

Effect of Centerline Markings on Driver Lane Positioning When Passing a Bicyclist on a Two-Lane Two-Way Suburban Road

Sagar Keshari, Sakar Pahari, Vahid Bahrami, Akshay Suresh Babu, Gagan Gupta, Yazmin Dasgar, Austin Detweiler, Timothy J. Gates, Peter Savolainen, and Kakan Dey
Department of Civil and Environmental Engineering, Michigan State University

Why This Study?

More People Are Riding in the United States

- Bicycling has become increasingly popular for both recreation and commuting (1).
- In 2024, more than 112 million individuals (≈35% of the population aged 3 and older) reported riding a bicycle at least once (2).

More Interaction Means More Risk

- As bicyclist activity increases, safety concerns related to motor vehicle–bicyclist interactions have intensified.
- In 2023, 1,116 bicyclist fatalities were reported nationwide, a 4.4% increase from the previous year (3).

The Critical Moment: Passing a Bicyclist

- A key factor contributing to vehicle-bicycle collisions is the lateral passing distance (LPD), the lateral gap between a motor vehicle and a bicyclist during an overtaking maneuver (4).

What is missing in the current literature?

- While prior studies have explored the effects of speed, lane width, and roadside features on lateral passing distance (LPD), limited research has examined how pavement marking configurations, specifically the presence and absence of centerlines and edgelines, influence driver behavior when overtaking bicyclists, particularly on suburban two-lane roads.

Objectives

Study evaluates how pavement marking configurations affect motorists' lateral positioning during normal driving and bicyclist overtaking on two-lane, two-way roads.

Marking Configuration:



Edgeline-only (no centerline)



Centerline-only (no edgeline)

Driving Condition:

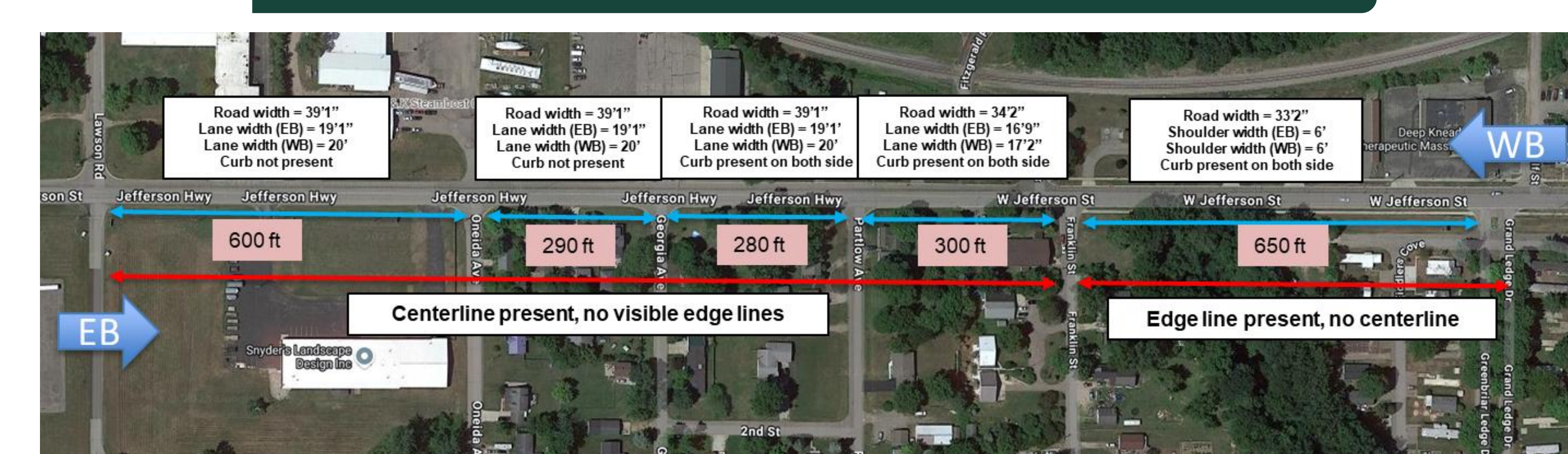


General traffic conditions



Bicycle overtaking events

Study Site



Field evaluation site layout at Jefferson Street, Grand Ledge, Michigan

- 1.5-mile segment of Jefferson Street, Grand Ledge, Michigan
- Two-lane, two-way suburban roadway
- Posted speed limit: 45 mph

Study Design & Data Collection



Bicycle travel paths utilized on Jefferson Ave. in Grand Ledge, Michigan

- A case-control study was designed, in which the lateral position of each vehicle was observed while overtaking a bicyclist riding on the shoulder under both striping conditions.

