

Automatic Speed Monitor: An Intelligent Vehicle Highway System Safe-Speed System for Advance Warning or Hazardous Speed Monitoring

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In the development of a safer highway driving environment, unsafe speeds have been found to be a cause of approximately one-third or more of all accidents. Monitoring of safe speeds has been commonly performed by radar enforcement. However, recent experience has indicated that long-term exposure to the radar emissions may pose a hazard for the law enforcement community. A new, simple and inexpensive intelligent vehicle highway system speed monitoring concept that can be easily adapted to existing vehicles and roadways is presented. The concept relies on the speed-distance-time relationship and an on-board impulse detector and constant timer to calculate the travel time or posted speed of the roadway. The calculated travel time or speed can then be compared with the current vehicle speed or with a constant time to warn the driver of hazardous approaching events (excessive speeds approaching construction or maintenance work sites, sharp curves, railroad crossings, or school zones). It can also be used to issue tickets to the vehicle registration if warnings remain unheeded. Current estimates indicate that the use of the speed monitoring device may save approximately 10,000 lives and 500,000 injury accidents per year. The cost of the on-board electronics for a magnetic detection system is approximately \$10 per vehicle with roadway detection costs for magnets of under \$10 per installation. An on-board magnetic sensing device has been successfully tested in field trials to warn of approaching sharp curves and awaits further development and testing of other applications and human factor considerations.

Each year in the United States alone, almost 40,000 persons die in automobile-related crashes, with more than 1,700,000 receiving disabling injuries. Even with new advances in the use of air bags, nonlocking brakes, mobile and air emergency medical service, and similar techniques, the total volume of fatalities and injuries remains constant because of the continuing increase in exposure by the ever-increasing amount of travel performed on the highway system. Research indicates that inappropriate speed is cited as a cause in over one-third of all fatal accidents and by implication in a similar number of injuries and total accidents (1). If driver speed can be maintained at safe levels either by providing warning assistance to the driver or by using stricter enforcement techniques applied to the vehicle registration itself, it may be possible to reduce total accidents by one-third (those caused by excessive speeds), which may save more than 10,000 lives and 500,000 disabling injuries each year.

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Technology for providing speed warning or enforcement has changed little since the 1930s and 1940s. In that era as today, the major technique to control speeds rested with the provision of either regulatory or warning signs to the driver, who compared the on-board speedometer with the roadside signing and in theory acted appropriately to conform to the signing. Where the driving speeds remained inappropriately high, enforcement by local authorities through the use of "car following" or radar speed monitoring and the issuance of tickets was and still is the primary resource to control high operating or erratic speeds. These techniques remain the primary methods of enforcement today, although video speed monitoring of passenger vehicles and even satellite speed monitoring of common carriers are helping maintain a safer driving environment. However, the costs of such monitoring in economic terms and even lost personal freedoms (video surveillance) are issues that remain to be addressed.

INTELLIGENT VEHICLE HIGHWAY SYSTEM AUTOMATIC SAFE-SPEED CONCEPT

The acquisition and use of information by a vehicle to assist in driver decision making requires either the presentation of information from a stationary roadway site to a moving vehicle or acquisition of information by the vehicle as it passes a specific site. An example is the application of a blanket radio signal that all vehicles receive or the vehicle itself searching out a particular frequency for information. For the purposes of accuracy and reliability, the concept of in-vehicle acquisition is clearly a more timely and reliable vehicle data acquisition system because it eliminates extraneous signals and searches only for a particular impulse. One of the most likely types of systems is an electronic system that transmits continuously from the roadside to the vehicle with limited distance, directional antennae where impulses may be given to independent vehicles in independent lanes from either overhead or roadside locations. A second, less-expensive impulse that the vehicle may receive independently is a magnetic impulse from each lane of the pavement itself. The research contains little information on the use of permanent magnets in intelligent vehicle highway system (IVHS) applications, probably because placing permanent magnets in pavement lanes may bear tort liability implications if the permanent

magnets are sufficiently strong to retain nails or magnetic debris in the lane. However, even with this limitation caused by tort liability concerns, if the magnetic field can be maintained at sufficiently weak levels, the magnetic transmission concept may be as sound as the use of electronic transmission media.

