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Dynamic Speed Feedback Signs

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Abstract

Dynamic speed feedback sign (DSFS) systems are traffic control devices that are programmed to provide a message to drivers exceeding a certain speed threshold. A DSFS system typically consists of a speed-measuring device, which may be loop detectors or radar, and a message sign that displays feedback to drivers who exceed a predetermined speed threshold. The feedback may be the driver's actual speed, a message like "SLOW DOWN," or activation of a warning device such as beacons or a curve warning sign.

For more on this topic by these authors, see also "Evaluation of Dynamic Speed Feedback Signs on Curves: A National Demonstration Project": http://www.trb.org/main/blurbs/172092.aspx

Keywords

85th percentile speed, Before and after studies, Crash analysis, Countermeasures, Crash analysis, Demonstration projects, Evaluation, Highway curves, Highway Safety, Rural highways, Speed Control, Speed signs, Safety, Traffic control devices, Traffic safety

Disciplines

Civil Engineering

Comments

Please note: this summary is part of the website Synthesis of Safety-Related Research <<a href="http://www.ctre.iastate.edu/research-synthesis/" target="_blank">http://www.ctre.iastate.edu/research-synthesis/> which brings together a number of individual reports available in the InTrans collections in this repository.

Dynamic Speed Feedback Signs

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Description

Dynamic speed feedback sign (DSFS) systems are traffic control devices that are programmed to provide a message to drivers exceeding a certain speed threshold. A DSFS system typically consists of a speed-measuring device, which may be loop detectors or radar, and a message sign that displays feedback to drivers who exceed a predetermined speed threshold. The feedback may be the driver's actual speed, a message like "SLOW DOWN," or activation of a warning device such as beacons or a curve warning sign.

Dynamic speed feedback signs are also referred to as dynamic warning signs, radar speed signs, radar message signs, electronic speed signs, and dynamic speed display signs.

One of the main advantages is that DSFS systems can specifically target drivers who are speeding rather than providing a message to all drivers. In this way, the system "interacts" with an individual driver, which may lead to better compliance because the message appears more personalized.

It alerts drivers that they are speeding while creating a sense of being monitored. These devices may also slow drivers who have radar detectors.

DSFS systems have been used to reduce vehicle speeds successfully and, subsequently, crashes in applications like traffic calming on urban roads.

Dynamic curve warning or intersection warning systems are included in DSFS systems and are set to activate at certain speed thresholds. For instance, LED lights on a stop sign may be programmed to activate when an approaching vehicle is traveling at a speed at which they are unlikely to be able to stop. One type of DSFS system is a sequential dynamic curve warning system, which consists of a series of solar-powered, LED-enhanced chevron signs installed throughout a curve (see Figure 1). The FHWA (2012) is continuing to evaluate the effectiveness of this system on rural curves in four states including Iowa.

Figure 1. Sequential dynamic curve warning system (FHWA 2012)

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Placement

Devices are placed in the location where a reduction in speed is desired. They may also be used in transition zones to slow traffic in advance of lower speed areas. Given DSFS systems are often expensive, they have typically been applied selectively to high-crash locations.

Sign placement should be placed based on perception-reaction, deceleration, and the expected reduction in speed so that the sign can be placed so drivers have time to adjust their speed. A clear line of sight to the radar or video equipment is also necessary (Ray et al. 2008).

Effectiveness of DSFS Systems in Reducing Speeds

Dynamic speed-activated feedback sign systems have been used in a number of applications such as school zones, work zones, and community entrances. Their use in reducing roadway departures has mainly been limited to use on curves. The results for studies about the use of DSFS to reduce speeds for roadway scenarios where lane departures are a concern are described in the following sections.

Table 1 summarizes the various studies for changes in mean speed while Table 2 summaries the results of changes in 85th percentile speeds for the various studies.

Effectiveness of DSFS Systems for Speed Management (Iowa Studies)

One study was conducted in Iowa that evaluted the effectiveness of two different types of DSFS systems in reducing speed and crashes on rural two-lane curves (Hallmark et al. 2013). One curve displayed a regular speed feedback sign when drivers exceeed the posted or advisory speed and the other displayed the corresponding speed avisory sign when the driver exceeded the posted or advisory speed (see Figure 2). Signs were also installed at 22 curves on rural two-lane roads in seven states (11 of each sign type) (Hallmark et al. 2015). Tangent speed limits ranged from 50 to 70, and advisory speeds ranged from no advisory speed to 50 miles per hour (mph). Volumes ranged from 346 to 5,506 vehicles per day (vpd) with the majority having less than 2,000 vpd.

