Lane Departure Warning Systems

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Problem

- **Lane departure is a precursor to many crashes!**
- **Traffic Safety Facts 2004**
  - **38,253 Fatal Crashes**
  - **15,124 (40%) Single Vehicle Fatal Crashes, relation to roadway as Off Roadway, Shoulder, or Median**
- **Additional benefits from LDW may be realized from a possible reduction in head on collisions.**

Past NHTSA LDW Work

- Run-Off-Road Collision Avoidance Using IVHS Countermeasures – CMU / Assistware (1994)
- IVI Gen 0 Field Operational Test – Mack Truck
- Road Departure Collision Warning Systems FOT – UMTRI / Visteon / Assistware
- Numerous programs looking at various research issues with LDW
  - VRTC – Driver behavior, lane keeping performance
  - Johns Hopkins – Warning algorithm development
  - NIST – Objective test procedures
  - VOLPE – Crash data analysis, FOT evaluation

LDW - Definition

- **Lane Departure Warning (LDW) systems**
  - **Advanced technology that can help prevent crashes resulting from an unintentional drift of the vehicle out of its travel lane.**

LDW is NOT

- **Curve Speed Warning (CSW) – technology that warns that you are traveling too fast for an upcoming curve**
- **Road Departure Warning (RDW) – technology warns that you are about to depart the road; can consist of both LDW and CSW.**
- **Lane Keeping Support (LKS) – extension of LDW technology that actively keeps the vehicle within the lane by counter steering the vehicle**

ESC and LDW

- **ESC and LDW both can reduce the number of single vehicle road departure crashes.**
- **LDW helps drivers who do not steer where ESC helps drivers that are steering**

LDW  ESC

LDW Market History

- LDW and LKS available in Japan as OE in the early 2000s from multiple Japanese manufactures
- LDW available in North America and Europe by 2 OEMs in 2005 (1 OEM in NA and 1 in Europe)
- LKS available in Europe by 1 OEM in 2006

- LDW has been available in heavy trucks and as aftermarket equipment from 2 OE suppliers since early 2000's

Note: all above systems are optical based

Vehicle-Based LDW Technology

- **Optical**
  - **Uses a forward looking or downward looking optical sensor with image processing algorithms to determine where the lane edge lines are located.**
- **GPS**
  - **Uses high accuracy GPS position data combined with a high resolution map database.**

Vehicle-Based LDW Technology
Optical Technology

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- **Used in all of today's OEM systems**
- **Typically uses a forward looking CMOS or CCD video camera (one known system uses sensors looking down at the road)**
- **Lane lines or road features are extracted to calculate lateral vehicle position, lateral velocity, and lane width (all in respect to the lane lines)**
  - **Pros**
    - **Uses today's existing infrastructure**
    - **Easily adapts to road changes (new lines for construction, road design changes, etc)**
    - **Camera can be used for other assistance systems**
  - **Cons**
    - **Trouble operating with poor or no lane lines**
    - **Low sun angle, snow, fog, oncoming headlights, and other environmental factors can effect system availability**
      - **These may be conditions where users would rely more on an LDW system**

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Vehicle-Based LDW Technology
GPS