When permanent magnets are embedded transversely in a pavement structure, a vehicle can pass over a magnetic field at any speed and still receive the most timely information that the vehicle is capable of receiving. By using two similar permanent magnets embedded a specific distance apart in the pavement (or from overhead in a particular lane), the vehicle can receive two independent impulses. By comparing the time

displacement between the two roadway impulses with an on-board constant timer, the vehicle has the ability to calculate the proper speed of the roadway from the following standard time-distance relationship:

$$\text{Distance} = 1.47 * V * T$$

where

- D = distance between roadway magnets sets (ft),
- V = posted speed of the roadway (mph),
- T = constant time (sec), and
- 1.47 = approximately 5,280 ft/3,600 sec/hr.

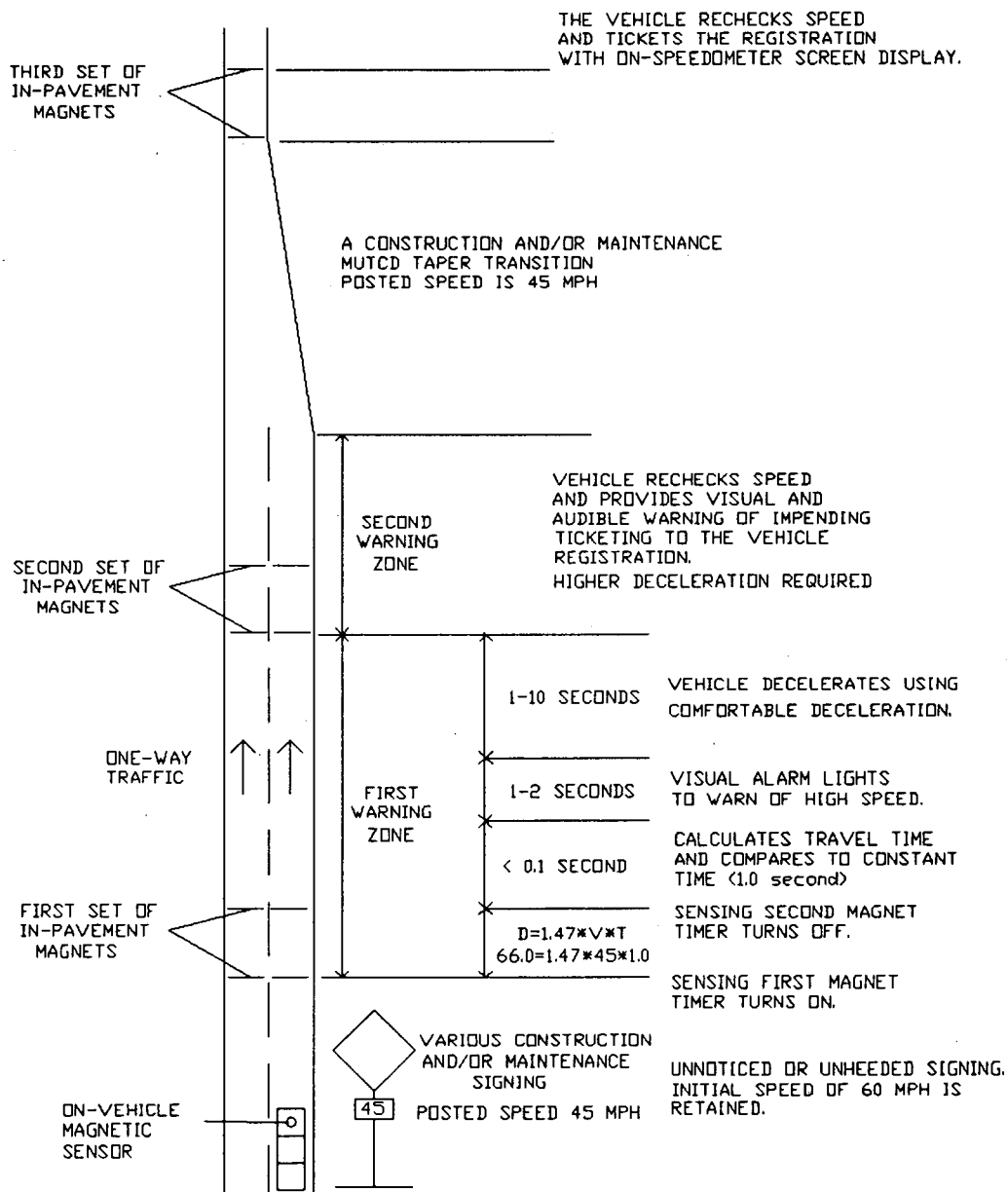


FIGURE 1 General concept of IVHS automatic safe speed system.