Table 1. Summary of Changes in Mean Speed (mph) with DSFS System

Sign Type	Reference	Sites	Before	Within 1 Year	Change	2 to 3 Years After	Change
Speed Feedback	(Ullman and Rose 2005)	2	36.2	35	-1.2	—	—
Speed Feedback	(Hallmark et al. 2015)	11	—	—	-2.7	—	-2.0
Curve Advisory	(Winnett and Wheeler 2002)	3	38.6	34.6	-4.0	—	—
Curve Advisory	(Knapp and Robinson 2012)	3 at PC	54.4	50.6	-3.8	—	—
		3 at Curve Center	53.2	49.9	-3.3	—	—
Curve Advisory	(Hallmark et al. 2015)	11	—	—	-2.5	—	-2.0

Table 2. Summary of Changes in 85th Percentile Speed (mph) with DSFS System

Sign type	Reference	Sites	Before	Within 1 Year	Change	2 to 3 Years After	Change	4+ Years After	Change
Speed/Slow	(Bellevue 2009)	1	35.5	31	-4.5	—	—	31.0	-4.5
Speed Feedback	(Bellevue 2009)	2	42.2	38.0	-3.3	38.0	-4.2	35.0	-6.3
Speed Feedback	(Ullman and Rose 2005)	2	41.5	40	-1.5	—	—	—	—
Speed Feedback	(Hallmark et al. 2015)	11	—	—	-2.7	—	-2.3	—	—
Curve Advisory		11	—	—	-2.4	—	-2.0	—	—
Curve Advisory	(Knapp and Robinson 2012)	3 at PC	60.8	56.6	-4.2	—	—	—	—
		3 at Curve Center	60.1	56.6	-3.5	—	—	—	—

Speeds were compared before installation of the signs and then at 1, 12, and 24 months after. Speeds were compared at the point of curvature and center of curve. Table 3 shows the average change in speeds across all 22 sites.

As noted, the average decrease in mean at the point of curvature (PC) ranged from 1.8 to 2.6 mph over the three time periods at the PC of the curves and ranged from 1.8 to 2.1 at the center of curve. Similarly, the average decrease in 85th percentile speeds across the three time periods ranged from 2.2 to 2.9 at the PC and 1.6 to 1.9 at the center of the curve.

The decrease in the fraction of vehicles traveling 5, 10, 15, or 20 or more mph over the advisory speed, if present, or posted speed if no advisory speed was present, is also shown in Table 3. As indicated, the average decrease in the fraction of vehicles traveling 5 mph over the advisory or posted speed limit ranged from 12 to 20 percent across the 1-, 12-, and 24-month periods after installation at the PC and ranged from 20 to 28 percent at the center of curve. The fraction of vehicles traveling 10 or more mph over ranged from 29 to 34 percent at the PC and 33 to 42 percent at the center of curve. The decrease in the fraction of vehicles traveling 15 or more mph over ranged from 30 to 36 percent at the PC and 37 to 57 percent at the center of the curve. The fraction of vehicles traveling 20 or more mph over the advisory or posted speed limit decreased by 29 to 50 percent at the PC and 14 to 37 percent at the center of curve.

As noted, moderate reductions were noted in the mean and 85th percentile speeds. The reductions were sustained across the two year period that the signs were evaluted. Signficant decreases in the fraction of vehicles traveling at various thresholds over the advisory or posted speed limit were observed, and these changes were also sustained over time.

Effectiveness of DSFS Systems for Speed Management (Other National Studies)

The City of Bellevue, Washington (2009) evaluated DSFS systems on urban two-lane roads (25 to 35 mph speed limits). Two different types of signs were evaluated: one with YOUR

Dynamic speed feedback sign

Dynamic curve advisory sign

Figure 2. Dynamic speed feedback sign evaluated in seven sates (Hallmark et al. 2015)

Table 3. Average Speed Changes Across Sites at the PC (Hallmark et al. 2015)

		At PC of Curve			At Center of Curve		
		1 Month	12 Months	24 Months	1 Month	12 Months	24 Months
Average Mean Speed (mph)		-1.8	-2.6	-2.0	-2.1	-1.7	-1.8
Average 85th Percentile Speed		-2.2	-2.9	-2.2	-2.5	-1.6	-1.9
Average Change in Fraction of Vehicles Exceeding Posted or Advisory Speed By:	**5 mph**	-12%	-19%	-20%	-28%	-20%	-26%
	10 mph	-30%	-34%	-29%	-42%	-33%	-42%
	15mph	-36%	-36%	-30%	-57%	-37%	-44%
	20 mph	-29%	-50%	-30%	-31%	-14%	-37%

