Safety Benefits of New Technologies

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Active/Automated Vehicle Technologies at UMTRI

Activities

• Crash problem definition
• Technology requirements
• Modeling & simulation
• Sensors capabilities and system-level performance
• Human factors & behavioral studies
• Occupant protection, human body models
• Methods, e.g., approaches to evaluation & testing
• Ridesharing, Car-sharing, Transit
• Traffic control / flow & interactions
• Safety benefits assessment
• Policy implications, life cycles
• Market studies

Technologies

• Traditional active safety (radar/camera/GPS) – warnings & control
• V2V applications
• V2I coordination of vehicles and traffic signaling
• ‘Convenience’ level-1 & level-2 systems (ACC, CACC, FSR ACC, Lane centering)
• Highly automated vehicles
• Passenger vehicles, commercial vehicles, motorcycles, transit, ...

Partners include:
Ford, GM, Toyota, Mercedes/Daimler, BMW, Nissan, Honda, USDOT, USDOE, AAA, Navistar, Delphi, Bosch, Denso.
UMTRI Vehicle Data Acquisition

Engineering…

- Vehicle dynamics & control (car, truck)
- Active safety & automated features
- Energy use during driving
- Early automation features

Venues

- Test tracks (e.g., Mcity, others)
- Public roads
- Naturalistic field tests

…Human Factors/Behavior

- Driving performance & behavior (with & without technology)
- Driver interfaces
- Usability & acceptance of technologies
- Driver vision
- Driver population differences (teens, aging, dementia, etc.)
- Personal travel information

Naturalistic data size & complexity

- DAS-multi CPU
- DAS
- GPS+OBD2
- GPS(+DSRC)
V2V/V2I: Safety Pilot Model Deployment

- 2836 vehicles equipped with DSRC wireless communication devices in a concentrated geographic area (Ann Arbor)
- Variety of vehicles, devices, functions, data collection
- Launched 2012, deployment is ongoing

- 19 Intersections
- 3 Curve-related sites
- 3 Freeway sites

- All DSRC communications logged
- Backhaul comm network
- Back-end data storage
- 180 Billion messages, 40M miles
- >3 million miles detailed data
UMTRI DAS
(one element of the data architecture)

- Highly reconfigurable
- Many off-the-shelf components
- Inputs are flexible, e.g.:
  - 2-4 CAN buses
  - Ethernet
  - Video (several)
  - Audio
  - Digital or analog
  - Serial
  - May host partners’ apps
  - Usable for control outputs

- Over-the-air data for monitoring, plus hardwire for remainder
- Turnkey or developer mode
- World class
Large-scale field test through telematics

- UMTRI and GM partnered to gather data from 1,958 consenting drivers over a year of unsupervised driving to study how drivers use crash warning systems, and how use and influences change over time. The OnStar telematics system was used.
  - A new approach to large-scale field data on driving
  - A statistically significant view into how new driver-interactive technologies actually play out – what works
  - A possible tool for large-scale feedback to designers and safety advocates, e.g., for safe and smooth deployment of automated vehicles

Crash avoidance systems

Forward crash alert (FCA)
Alerts intended to help drivers avoid or mitigate hitting vehicle rear ends. (beeps or seat vibration)

Headway alert: Visual icon only.

Lane departure warning (LDW)
Alerts intended to help drivers avoid or recover from unintended lane or road departures (beeps or seat vibration).

Chevrolet Equinox (crossover): Audible beep/icon
Cadillac SRX (crossover): Audible beep/icon or Seat vibration/icon
Cadillac XTS (sedan): Audible beep/icon or Seat vibration/icon

Drivers can turn either or both systems off. When on, FCA has three gap settings.
Scope of Experiment

- GM recruited owner/drivers by offering OnStar subscription.
  - Drivers were aware of the study and signed consent
  - From 48 of 50 US states
- The OnStar system collected and transmitted data from each of the drivers’ trips addressing travel statistics and LDW and FCA events.

- 1,958 drivers over a year
- 18.8 million miles
- 2.5 million ignition cycles
- 10.0 million LDW alerts (beep/seat vibr.)
- 1.8 million FCA headway alerts (icon only)
- 0.26 million FCA imminent alerts (beep/seat vibr.)

- 1 LDW every 2 or 3 miles (median rates)
- 1 FCA imminent alert every 75 to 200 miles
Drivers Sometimes Turn Off Systems

FCA Use (driver settings: off, on (far, med, near))
- Equinox (audible only): 17% of time is with FCA off.
- Cadillacs (when safety seat selected, which is 90% of the time): 6% of time is with FCA off.
- Higher use of FCA for older drivers. Some experimentation with gap setting – far was most popular in the end.