Using this relationship, the vehicle itself can calculate the posted speed of the roadway by using the time displacement of the two magnetic impulses. In a similar manner, where a constant timer (imputing a constant time— T) is used and the distance on the ground is varied to conform to posted speed limits, the vehicle can also determine whether the actual time to traverse the distance between the magnets is too short (speed too high) or the time between the impulses is below a specified threshold, indicating actual speed below the posted speed limit. Used in this manner, the vehicle is not testing speed but the surrogate of time displacement, which is compared with a time preset into a microchip on board the vehicle. As shown in Figure 1 (assuming a preset microchip timing device of 1 sec on board the vehicle), a vehicle is approaching a construction or maintenance work zone, which is speed restricted to 45 mph; if the vehicle is to traverse the site at or below 45 mph, the magnets must be placed 66.1 ($1.47 \times 45 \times 1$) ft apart. If the vehicle traverses this distance in less than 1 sec, the speed must be above 45 mph, and if the time to traverse the 66.1 ft is greater than 1 sec, the vehicle must have traversed the segment at less than 45 mph. In this manner, the vehicle has the ability to ascertain for itself whether the driver is acting properly in advance of a particular site where the magnets are placed in the pavement. Sensitivity of the warning and ticketing function (and the lack of precision in sensing the magnetic field) can also be addressed by using a distance greater than 66.1 ft to represent a factor of safety.

The operation of this concept may be triggered by a variety of devices that may be implanted in the roadway, including standard electromagnetic loops powered by on-site electricity, or may even include optical spectrometers to sense vehicular presence. However the information is provided to the vehicle, an on-board electronic microtimer receives the information and, using the above speed-distance model, can determine through a variety of comparative means whether the vehicle is above the desired speed in advance of a hazard and then relay that information to the driver through visual or audible or a combination of visual and audible signals to alert the driver of inappropriate driving behavior with respect to speed. Ultimately, an in-vehicle sensor can be given the capability to issue warning or actual speeding tickets to the owner of the vehicle through the use of speed or odometer "cover-up" devices (much like an "emissions" flag over the odometer) if the vehicle continues to violate the maximum speed. In this instance the speeding tickets recorded in the vehicle memory may be issued when the next regular emissions check is made or at the vehicle registration when the vehicle ownership is transferred.

Hazardous speed locations that may benefit from this application may include both rural and urban driving, but because of the speed of rural operations, it may be expected that such an advance-speed-warning IVHS system would offer greater benefit where the speed and therefore severity of the accident can be reduced. In the rural environment this may occur at isolated stop locations on high-speed roadways, on sharp, high-speed curves, locations of poor skid resistance, railroad crossings, or a variety of other locations involving high-speed roadway or roadside accidents. In the urban environment, this need for speed reduction may occur at a variety of similar locations such as hazardous intersections, neighborhood speed restraints, school zones, or even sight restrictions on vertical crest freeway curves subject to peak-hour queuing. However, probably one of the most productive applications will be at construction and maintenance work sites where speed monitoring and control are almost impossible to perform and yet where approximately 80 percent of accidents occur (2).

At present, an on-board magnetic detector and timers have been produced at a cost of under \$10, with the permanent pavement magnets also purchased for under \$10. The magnetic concept using permanent magnets laid on the pavement surface was field tested at several sharp curve sites in Tampa, Florida, and performed as expected by warning the driver of excessive speeds approaching sharp curves.

Future efforts, including human factors testing of visual or audible warnings systems and automatic vehicle speed ticketing mechanisms await the interest of FHWA, NHTSA, or the IVHS industry. Most important, if inappropriate speed is responsible for an estimated one-third of all fatal accidents as reported, it may be expected that federal insistence on the introduction of the automatic speed monitoring device to the vehicle has the clear potential to save over 10,000 lives and over 500,000 disabling injury accidents, and, by assumption, a similar amount of property damage accidents each year, while also freeing the law enforcement community from the potential hazards of radar speed enforcement.

REFERENCES

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