Accidents, Speed Deviation and Speed Limits

by Leonard B. West, Jr., and J. W. Dunn

"Speed regulations and speed limits denote a restraint upon the freedom of the speed which he (the driver) desires to travel. Therefore limits or restraints should be imposed only to the extent that their use will facilitate traffic flow or decrease a traffic hazard. Public acceptance is a prerequisite to effective public obedience to traffic regulations. If regulations are imposed only where and when they are necessary, the driver will more readily accept the need for them."[1]

The Traffic Engineering Handbook recommends four basic factors to be considered in establishing speed limits: Prevailing vehicle speed, physical features of the road, accident experience, and traffic characteristics and control. One element of this group that has not been totally researched will be discussed in this article—the accident experience. Studies by Solomon[2] found a U-shaped curve relating accident involvement rates and the speed of the involved vehicles. Involvement rate is a measure of the likelihood of being involved in an accident, and is the ratio of cars involved in an accident to the number of cars having a particular characteristic, such as a given speed.

A recent study[3] conducted to determine the relationships between involvement rate and speed deviations from the mean traffic speed, utilized the mean traffic speed as measured at a nearby point and the estimated speed of the vehicles involved.

The data were gathered by using on-line digital computer and magnetic loop detectors in the pavement of Indiana Highway 37 (Figure 1). The on-line computer received the time of presence or absence of a vehicle through a regular search of the detector pairs. Upon finding a change in state, the computer utilized a group of subroutines to compute vehicle headways, speeds, lengths, and volumes (Figure 2).

Although the system was scheduled for four-hours' preventative maintenance each week, allowing a planned availability of 97.6 percent, this was seldom observed because of malfunctions, designated "bad car counts" (BCC). A BCC occurs when the system "senses" a vehicle passing but the speed and length are computed as zero. The BCC can result from improper lane usage, failure of one interconnect, loop inductance out of tune with interconnect, or from a malfunction of the phone line connecting the sensors with the computer. A figure of 5 percent BCC was selected as critical for acceptance or rejection of a data set. The 16 loop pairs weekly availability (i.e., time when BCC $\leq$ 5 percent) varied from 54 percent to 93 percent over a 22-week period. All but one pair had one or more weeks in which their availability was 96 percent or higher. The overall system availability, excluding the consistently poor pair of detectors, was 77 percent or 79 percent of the planned availability of 164 hours per week.

An accident investigation team, provided by the Institute for Research in Public Safety at Indiana University, investigated accidents that occurred on this road. This allowed the speed deviation as estimated by the professional accident investigators to be correlated with

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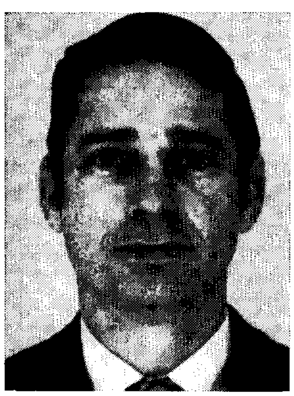

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the traffic speed prior to the accident as measured by the computer. This provided good estimates of both the mean traffic speed and the speed of the accident-involved vehicle. In nine of the 36 cases studied by means of the computer sensor system, the speed of the involved vehicle or the platoon containing the vehicle was identified with high confidence. This identification was based on several particular characteristics of these vehicles, or the traffic surrounding them, and an accurate knowledge of the time that the accident occurred. For example, one vehicle was identified by witness reports of two tractor trailers that had been traveling together behind the involved vehicle. In 23 of the 36 accidents, the computer sensor provided speed inputs for at least one involved vehicle.

A computer program was written which can, on a time increment basis, queue the vehicles by sensor into a time sequence. This sorted vehicle speed-length data is then printed with the time sequence down the page and the sensor distance spacing at a predetermined scale across the page, providing an overview of the traffic flow at each of the sensors.

Certain vehicles which have "unique" lengths or speeds are easily found when they cross a detector. A line may then be drawn which connects these vehicles at each detector. These "different" vehicles effectively break the vehicle stream up into segments which contain groups of vehicles. Within these smaller groups several events are possible:

All vehicles remain on the road and no new vehicles enter.