LDW Use (driver settings: on/off)
- Equinox (audible only): 71% of time is with LDW off.
- Cadillac (when safety seat selected): 38% LDW-off time.
- As a set, drivers’ LDW use dropped over 10,000 miles and stabilized. Drivers tend not to change settings often.
- More likely to turn off LDW if driver is high mileage driver.
### Scenarios in which FCA alerts occurred

<table>
<thead>
<tr>
<th>Measure</th>
<th>Vehicles always share lane</th>
<th>False Not in path</th>
<th>Lateral motion of a vehicle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent of alerts:</td>
<td>Slowing 19%</td>
<td>0.40%</td>
<td>31%</td>
</tr>
<tr>
<td>How often drivers don't respond:</td>
<td>Stopped 0.40%</td>
<td></td>
<td>2%</td>
</tr>
<tr>
<td>Does experience reduce the rate?</td>
<td>Other 31%</td>
<td></td>
<td>11%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Target change 16%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Unknown 20%</td>
</tr>
</tbody>
</table>

Analysis using prior data from UMTRI studies using vehicles equipped with cameras and radars allows us to identify these scenarios from the very sparse OnStar data.

“From empirical data to models”
Key Takeaway:

- Alert rates for LDW increase with experience (similarly if system if on or off)
- Alert rates for FCA decrease with experience
- Decrease in FCA alert rates is smaller for drivers who use the Off setting
- Oncoming-vehicle alerts do not decrease appreciably *

Drivers brake faster with FCA than without. 0.1 sec difference, over all events.
Ongoing

Similar study with front automatic braking to avoid/mitigate striking the rear end of another vehicle
– In final report review – NHTSA, UMTRI, GM
### Levels of Automation (SAE)

<table>
<thead>
<tr>
<th>SAE level</th>
<th>Name</th>
<th>Narrative Definition</th>
<th>Execution of Steering and Acceleration/Deceleration</th>
<th>Monitoring of Driving Environment</th>
<th>Fallback Performance of Dynamic Driving Task</th>
<th>System Capability (Driving Modes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No Automation</td>
<td>the full-time performance by the human driver of all aspects of the dynamic driving task, even when enhanced by warning or intervention systems</td>
<td>Human driver</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1</td>
<td>Driver Assistance</td>
<td>the driving mode-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the human driver perform all remaining aspects of the dynamic driving task</td>
<td>Human driver and system</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>2</td>
<td>Partial Automation</td>
<td>the driving mode-specific execution by one or more driver assistance systems of both steering and acceleration/deceleration using information about the driving environment and with the expectation that the human driver perform all remaining aspects of the dynamic driving task</td>
<td>System</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>3</td>
<td>Conditional Automation</td>
<td>the driving mode-specific performance by an automated driving system of all aspects of the dynamic driving task with the expectation that the human driver will respond appropriately to a request to intervene</td>
<td>System</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>4</td>
<td>High Automation</td>
<td>the driving mode-specific performance by an automated driving system of all aspects of the dynamic driving task, even if a human driver does not respond appropriately to a request to intervene</td>
<td>System</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>5</td>
<td>Full Automation</td>
<td>the full-time performance by an automated driving system of all aspects of the dynamic driving task under all roadway and environmental conditions that can be managed by a human driver</td>
<td>System</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

Human driver monitors the driving environment

Automated driving system ("system") monitors the driving environment

None

Certain driving situations

All driving situations
Translating to Automated Driving Systems (ADS)

**ADS:**
- **ODD:** Operational design domain (where ADS is designed to work)
- **Functionality:** What parts of the driving task will the ADS handle?
- **Human operator interaction:** What role, if any, is the human playing?

**Regulatory aspects in the US**
- **Voluntary safety self assessments:** NHTSA encourages those fielding ADSs to publish descriptions of how they are ensuring safety.
- **Exemptions:** To accelerate ADS, federal legislation is being considered to greatly increase the number of vehicles that can be fielded without meeting FMVSS, but with securing NHTSA “exemptions” with a safety argument.
Need Data: What is the ADS Crash Population?

- ADS description
- Rate of crashes
- Crash types (e.g., rear end)
- Crash details (environment, circumstances inside / outside vehicle, state of ADS (e.g., ‘active’))
- Causes / involvements
## Capturing ADS Crashes – and Operations

**Extended EDRs** (Event data recorder)

- Today’s EDRs: Direction of force, vehicle velocity change, occupant protection status & events, crash pulse, 5 to 10 pre-crash speed, brake, accel pedal, throttle, …
- SAE committee has begun work to extend for ADS:
  - Support crash reconstruction…. plus??....
  - Crash partner motion, ADS states, …
- The “**numerators**”

**UMTRI proposing:** Extended **Operational Data Recorder**

- ADS states (driver usage, interventions, warnings, …)
- Events of interest
- Speeds, maneuver counts, time with various target types
- Operating environment & conditions: time/distance as function of ODD descriptors (road types, speed limits, rain, etc.)
- The “**denominators**”
THANK YOU

Presenter:
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Conference organizer:
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OBD-II port dongle with passive listening to OEM data buses

- AAA Foundation: 3000 vehicles of older drivers (longitudinal study of safety, travel, health) (PI: D. Eby UMTRI)

*Figure 1: The Danlaw Datalogger*

*Figure 2: Typical locations of the OBD port in most light vehicles*