Data Collection Period – Summer of 2024 and 2025

- Clear, dry, and daylight conditions
- Weekdays, both during peak and off-peak hours

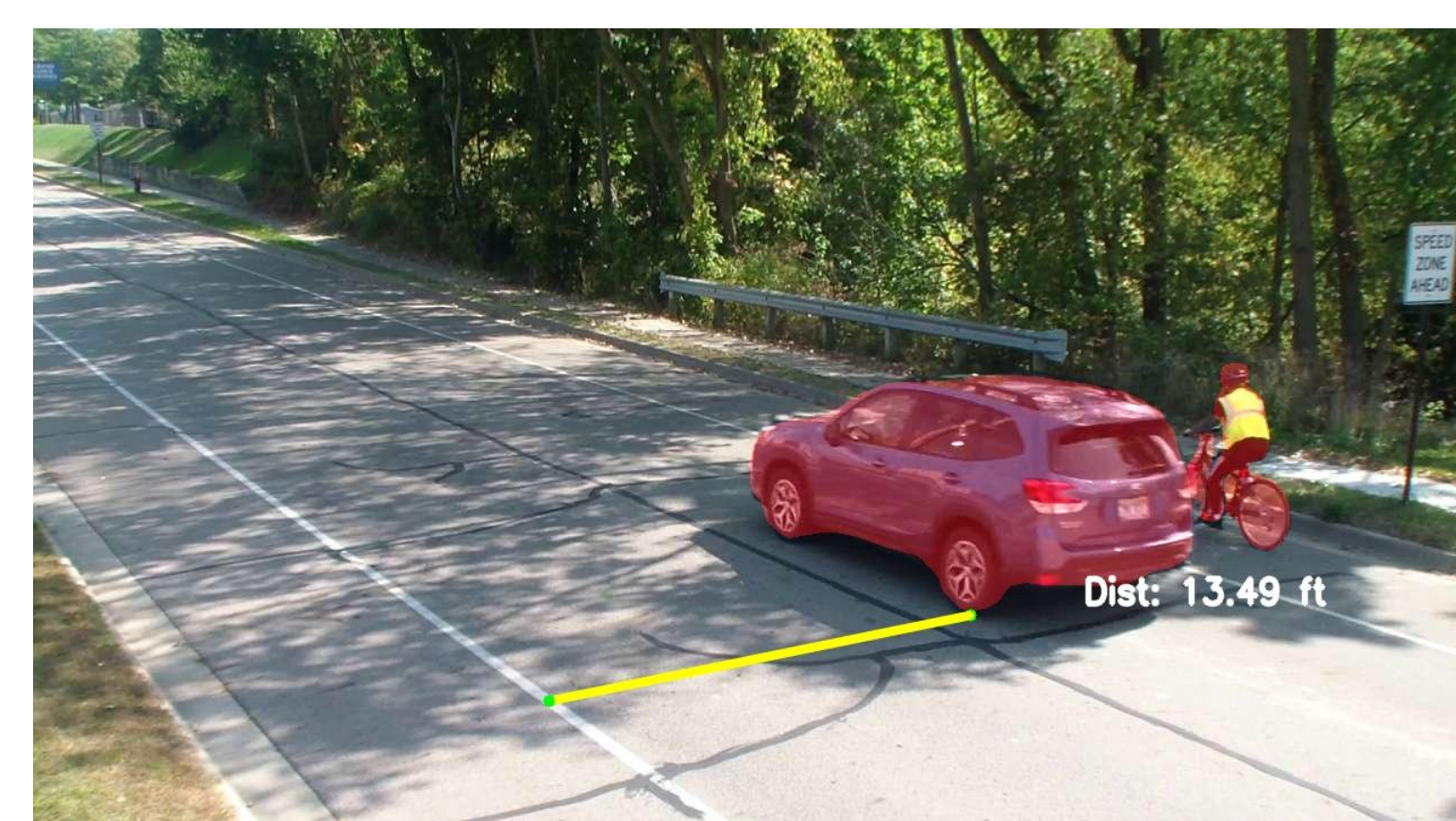
Bicyclist Operations

- Two bicyclists, one assigned to each pavement marking configuration
- Continuous loops ridden at consistent shoulder positions within each segment

Vehicle Observation

- Vehicle trajectories captured using high-definition video cameras
- Data collected:
 - With bicyclist present (overtaking behavior)
 - Without bicyclist present (baseline lateral positioning)