Some vehicles leave the road and no new vehicles enter.

All vehicles remain on the road and new vehicles enter.

Some vehicles leave the road and new vehicles enter.

Vehicle order remains the same.

Vehicle order changes (passing).

In tracking a vehicle, the first step is to locate a vehicle which has either unique speed or length characteristics at several detector locations; then connect the unique vehicle-detector-time points with straight lines. Next, examine the vehicles which are bounded by the vehicles located in steps one and two for speed, headway, length, and platoon characteristics, and repeat the second step. This sequence can usually be repeated within the vehicle groups until most trajectories can be traced.

Proportional spacing of the computer printout of the arrival times and speeds at each detector allows a visual study to be made of the traffic flow. A change in the slope of the trajectory line indicates a speed fluctuation between the detectors. An accident blocking traffic would prevent vehicle flow in either lane and, by analyzing the computer printouts, the involved vehicles could be found.

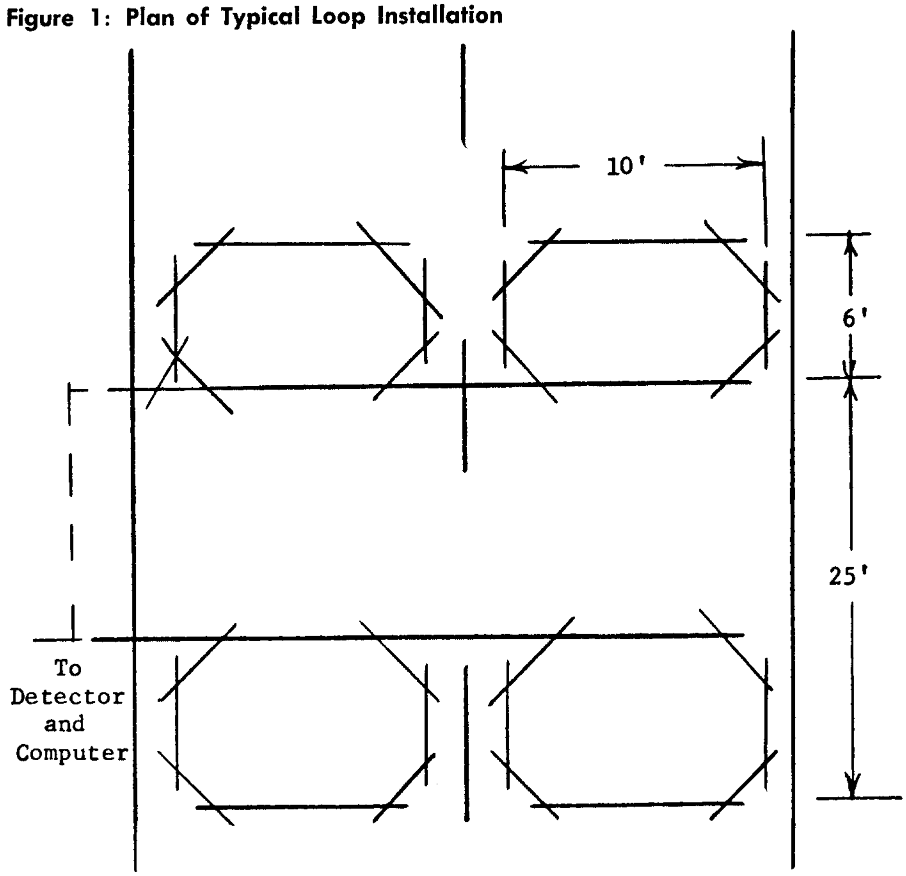
In five of the accidents during this study, the traffic flow patterns were analyzed by means of similar milestones so that the trajectories could be estimated. The primary identification came from the vehicle length patterns and platooning effects found within the traffic flow stream. Figure 3 shows the type of printout available and the resultant traffic data that were collected. The arrows indicate approximate trajectory between sensors. The columns with the decimal points are hours (24-hour clock).

