Overview and Evaluation of the Automotive Collision Avoidance System Field Operational Test (ACAS FOT)

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Outline

• **Program Overview:**
  – Program Phases
  – System Description
  – FOT Description

• **Evaluation Overview:**
  – Analysis Framework
  – Safety Benefits Estimation
  – Rare Events
  – Unintended Consequences
Rear-End Crash Problem

- 2003 General Estimates System data
- Light vehicle crash statistics
- Total 6,071,000 police-reported crashes
Automotive Collision Avoidance System Field Operational Test (ACAS FOT) Program

- **Sponsor:** U.S. DOT/NHTSA
- **Private Consortium:**
  - System Development and Build: GM/Delphi
  - Conduct of Field Operational Test: UMTRI
- **Independent Evaluator:** U.S. DOT/RITA/Volpe Center
System Description

• **Forward Crash Warning (FCW):**
  – Provide drivers with visual and audible alerts to help them avoid or reduce the severity of rear-end crashes.
  – Enabled when vehicle speed exceeds 25 mph.

• **Adaptive Cruise Control (ACC):**
  – Maintain *selected cruise speed* if no lead vehicle is impeding the forward motion of the host vehicle.
  – Maintain *selected headway* (1 – 2 seconds) if lead vehicle is traveling below selected cruise speed.
  – Driver use of ACC is optional
  – ACC uses throttle & brake control up to 0.3g
Driver-Vehicle Interface – Head Up Display

- **65 MPH**
- **Set: 65 MPH**
- **ACC ON**
- **FCW ON**
- **Flash at 4 Hz**
- **Imminent**
Steering Wheel Controls

- GAP/WARN
- AM/FM SCAN
- SEEK
- VOL
- ON/OFF
- Resume/Accel
- Set/Decel
- ACC
### FOT Experimental Design

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>Total Subjects</th>
<th>Age Groups</th>
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<tbody>
<tr>
<td></td>
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<td>20 - 30</td>
</tr>
<tr>
<td>A</td>
<td>15</td>
<td>5</td>
</tr>
<tr>
<td>B</td>
<td>15</td>
<td>5</td>
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<tr>
<td>C</td>
<td>66</td>
<td>22</td>
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</tbody>
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- 10 ACAS-equipped 2002 Buick LeSabres used
- Participants used vehicle as personal car unsupervised and unrestricted
- 4-week test period per subject:
  - 1 week baseline
  - 3 weeks with ACAS enabled
FOT Exposure

ACAS Disabled
Total Distance Traveled
36,000 Km

ACAS Enabled
Total Distance Traveled
122,000 Km
Independent Evaluation

Goals:

- **Estimate Safety Benefits**
- **Determine Driver Acceptance**
- **Characterize System Capability**
Safety Impact

1. **Driving Conflict Analysis** – Global level examination of all FOT driving conflicts to develop quantitative estimates of overall safety benefits of ACAS.

2. **Near Crash Analysis** – Detailed Examination of the most severe near crashes to assess the usefulness of ACAS in preventing crashes.

3. **Driver Impact Analysis** – Examination of driver performance data to identify positive or unintended negative effects of ACAS on driving performance and behavior.
Driving Conflict Analysis

Exposure to Driving Conflicts
- Familiarity with New Vehicle
- Experimentation with ACAS
- ACAS Impact on Exposure to Conflicts
- ACAS Effectiveness in Reducing Exposure to Conflicts

Response to Driving Conflicts
- Exposure to Rear-End Dynamic Scenarios
- Response to Dynamic Scenarios
- Safety Benefits Estimation
- Monte Carlo Simulation

ACAS Impact on Exposure to Conflicts by Dynamic Scenario
- Overall
- Lighting
- Road Type
- Weather
- Traffic
- Travel Speed

ACAS Effectiveness in Reducing Exposure to Conflicts by Dynamic Scenario
- LVS
- LVM
- LVD
- Brake
- Steer
- Brake & Steer

Safety Benefits Estimation Method Application

Response Initiation
Response Intensity

-LVS
-LVM
-LVD

- V < 25 mph
- 25 ≤ V < 35 mph
- V ≥ 35 mph
Driving Conflict Type and Intensity

Driving Conflict Type

• Conflicts: CAMP data from last-second response studies at comfortable braking or steering level.
• Near crashes: CAMP data from last-second response studies at hard braking or steering level.

Driving Conflict Intensity

• Low-intensity: Quantified by TTC versus Range rate diagrams derived from CAMP’s 50%-ile data.
• High-intensity: Quantified by TTC versus Range rate diagrams derived from CAMP’s 95%-ile data.
Conflict Type and Intensity Classification

Lead Vehicle Stopped – Braking Response
Safety Benefits Estimation

Simplest Form

\[ B = [P_{wo}(C) - P_w(C)] \times \text{Miles Driven} \]

Useful form

\[ B = N_{wo} \times \sum_i P_{wo}(S_i | C) \times [1 - \frac{P_w(C | S_i)}{P_{wo}(C | S_i)} \times \frac{P_w(S_i)}{P_{wo}(S_i)}] \]

- From GES: Population Statistics
- “Prevention Ratio”
- “Exposure Ratio”
- FOT Data and Analytical Models
- FOT Data
Exposure Ratio Analysis

Analysis:

• Comparison between ACAS disabled (1st week) and 2nd half distance traveled with ACAS enabled.

Dynamic Scenarios:

• Lead vehicle stopped
• Lead vehicle moving at slower constant speed
• Lead vehicle decelerating

Measures of Performance:

• MOP1= No. of conflicts per 100 Km traveled
• MOP2= No. of near crashes per 100 Km traveled
Prevention Ratio Analysis

Driver Response Analysis:

• Initiation Measures:
  – Time-to-collision
  – Time headway

• Intensity Measures:
  – Minimum time-to-collision
  – Peak acceleration
  – Average acceleration

Prevention Ratio Estimation:

Monte Carlo simulations based on data from bins with statistically significant difference in response initiation
Rare Events

• Analysis of *severe* near crashes based on response intensity using aggregate numerical data:
  – TTCmin ≤ 3 seconds and
  – Peak acceleration > 0.3g

• Analysis of video episodes triggered by crash imminent alerts that might have prevented a rear-end crash:
  – Driver distraction
  – High peak deceleration
Unintended Consequences

• Analysis of low risk (host vehicle @ constant speed) driving performance using numerical data:
  – Time headway
  – Position within travel lane
  – Speed ratio (vehicle speed/speed limit)
• Analysis of inattention (distraction or eyes-off-the-road) using alert-triggered video episodes.
• Anecdotal remarks based on few observations.
Observations
Questions?

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