Table 4. 85th Percentile Speed (mph) Results for DSFS in Bellevue, WA (2009)

Site	Speed Limit (mph)	Before	1 to 6 Months	Change	12 Months	Change	2 to 3 Years	Change	4+ Years	Change
Speed Sign										
Sammamish/117th	35	43					40	-3		
Sammamish/Vasa	30	41.3	38	-3.3			36	-5.3	35	-6.3
Average for speed sign		**42.2**	**38.0**	**-3.3**			**38.0**	**-4.2**	**35.0**	**-6.3**
Speed/SLOW sign										
Phantom/160th	25	35.5	31	-4.5					31	-4.5

SPEED signing and a DSFS displaying the vehicle speed for vehicles traveling over the posted speed limit. Speed results for curve sites are shown in Table 4.

The average reduction in 85th percentile speed was 4.2 mph for data collected 12 months after installation of the signs. Signs were installed between 2001 and 2008. An average speed reduction of 6.3 mph was noted when data were collected four to eights years after the signs were installed.

The second sign type displays a specific static message, YOUR SPEED, and the vehicle speed for vehicles traveling over the posted speed limit up to a certain threshold. Once that threshold is reached, the sign then displays the message SLOW DOWN.

One curve location had this sign type (see Table 4). As noted, the average decrease in 85th percentile speed was 4.5 mph within the first year after installation. This reduction was sustained four or more years after installation.

Preston and Schoenecker (1999) also evaluated the safety effect of a DSFS system on Minnesota State Highway 54, which is a two-lane rural roadway with a speed limit of 55 mph and an annual average daily traffic (AADT) of 3,250 vpd. The curve had an advisory speed of 40 mph.

The DSFS system had a changeable message sign and radar unit. The researchers conducted a field test over a four-day period with a unit that consisted of a closed circuit TV camera, a VCR, and a personal computer. A portable trailer housed the entire system.

The sign displayed the following information:

- CURVE AHEAD from 6 to 10 a.m., 11 a.m. to 2 p.m., and 4 to 7 p.m.
- No message during other times of the day unless activated.

The team randomly evaluated whether vehicles negotiated the curve successfully based on curve messages. Vehicles that crossed a left or right lane line on one or more occasions were defined as not navigating the curve successfully.

The team found that about 35 percent of the drivers who received the static message were unable to negotiate the curve successfully. Vehicles that received the CURVE AHEAD sign were more likely to negotiate the curve successfully, but the difference was not statistically significant. Only 26 percent of vehicles that received the CURVE AHEAD – REDUCE SPEED sign were unable to negotiate the curve successfully, and the difference was statistically significant at the 90 percent level of confidence.

Figure 3: DSFS on curve in the UK (© TRL (Transport Research Laboratory) 2002, from Winnett and Wheeler 2002)

Knapp and Robinson (2012) evaluated the impacts of a dynamic curve warning sign on three curves on rural two-lane roadways in Minnesota. The sign is similar to the one shown in Figure 3. The three sites were along county roads with volumes ranging from 455 to 710 vpd. Data were collected before, at 1 month and 12 months after installation of the signs. Results are listed for the point of curvature and center of curve in Table 5. As noted, the average reduction at 1 month was 3.3 at the PC and 2.9 at the center of curve. The average change in 85th percentile speed at 1 month was -3.9 mph at the PC and -3.6 at the center. Similar results were found at 12 months with an average change in mean speed of -3.8 at the PC and -3.3 at the center of curve with an average decrease in 85th percentile speed of 4.2 at the PC and 3.5 mph at the center of curve.

Ullman and Rose (2005) evaluated the effectiveness of DSFS systems at two curves on two-lane roadways. The signs displayed the static message YOUR SPEED and the vehicle's speed. The tangent speed was 55 mph and the advisory speed was 20 mph. Results are shown in Table 6. As noted, the average decrease was 1 to 3 mph for mean speed and about 2 mph for 85th percentile speeds.