These data are, to our knowledge, the largest body of two-lane,

Table 1: Relationship between involvement rate and speed deviation including turning accidents

Speed Deviation Class Interval (mph)	Number Involvements	Total Vehicle Mileage MVM	Rate (Involvements per MVM)
< -15.5	80	1.890	42.3
-15.5 to - 5.5	37	16.243	2.3
- 5.5 to + 5.5	63	39.976	1.6
+ 5.5 to +15.5	20	16.243	1.5
> +15.5	16	1.890	8.5

Figure 1: Plan of Typical Loop Installation



two-way traffic flow information, and have numerous potential applications for analysis. The printout form shown in Figure 3 was used to identify the characteristics of accident-involved vehicles prior to their accident. By virtue of its time-space scale, it can also be used to study gross traffic flow characteristics.

To provide an estimate of the involvement rate and deviation, the axis of speed deviation was divided into classes (Table 1). Table 1 also shows the relationships between the involvement rates of the vehicles and their speed deviation from the mean traffic speed. These data are based on 36 accidents that occurred on Indiana Highway 37 (a north/south highway) running through Bloomington, Indiana, and it is especially interesting because it indicates that the involvement rate per million vehicle-miles is higher for the slow deviation vehicles than for the fast deviation vehicles. A person involved in a low-speed accident is, of course, less likely to be injured, but he is also more likely to be involved in an accident. There was a rate of 42.3 involvements per million vehicle-miles (I/MVM) among vehicles traveling 15½ mph below the mean speed while, for those vehicles traveling faster than 15½ mph from the mean, it is only 8.5 I/MVM.

This can be partially explained by the fact that a car stopping to turn left or right or coming onto the road from an intersection is naturally going to be deviating a great deal from the mean traffic speed.

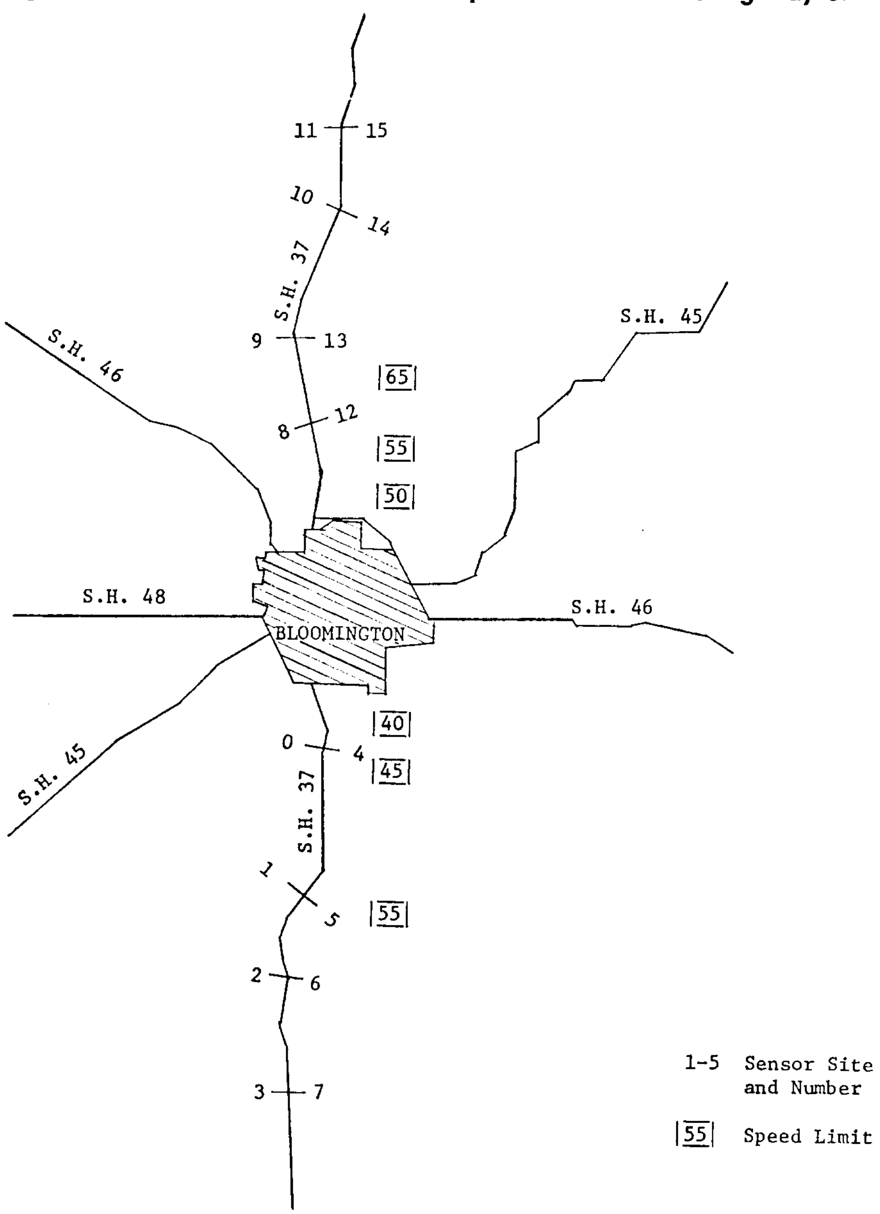
The high accident experience at intersections is another indication that through drivers should be protected from drivers who must deviate from the average traffic speed to turn onto or off of a roadway. This can be accomplished, in part, with acceleration or turning lanes, but a driver exiting from low volume conflict points onto a heavily traveled road must accept a risk of accident involvement about 40 times as great as if he were traveling at within 5 mph of average highway speed.