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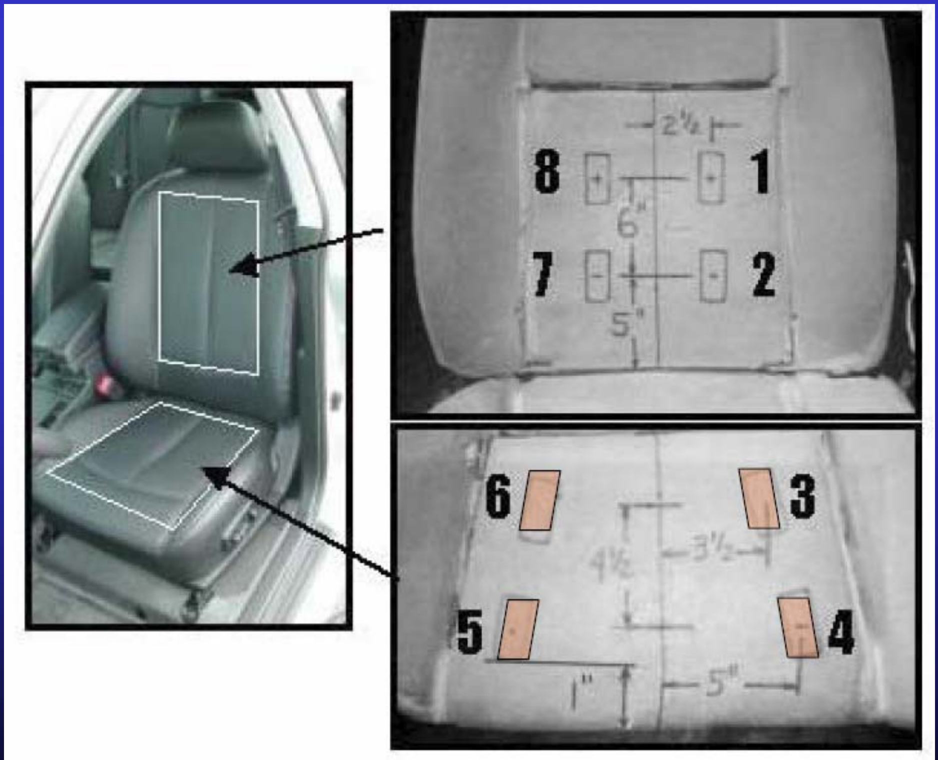
- **High accuracy GPS position data is compared to a detailed map data base to determine where the vehicle is within the lane**
- **Dynamic GPS accuracy is getting better (4-6 inches on the high end equipment).**
  - **Pros**
    - **Works in all weather conditions bright sun, rain, snow, fog, etc.**
    - **Many additional uses for sensor (CSW, Route Nav, ACN, etc.)**
  - **Cons**
    - **Requires very highly detailed map databases that must be continuously updated for high availability**
    - **Updates would require DSRC or similar infrastructure**
    - **GPS dropouts from bridges and other objects may affect availability**

LDW User Interface

- Very important for LDW
- Needs to be effective in modifying the drivers behavior yet benign enough not to ‘annoy’ the driver (nuisance alarms)
- Do not want to confuse the driver
- Sensing systems could be 100%, yet system effectiveness could 0% if the warning does not elicit the correct response from the driver

LDW User Interface

- **Auditory Alert**
  - **Rumble Strip sound**
  - **Buzzer, chime, etc.**
- **Visual Alert**
- **Haptic Alert**



NHTSA and LDW

- **RDCW FOT just completed**
  - **UMTRI / Visteon / Assistware**
  - **10 Vehicles with RDCW**
    - **Lateral Drift Warning (Optical)**
    - **Curve Speed Warning (GPS)**
    - **Sensors to determine road side objects**
  - **78 drivers (balanced age / gender)**
  - **4 weeks (1 baseline, 3 RDCW enabled)**

Preliminary FOT Findings

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- Drivers with LDW alerts displayed:
  - Reduced their lane position variation, including the frequency of travel near, or beyond, a lane edge.
  - Increased their use of turn signals in lane changes.
  - Responded favorably to LDW and its effects.
- Key challenge for LDW:
  - Managing the tradeoff between system availability and nuisance alert rate is the primary technical challenge for LDW.
- FOT Final Report will be available this summer.

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Current LDW Work

- **NHTSA is researching potential performance evaluation tests for Lane Departure Warning systems.**
  - **Currently holding discussions with OEMs and suppliers about LDW technology**
  - **Reviewing ISO and other performance tests that evaluate LDW**
  - **Develop maneuvers and test procedures for a performance test**
    - **OEM installed LDW**
    - **Aftermarket LDW**

LDW Sensor Tests

- **Under what conditions should the sensor work?**
  - **Roadway**
    - **Straight vs. Curved**
    - **Interstate vs. Rural Roadways**
  - **Environment**
    - **Day vs. Night**
      - **Low sun angle**
    - **Dry vs. Rain vs. Snow vs. Ice**
  - **Road Line Quality (optical systems)**
    - **How degraded can the road marking be before the system cannot track?**

LDW System Tests

- **What is the range of warning times sufficient to allow the driver to react correctly?**
  - **How accurate?**
  - **How repeatable?**
- **False Alarm Rate Tests**
  - **What is an acceptable rate?**
- **User Interface Tests**

Many Challenges

For Example

- **What is the "real world" availability for an LDW system?**
  - **1997: VRTC study, lane tracking 62%**
  - **2006: RDCW FOT, lane tracking 62% - 60%**
- **How do we test this?**
  - **Many conditions cause the system to be unavailable**
  - **Can be technology dependent**
    - **What makes an optical system unavailable vs. a GPS based system is different!**

Questions or comments?

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