

## Lane Departure Warning Systems

### Objective

To reduce crashes caused by unintentional lane departures, lane departure warning systems (LDWS) monitor the position of a vehicle within a roadway lane and warn a driver if the vehicle deviates or is about to deviate outside the lane.

### Description

Currently available LDWS are forward-looking, vision-based systems that use algorithms to interpret video images to estimate vehicle state (lateral position, lateral velocity, heading, etc.) and roadway alignment (lane width, road curvature, etc.). These LDWS use a forward-facing camera that is mounted to the windshield in the cab of the vehicle. The systems also include an electronic control unit and a warning indicator. Some LDWS may issue directional warnings to alert the driver to which side of the lane the vehicle is drifting. A directional warning may be audible, such as rumble strip sounds in left or right in-cab speakers, or tactile. LDWS may graphically indicate on a user interface display how well the vehicle is centered in the lane on a time-averaged basis.



SafeTRAC Lane Departure Warning System by Assistware



AutoVue<sup>TM</sup> Lane Departure Warning System by Iteris

LDWS warn the driver of a lane departure when the vehicle is traveling above a certain speed threshold and the vehicle's turn signal is not in use. In addition, LDWS notify the driver when lane markings are inadequate for detection, or if the system malfunctions. LDWS do not take any automatic action to avoid a lane departure or to control the vehicle; therefore, drivers remain responsible for the safe operation of their vehicles.

Although traditional LDWS do not take any automatic action to avoid a lane departure or to control the vehicle, some emerging systems actually incorporate the use of a steering shaft actuator. If the driver does not react appropriately to a lane departure warning, the system automatically applies torque to the steering wheel and steers the vehicle back within the lane boundaries.

### Application

LDWS can help prevent single vehicle roadway departure, lane change/merge, and rollover crashes involving large trucks.

To help avoid single vehicle roadway departures, LDWS issue a warning as the truck crosses the shoulder lane marking. Without the system, the truck might be driven off the shoulder and crash into off-road obstacles (e.g., light poles, signs, guardrails, trees, and stopped vehicles) or roll over.

In unintentional lane change/merge situations, LDWS issue a warning as the truck crosses center lane markings on multi-lane roadways, including solid lines, double lines, dotted lines, dashed lines, and raised pavement markers (Bott's Dots). Without the system, the truck might be driven into an adjacent lane, resulting in a head-on or sideswipe collision.

LDWS may also help prevent rollover crashes. For example, if the vehicle drifts out of the lane onto the shoulder, the truck could roll over if a sudden recovery maneuver is made. In addition, a truck may roll over due to any recovery maneuver involving a high lateral velocity (rate of departure), requiring a relative large amplitude and/or rapid steering action.

Other potential benefits from the use of LDWS include:

- Assisting the driver in consistently keeping a vehicle in the lane, thereby reducing lane-departure crashes.

- Encouraging the driver to use turn signals when changing lanes (otherwise, a lane departure warning sounds).

- Reinforcing driver awareness of vehicle position in the lane to maintain a more central lane position and improve the driver's attentiveness to the driving task.

## **Operations and Benefits**

The movement of goods by truck is conducted on all types of roads, at all hours of the day, and in all types of driving conditions. Since unintentional lane departures can occur along any route, many fleet types may benefit from using LDWS. Yet, these systems may be most promising for trucks with high mileage accumulated over their operational life or that operate under conditions that may present driving challenges such as nighttime driving, limited visibility due to weather, congestion, or roadway configurations or geometry that can be difficult to negotiate.

A driver may encounter several types of roads and conditions where these systems perform optimally, but some conditions limit the devices, especially when lane markings cannot be well-detected.

The most commonly encountered roadway markings include single and double solid lines, dashed and dotted lines, and raised pavement markers (Bott's dots) where LDWS should detect lane departures and issue warnings to a driver traveling over the minimum tracking speed.

If lanes have missing or degraded lane markings, the driver may not receive a warning as the vehicle progresses outside of the lane, depending on the particular LDWS. On roads with only one set of markers, the driver should receive a warning when the warning threshold is crossed on that side, even if the system cannot detect the lane boundary on the other side.

Currently available LDWS will not operate at delivery points and roads where the truck travels at speeds below the minimum LDWS tracking speed. These systems are geared primarily for highway driving and will not function at lower speeds associated with some local roads. As a result, LDWS would notify drivers that the system is operational, but it is not providing warnings under these conditions.

LDWS are valuable in situations where road visibility is limited and in conditions such as rain, fog, and falling snow when lane markings are present. In some cases, however, LDWS will not be able to recognize lane markings for reasons such as lack of or poor quality of lane markings, poor visibility, or a dirty/icy windshield. When lane markings are not visible on roads covered by mud, ice, or snow, the lane tracking indicator will show that the system is inactive.

## Cost

LDWS may be installed directly by the fleets as an aftermarket accessory, while other LDWS are installed by truck Original Equipment Manufacturers (OEMs) when the vehicles are manufactured. As technology advances, new features and components may be added to these systems. The costs of LDWS vary greatly depending on the number of units wanted. The list price of a single unit is normally in the \$1,000 to \$2,000 range, but this price steadily decreases with additional units.

## Vendors

<p><b>Siemens VDO Automotive AG</b>          Sodener Straße 9          65824 Schwalbach          Germany          Ph: 06196 87-0  <a href="http://www.siemensvdo.com">www.siemensvdo.com</a></p>	<p><b>Iteris, Inc.</b>          1515 S. Manchester Avenue          Anaheim, CA 92802-2907          Ph: (714) 774-5000          Fax: (714) 780-7246  <a href="http://www.iteris.com">www.iteris.com</a></p>
<p><b>Mobileye, Inc.</b>          2000 Town Center, Suite 1900          Southfield, MI 48075          Ph: 248-351-2683  <a href="http://www.mobileye.com">www.mobileye.com</a>          Email: usa-office@mobileye.com</p>	<p><b>Delphi Electronics and Safety</b>          World Headquarters          P.O. Box 9005          Kokomo, IN 46904          Ph: 765-451-5001  <a href="http://www.delphi.com">www.delphi.com</a></p>
<p><b>AssistWare Technology</b>          4005 Vista Vue Drive          Gibsonia, PA 15044          Ph: 724-449-7233  <a href="http://www.assistware.com">www.assistware.com</a></p>	<p><b>Siemens VDO</b>          North American Headquarters          2400 Executive Hills Blvd          Auburn Hills, MI 48326          Ph: 248-209-4000  <a href="http://www.siemensvdo.com">www.siemensvdo.com</a></p>

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