they would have a consistent position: within standard travel lanes.

Given the inherent failings of BLs, governments should reconsider their endorsement of these structures for normal, non-freeway design roads. They are inconsistent with standard roadway design and traffic operating theory.

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Appendix A

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NOTES ON RESISTANCE AND POWER IN CYCLING

The standard model for calculating the resistance to motion of bicycles, using pounds, feet, and seconds, is:

Resistance (lbs)	= Slope Resistance + Rolling Resistance + Air Resistance
Slope Resistance	=Mass * Slope
Rolling Resistance	=Bearing Friction + Tire Losses (both empirically determined)
Air Resistance	=Density of air/2 * Cross Sectional Area * Drag Factor * Speed * Speed

The accepted standard density of air at sea level is 0.002378 slugs/cu.ft. (Which equals 0.07657 lbs/cu.ft)

The FHWA research done in Davis (FHWA-RD-75-112) gives the following resistances when using a system that uses pounds and hours and mixes feet with miles:
Resistance, lbs (FHWA) =Weight*Slope + Weight*(0.005 + 0.15/TirePressure) + 0.00256*(AirSpeed*AirSpeed*DragArea* DragFactor)

The 0.00256 factor converts the 0.002378 by combining the division by 2 and the conversion from feet per second to miles per hour. Also, their values for bearing and tire friction are high relative to what is available today. Good wired-on tires have improved greatly since then. The CycSpeed program reflects this change by using bearing friction of 0.002 and tire losses as 0.10/TirePressure.

Whitt and Wilson give the following for typical drag areas and factors:

Cyclist on roadster bicycle:	5.3 Square Feet and 1.2 Drag Factor
Cyclist on sporting bicycle:	4.3 Square Feet and 1.0 Drag Factor
Cyclist on racing bicycle:	3.55 Square Feet and 0.9 Drag Factor

The resistance to acceleration (inertia) is greater than the mass by an amount very nearly equal to the mass of the tirs and rims. CycSpeed adds in the masses of the tires and rims. Whitt & Wilson call this the WheelResistanceFactor and typically give it a value of 0.01 for all bicycles.

Whitt & Wilson give the following for resistance using metric (MKS) system:

Res (newtons) = Mg(Rolling Resistance + Slope Resistance + Wheel Resistance Factor) + 0.5*(Drag Factor*Drag Area*Air Density*Airspeed*Airspeed)
=Mg*(Cr + slope + a/g*1.01) + 0.5*Cd*A*R*(Vc + Vw)*(Vc + Vw)
=Mg*(Cr + slope + a/g*1.01) + 0.5*1.0*0.4*1.226*V*V
=K1 + K2V*V +10.32M(slope +a/g*1.01)

Where K1 and K2 are per the following:

	K1	K2
Roadster bicycle	7.845	0.3872
Sports bicycle	3.509	0.2581
Racing bicycle	2.508	0.1916