



Curve Safety Solutions

INTRODUCTION

Horizontal curves account for more than 25 percent of fatal crashes and the average crash rate for curves is approximately three times higher than tangent segments.¹ Transportation agencies have a number of horizontal curve safety countermeasures at their disposal to improve the safety of collision-prone curves.

This flyer introduces a family of curve solutions that are underutilized but still highly effective, and can be considered if other treatments do not address site- or crash- specific needs. The following sections will demonstrate that these countermeasures may be within the agencies' scope or ability to deploy.

List of Treatments

SIGNS OR DEVICES

DYNAMIC SPEED FEEDBACK SIGN (OR SPEED ACTIVATED SIGNS)

Dynamic speed feedback signs are typically radar-activated roadside signs that display a vehicle's current speed in relation to the posted speed limit. As a vehicle approaches at a speed higher than the advisory speed, the dynamic portion of the sign alerts drivers. This creates an opportunity to raise drivers' awareness. These devices can be portable or permanent depending on the agency's requirement for a particular location.



Source: Dwernertl at the English Wikipedia, [CC BY-SA 3.0](https://creativecommons.org/licenses/by-sa/3.0/)

Figure 1. Dynamic speed feedback sign.

Application Conditions

- Typically installed in transition zones to slow traffic upstream in advance of curves or lower speed areas.

Limitations

- Requires increased maintenance and a power source.
- Drivers may become immune if overused and with no perception of further enforcement.
- Single directional results unless posted on both travel directions.

Safety Benefits

- CMF = 0.93** (For 2-lane undivided roads)
 - Applicable to all crash types and severities.
 - Studies have shown that dynamic feedback reduces average speeds by 5 mph and 85th percentile speeds by 7 mph, which can help drivers navigate curves more safely.

Cost: This treatment has a high initial cost (compared to standard signing).

¹ FHWA, *Horizontal Curve Safety*, https://safety.fhwa.dot.gov/roadway_dept/countermeasures/horcurves/.

DYNAMIC CURVE WARNING SYSTEMS

Dynamic curve warning systems can take a variety of forms. One example combines a speed measuring device (such as loop detectors or radar) with flashing beacon and a warning sign (see Figure 2). It works by measuring the speeds of approaching vehicles and providing either static or dynamic messaging to drivers traveling too fast.

Another related treatment is known as the Sequential Dynamic Curve Warning System (SDCWS) as shown in Figure 3. This system includes chevron signs with solar powered flashing lights embedded in the sign. The lights can be programmed to flash in different patterns in order to grab the driver's attention.

Application Conditions

- Locations with poor performance especially those involving fatalities and injuries.
- SDCWS have been implemented as a countermeasure on two-lane rural and multilane urban highway curves as a means to reduce vehicle speeds and improve curve delineation.

Limitations

- Even the least expensive dynamic curve warning system is significantly more costly than static signs.
 - As such, agencies may limit their application to locations where other less expensive devices have failed to solve the issue.

Safety Benefits

- CMF = 0.56 (For SDCWS)
 - Applicable to all crash types and severities.
 - Studies have shown speed reductions as high as 8.8 mph.



Source: FHWA.

Figure 2. Flashing beacon with warning sign.



Source: FHWA.

Figure 3. Example of sequential dynamic curve warning system.

Cost:

- Cost of these systems varies depending upon the specific design and the availability of a power source.
- Overall, this countermeasure is moderate cost.

MARKINGS

OPTICAL SPEED BARS (OR SPEED REDUCTION MARKINGS)

Optical speed bars are transverse stripes on the roadway spaced at gradually decreasing distances. They are used to increase drivers' perception of speed, causing them to slow down. As spacing between bars slowly shortens, drivers feel they are going faster and will reduce speed accordingly.

Application Conditions

- Reserved for unexpected horizontal or vertical curves or other feature where drivers need to decelerate in advance of the feature.
- Supplements, and does not substitute for, appropriate warning signs and other traffic control devices.

Limitations

- Only allowed where longitudinal lines are present on both sides of the lane.
- Requires maintenance due to extensive exposure to traffic over time.
- Not intended for use on long roadway sections.
- Overuse could jeopardize the visual effect of the countermeasure.

