Human Factors Evaluation
Considerations for
Safety Enhancing Systems

Robert C. Lange
GM Structure & Safety Integration Center

January 25, 2007
Illustration of a Broad Range of Advanced Driver Assistance Systems with HMI Implications

- Adaptive Cruise Control
- Collision Preparation
- Forward Collision Alert
- Auto Emergency Braking
- Auto Lanekeeping
- Lane Departure Warning
- Side Blind Zone Alert
- Lane Change Warning
- Rear Video Backup Warning
- Auto Emergency Braking
**Human Factors**

**Evaluation Considerations**

- **Establish a safety benefit**
  - Direct
  - Indirect
  - Implied

- **Evaluate & address potential unintended consequences, for example:**
  - Does a driver with an ACC system engage in more in-cab distraction activities?
  - Does a driver with a Side Blind Zone Alert system stop using turn signals?
  - Does a driver with a Rear Video system stop looking behind when backing?

- **Develop appropriate customer education materials**
  - Inform driver in an effective manner of how to operate system, proper and improper usage, system limitations, and use cautionary information to mitigate any potential unintended consequences
  - Owner's manuals, quick reference guides, etc.
Establishing a Safety Benefit

- **Direct data**
  - Safety benefits directly suggested based on crash database analyses (e.g., Electronic Stability Control, Daytime Running Lamps)

- **Indirect data**
  - Safety benefits indirectly suggested based on data gathered under well-controlled, realistic conditions where the experimentation is specifically designed to place drivers in “target” crash scenario(s) (e.g., “Distract and Surprise” Methodology)

- **Implied data**
  - Safety benefits implied based on “improved driving behavior” observed under less-controlled, realistic conditions where the experimentation is not specifically designed to place drivers in “target” crash scenario(s) (e.g., A decrease in tailgating behavior with a ACC system observed during an in-traffic study)
Primary Research Methods & Challenges

• Safely create well-controlled, experimental crash scenarios to assess crash avoidance system effectiveness under realistic conditions
  ➔ Challenge: Creating safe, “realistic as possible” crash threats so that lay driver behavior can be observed

• Understand effects of a system under less controlled, in-traffic, real-world driving
  - With versus without experimenter presence
  - “near crash” or “actual crash” events are rare
  - False alarm experiences vary substantially across drivers, which impacts both system effectiveness and driver acceptance
  ➔ Challenge: Making sense of large “uncontrolled” datasets, where “near crash” or “actual crash” events are still rare
Experimental Crash Scenario Studies

~ CAMP-US DOT Forward Collision Warning Projects ~

Last-Second Braking to a Surrogate Lead Vehicle

When do drivers start braking when they are instructed to wait until the last second to brake? How hard do they brake?

What levels of last-second braking are observed?
Experimental Crash Scenario Studies

~ CAMP-US DOT Forward Collision Warning Projects ~

“Distract and Surprise” Method

Video Still of Surprised Driver

Passenger-side test driver with access to add-on brakes & steering wheel, and “bail out” alert

How does a driver respond to a lead vehicle braking unexpectedly when the experimenter distracts them, with and without FCA support?
Experimental Crash Scenario Studies

~ CAMP-US DOT Forward Collision Warning Projects ~

“First Look” Method

How will a driver respond under “extreme distraction” conditions?
Will they brake or steer? How aggressive is their maneuver?
Experimental Crash Scenario Studies

~ CAMP-US DOT Forward Collision Warning Projects ~

“First Look” Method

YOU ARE ABOUT TO CRASH
How will a driver respond under “extreme distraction” conditions?
Will they brake or steer? How aggressive is their maneuver?
Would a driver detect or strike an object behind them when backing?

Experimental Crash Scenario Studies

~ GM–Virginia Tech Transportation Institute ~

Surprise Trial
Video Clip

“Distract and Surprise” Method

REAR VIDEO MONITOR
Will the driver of a Side Blind Zone Alert System check their mirrors more before change lanes? Will turnaround behavior change? How about turn signal usage?
What were the effects of ACC & FCA on driver behavior and what are the potential safety implications of these effects?

Were systems well-accepted?
In-Traffic, Real-World Driving Studies

~ ACAS FOT ~

FCW System Alert Video Clip

An example of a useful FCA alert
### In-Traffic, Real-World Driving Studies

#### ~ ACAS FOT ~

<table>
<thead>
<tr>
<th>Safety</th>
<th>Acceptance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Forward Collision Alert</strong></td>
<td><strong>Acceptance</strong></td>
</tr>
<tr>
<td>- Some reduction in tailgating behavior</td>
<td>- Purchase interest lower than desired to due to frequency and nature of false alarms</td>
</tr>
<tr>
<td>- &quot;Valuable&quot; alerts identified</td>
<td></td>
</tr>
<tr>
<td>- No broad &quot;closing conflict&quot; effect</td>
<td></td>
</tr>
<tr>
<td>- Imminent alert rates varied widely from 0.08 to 4.34 per 100 miles across drivers</td>
<td></td>
</tr>
<tr>
<td>- No unintended safety consequences</td>
<td></td>
</tr>
<tr>
<td><strong>Adaptive Cruise Control</strong></td>
<td></td>
</tr>
<tr>
<td>- Substantial reduction in tailgating behavior</td>
<td>- Purchase interest high</td>
</tr>
<tr>
<td>- Increased lane dwelling</td>
<td></td>
</tr>
<tr>
<td>- Perceived by drivers as having more safety value than FCA</td>
<td></td>
</tr>
<tr>
<td>- No unintended safety consequences</td>
<td></td>
</tr>
</tbody>
</table>

No rear-end crashes were observed in entire FOT; and none were predicted.
Review of Human Factors Evaluation
Considerations for Safety Enhancing Systems

• Establish a safety benefit
  - Direct
  - Indirect
  - Implied
• Evaluate & address potential unintended consequences
• Develop appropriate customer education materials
• Gather data to address the above under:
  - Well-controlled experimental crash threat conditions
  - Less controlled “in traffic” real-world driving conditions
**Closing Thoughts**

- Research needs in this emerging area should focus on developing common evaluation methodologies and techniques.
- It is the OEM’s role to integrate safety enhancing systems (including the HMI approach).
- Premature standards for these emerging systems could hinder system deployment:
  - Discourages “healthy” OEM competition to develop effective and well-accepted safety enhancing systems.
  - Even within an OEM, vehicle models will vary in the number of these systems on a given vehicle, as well as system combinations.
  - Driver demographics considerations also play an important role.