Lane Departure Warning Systems

May 9, 2005

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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

- 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 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

- 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
High accuracy GPS position data is compared to a detailed map database 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

- 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.
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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