Safety Benefits

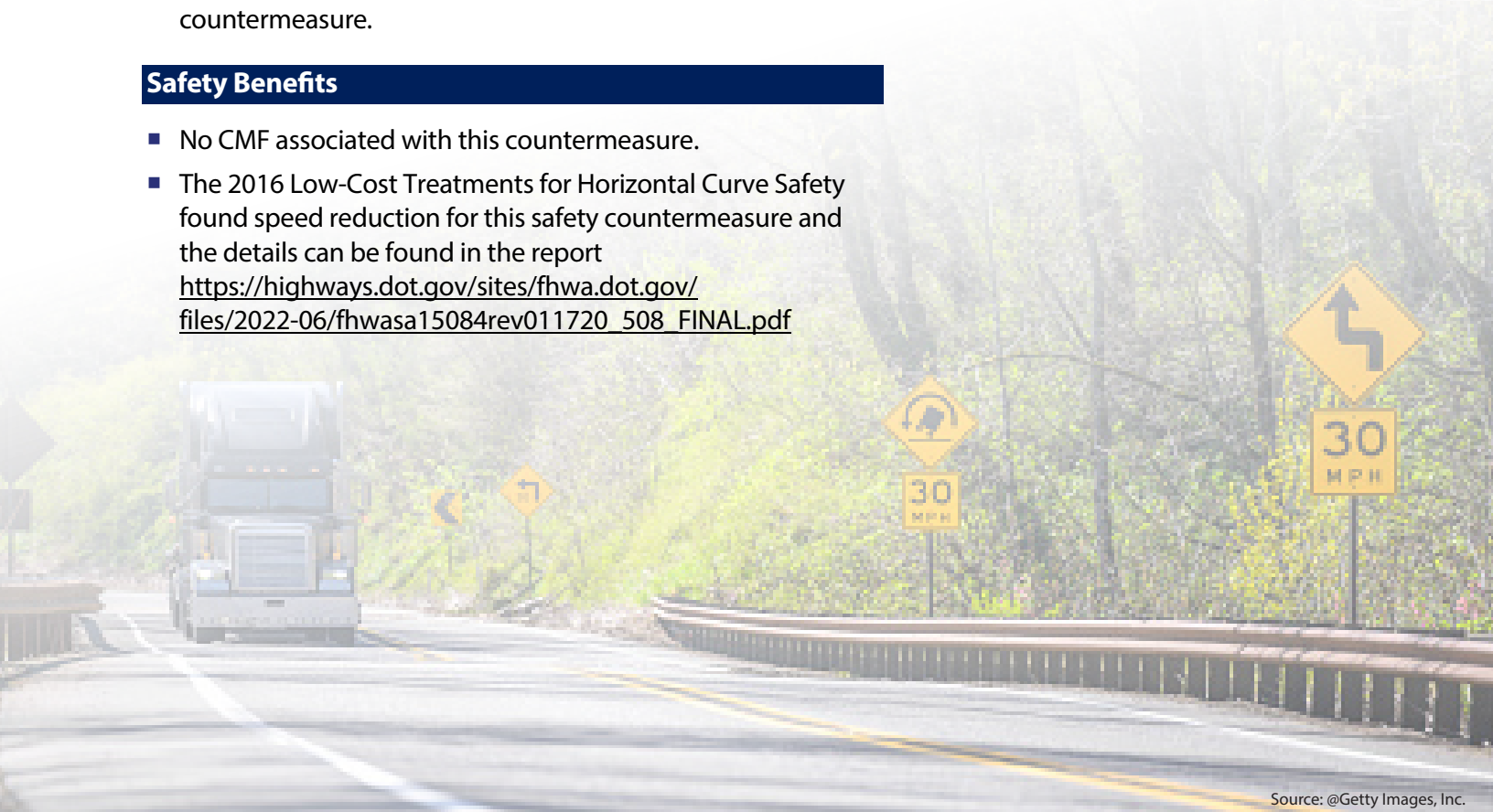
- No CMF associated with this countermeasure.
- The 2016 Low-Cost Treatments for Horizontal Curve Safety found speed reduction for this safety countermeasure and the details can be found in the report https://highways.dot.gov/sites/fhwa.dot.gov/files/2022-06/fhwas15084rev011720_508_FINAL.pdf



Source: FHWA.

Figure 4. Optical speed bars.

Cost: This is a low cost treatment.



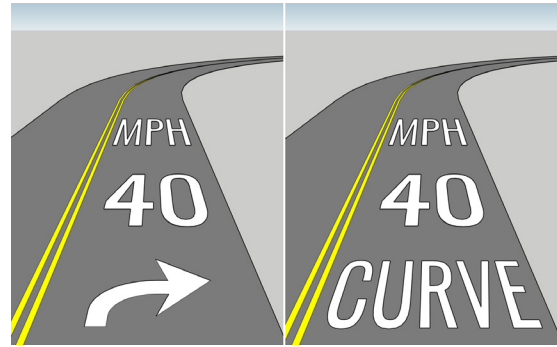
Source: @Getty Images, Inc.

SPEED ADVISORY MARKINGS IN LANE

This treatment involves in-lane pavement markings that supplement curve warning signs, by providing the same information in the driver's direct line of sight, re-emphasizing the message to the driver.

Application Conditions

- Higher speed roads where curve advisory speed is significantly lower than the posted speed.
- Curves where crash reports indicate speed-related issues.
- Corridors where speed studies indicate excessive speeding.
- Rolling or mountainous terrain where the horizontal curve may be hidden by a vertical crest.



Source: FHWA.

Figure 5. Design guidelines for pavement markings.

Cost: This is a low cost treatment.

Limitations

- Requires maintenance due to extensive exposure to traffic over time.

Safety Benefits

- [CMF = 0.652](#) (For 2-lane undivided roads)
 - Applicable to all crash types and severities.
- Studies have shown that speed advisory markings significantly reduce vehicle speeds at the entrance to the curve.
 - Refer to [NCHRP 600 Human Factors Guidelines for Road Systems](#) for further details.

FOR MORE INFORMATION

- Low-Cost Treatments for Horizontal Curve Safety 2016. FHWA-SA-15-084. https://safety.fhwa.dot.gov/roadway_dept/countermeasures/horicurves/fhwasa15084/
- CMF Clearinghouse. <http://www.cmfclearinghouse.org/index.cfm>
- NCHRP Report 600: Human Factors Guidelines for Road Systems: Second Edition. <http://www.trb.org/Main/Blurbs/167909.aspx>
- FHWA, Roadway Departure, Horizontal Curve Safety. https://safety.fhwa.dot.gov/roadway_dept/countermeasures/horicurves/

CONTACT

Joseph Cheung
Joseph.Cheung@dot.gov



U.S. Department of Transportation
Federal Highway Administration

<http://safety.fhwa.dot.gov>

ZERO IS OUR GOAL
A SAFE SYSTEM IS HOW WE GET THERE
FHWA-SA-21-092