Effectiveness for Speed Management (International Studies)

A vehicle-activated curve warning sign was tested on three curves on two-lane roads in the United Kingdom as shown in Figure 3 (Winnett and Wheeler 2002). The signs were blank when drivers were under the 50th percentile speed. As shown

Table 5. Results for DSFS Systems on Curves along County Roads in Minnesota (Knapp and Robinson 2012)

Site	Vpd	Posted/ Advisory Speed (mph)	Mean (mph)					85th Percentile Speed (mph)				
			Before	1 Month	Change	12 Months	Change	Before	1 Month	Change	12 Months	Change
Point of Curvature												
25	630	55/NA	53.4	51.7	-1.7	54.5	1.1	59.3	58.4	-0.9	61.5	2.2
3	455	55/40	53.9	48.2	-5.7	45.1	-8.8	61.8	53.9	-7.9	51	-10.8
7	710	55/50	55.8	53.4	-2.4	52.2	-3.6	61.3	58.4	-2.9	57.2	-4.1
Average					**-3.3**		**-3.8**			**-3.9**		**-4.2**
Center of Curve												
25	630	55/NA	56.2	51.9	-4.3	52.5	-3.7	63.2	59	-4.2	60	-3.2
3	455	55/40	51.5	47.9	-3.6	45.2	-6.3	59.3	54.2	-5.1	52.4	-6.9
7	710	55/50	52.0	51.3	-0.7	52.1	0.1	57.7	56.3	-1.4	57.4	-0.3
Average					**-2.9**		**-3.3**			**-3.6**		**-3.5**

Table 6. DSFS Systems on Rural Two-Lane Curves (Ullman and Rose 2005)

Site	Time Period	Mean Speed (mph)			85th Percentile Speed (mph)		
		Before	After	Change	Before	After	Change
1	1 Week	35.3	33.2	-2.1	41	38	-3
2		37.1	33.6	-3.5	42	40	-2
Average		**36.2**	**33.4**	**-2.8**	**41.5**	**39**	**-2.5**
1	4 Months	35.3	32.9	-2.4	41	38	-3
2		37.1	37.1	0	42	42	0
Average		**36.2**	**35**	**-1.2**	**41.5**	**40**	**-1.5**

in Table 7, mean speeds were reduced by 2.1 to 6.9 mph, and the authors note that speed reductions were maintained over time. The average decrease was 4 mph.

Effectiveness of DSFS in Reducing Crashes

Hallmark et al. (2013) also compared crashes before and after installation of the DSFS on rural two-lane curves and developed crash modification factors (CMFs) using a Bayesian analysis. Control sites were also included. Depending on the direction and type of crash, reductions from 5 to 7 percent resulted (see Table 8). No other U.S. studies were found that evaluated crash reduction for DSFS for lane departure applications.

A study in the United Kingdom (Winnett and Wheeler 2002) conducted a simplistic analysis of DSFS on curves (see Table 9). Crash data were available for two sites and the researchers found that crashes decreased from 3.2 personal injury crashes per year to 1.5 (54 percent) at one site and from 0.7 to 0 (100 percent) at the other.

Table 7. Curve Warning Sign Changes in UK (Winnett and Wheeler 2002)

Sites	Speed limit (mph)	Mean speed (mph)		
		Before	After	Change
Norfolk	30	36.7	29.8	-6.9
Wiltshire	60	38.3	35.3	-3.0
W Sussex	50	40.9	38.8	-2.1
Average		**38.6**	**34.6**	**-4.0**

Table 8. CMFs for Dynamic Speed Feedback Signs (Hallmark et al. 2013)

Treatment	Crash type	CMF
Dynamic speed and curve advisory feedback signs on rural two-lane curves	All in both directions	0.95
	All in the direction of the sign	0.93
	SV in both directions	0.95
	SV in the direction of the sign	0.95

Table 9: Change in Crashes for Dynamic Speed Feedback Signs (Winnett and Wheeler 2002)

Treatment	Sites	Crash Type	Change in Crashes
Dynamic curve advisory feedback signs on rural two-lane curves (UK)	2	Personal Injury	-54% to -100%

Advantages

- Do not physically affect vehicle operation
- Do not have an impact on emergency vehicles
- Do not impact drainage
- Can be moved and used at different locations when portable
- Provide a sense of enforcement
- May be implemented immediately

Disadvantages

- DSFS have high initial cost
- They require regular maintenance and a power source
- Motorists may speed up to see how fast they can go (can be addressed by only posting speeds in a certain range)
- Drivers may become immune to them if overused with no perception of further enforcement

Appropriateness

Dynamic speed feedback signs are appropriate for most roadways.

Cost

Dynamic speed signs cost from $2,000 to $11,000 per display.

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