Video Data Processing



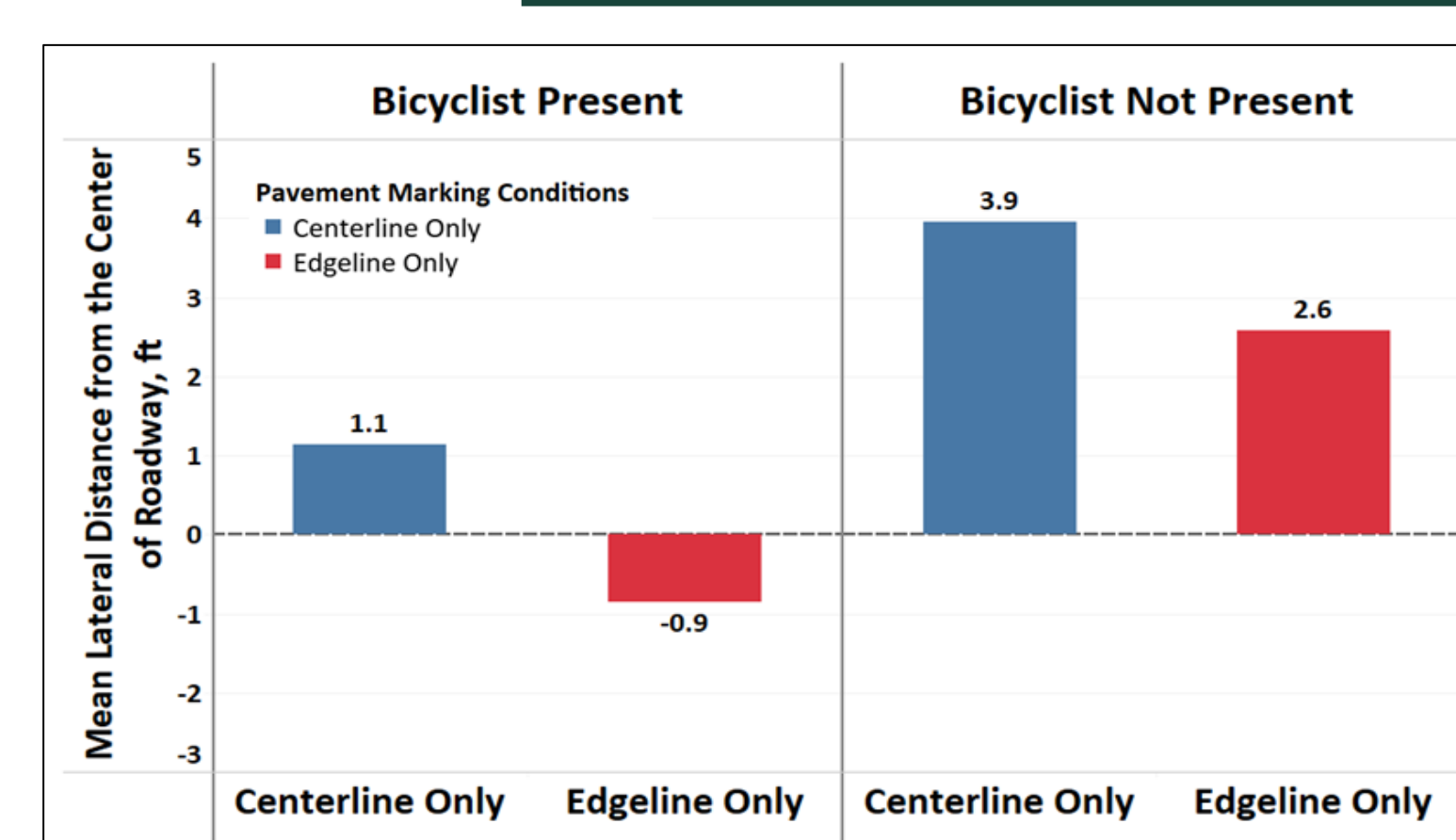
Computed lateral distance measurement



Computed lateral distance measurement

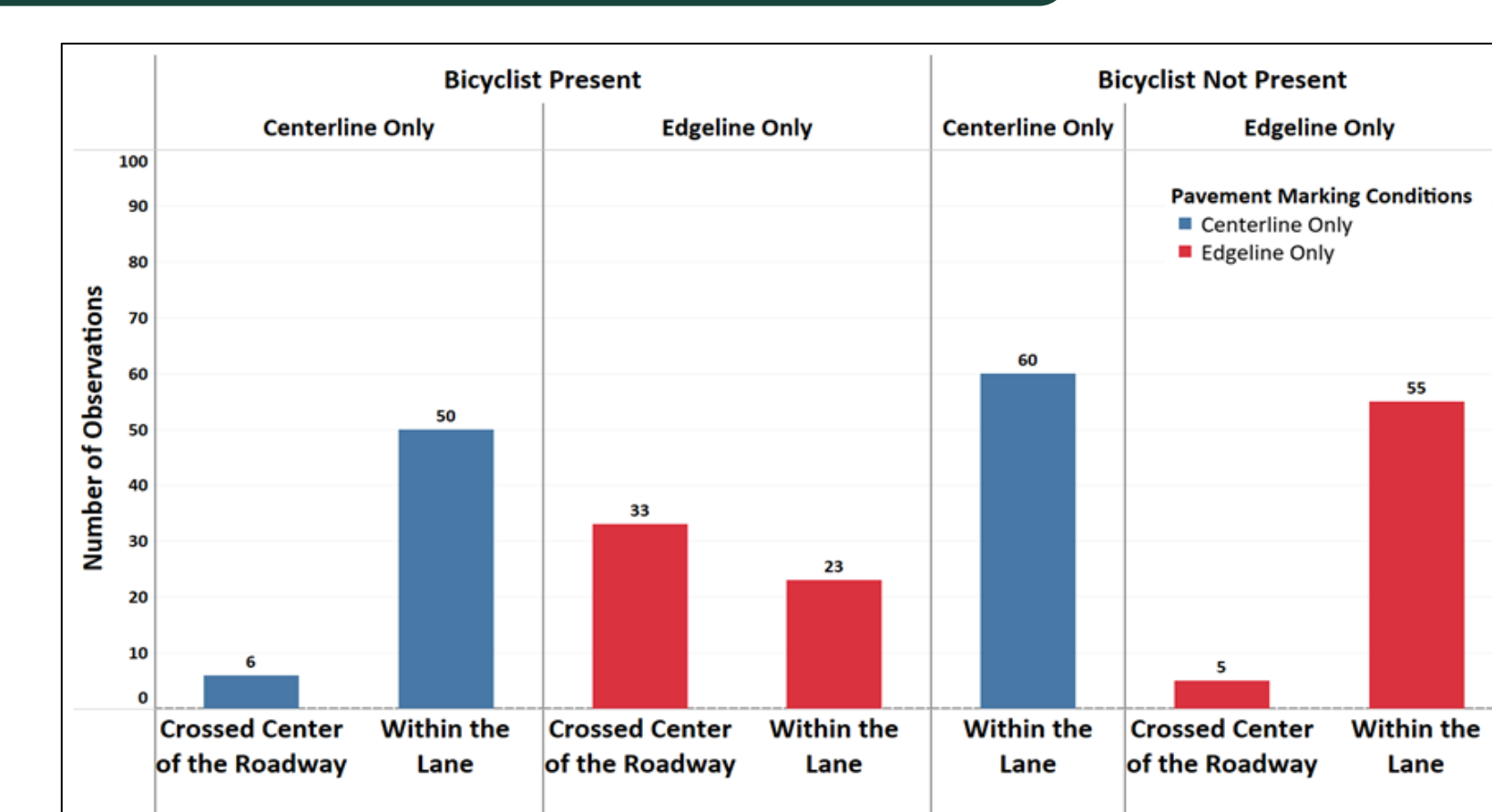
- Vehicle lateral positions were extracted from HD video using computer vision techniques
- For each vehicle, the measurement frame was selected at the exact moment of overtaking, when:
 - The vehicle and bicyclist were laterally aligned
 - Both were fully visible within the camera view
- Detectron2, an open-source computer vision framework, was used with a pre-trained Mask R-CNN (ResNet-50 FPN 3x) model to perform instance segmentation and extract vehicle shapes as pixel-wise masks