The relationship between involvement rates and speed deviations after deletion of the accidents involving turning vehicles shows a marked change (Table 2). The involvement rate is approximately the same for high and low speed deviations—6.9 and 6.3 respectively, and the involvement rates in the mid-ranges of speed deviation are also approximately the same (.7, .8, 1.0). This indicates that the accident involvement rate can be reduced by providing properly set and enforced speed zoning with both maximum and minimum limits, thus reducing the number of high and low deviations and lower

Table 2: Relationship between involvement rate and speed deviation not including turning accidents

Speed Deviation Class Interval (mph)	Number Involvements	Total Vehicle Mileage MVM	Rate (Involvements per MVM)
< -15.5	12	1.890	6.3
-15.5 to - 5.5	11	16.243	.7
- 5.5 to + 5.5	32	39.976	.8
+ 5.5 to +15.5	16	16.243	1.0
> 15.5	13	1.890	6.9

Figure 2: Location of Sensor Sites and Speed Zones on State Highway 37



the accident involvement rate. For example, the vehicle speed data show the standard deviation of the mean traffic speed to be approximately 7 mph and to follow a normal distribution; therefore, we may infer that fifty-two percent of the drivers will be traveling at speeds ±5 mph of the mean. Their involvement rate is 0.8 per million vehicle miles. An additional twenty-two percent of the drivers are found in each of the deviation regions —5.5 mph to —15.5 mph and +5.5 mph to +15.5 mph with involvement rates 0.7 and 1.0 respectively. Ninety-six of the drivers drive their cars at speeds which this study found to be lowest involvement rates. Four percent of the drivers operate their vehicles at speeds which create a hazard to themselves and the other drivers on the road. They have an accident involvement rate which is more than six times that of the ninety-six percent group.

This also indicates what these limits should be for safe travel on the highways. Since the standard deviation of speed is approximately 6 to 8 mph for these roads in Indiana, if the standard 85th percentile speed were used and enforcement were provided at the 95th percentile for the upper limits, this would provide speed enforcement for the high speed drivers in the high accident involvement region. Likewise, if the minimum speed limit was set at the 15th percentile and the enforcement at the 5th percentile, then the low speed deviators would be afforded equal protection from accident involvement.

References

1. *Traffic Engineering Handbook,* Institute of Traffic Engineers, 1965.
2. Solomon D. "Accidents on Main Rural Highways Related to Speed, Driver and Vehicle," U. S. Department of Commerce, July 1964.
3. Speed and Accidents, Vols. I and II, RTI, June 26, 1970.

Figure 3: Sample Printout

Source: "Speed and Accidents," Research Triangle Institute Final Report, Contract FH-11-6965.