Data Summary



Mean lateral distance from the center of the roadway to the left tire

- The final dataset contained paired observations for 116 vehicles (232 total observations), including
 - 56 vehicles overtaking a bicyclist in both sections and
 - 60 vehicles traversing the corridor without a bicyclist in either section



Vehicle lane excursions

Model Results – Lateral Lane Position

Table. Mixed-Effect Linear Regression Model Results for Vehicle Lateral Position

Parameters	Estimate (ft)	Std Error	p-value
(Intercept)	4.500	0.247	<0.001
Test Conditions			
Centerline-Only with Bicyclist Not Present		Baseline	
Edgeline-Only with Bicyclist Not Present	-1.360	0.241	<0.001
Centerline-Only with Bicyclist Present	-2.714	0.304	<0.001
Edgeline-Only with Bicyclist Present	-4.709	0.304	<0.001
Travel Direction			
Westbound		Baseline	
Eastbound	-1.070	0.251	<0.001
Random Effect			
Group Name		Std Dev	
Vehicle ID		0.954	

- Without bicycle** – on average, 1.4 ft further to the left at the edgeline-only section compared to the centerline-only section
- With bicycle** – on average 2.0 ft further left at the edgeline-only section compared to the centerline-only section

The magnitude of this leftward shift (compared to the intercept) indicated that, on average, the left tire encroached onto the center of the road when overtaking a bicycle.

Model Results – Lane Excursions

Table. Mixed-Effect Logistic Regression Model for Vehicle Lane Excursions When Overtaking a Bicyclist

Parameters	Estimate	Std Error	p-value
Intercept	-11.170	0.001	<0.001
Road marking			
Centerline-Only with Bicyclist Present		Baseline	
Edgeline-Only with Bicyclist Present	21.128	0.001	<0.001
Random Effects			
Group Name		Std Dev	
Vehicle ID		37.89	

The extremely large coefficient estimate (21.1) for the edgeline-only conditions indicates that drivers were significantly more likely, both in practical and statistical terms, to cross the center of the road when overtaking a bicyclist in the absence of centerline striping.

Conclusions and Recommendations

Based on the findings of this study, it was concluded that

- In the absence of a centerline, drivers are more willing to encroach into the opposing lane when overtaking a bicyclist and, on average, provide an additional 2.0 ft of lateral separation from the bicyclist.
- Even when no bicyclists were present, drivers shifted 1.4 ft further left in the absence of a centerline stripe.

The 11th Edition MUTCD notes that centerline markings may be considered optional on urban roadways with daily traffic volumes below 4,000.

- Based on the results of this study, transportation agencies should consider the elimination of the centerline on low-speed urban streets with considerable demand for on-road bicycling.
- Edgeline markings should be maintained to delineate the shoulder (or bicycle lane) from the vehicular traffic lane, creating an “edgeline road”, but may be eliminated for locations where bicycle activity is low and on-street parking is allowed.

References

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