Enhancing Safety Through Automation

SAE Gov’t-Industry Meeting, Automation and Connected Vehicle Safety, January 31, 2013

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The Problem!!!

Safety
• 32,788 highway deaths in 2010
• 6,000,000 crashes/year
• Leading cause of death for ages 4 - 34

Mobility
• 4,200,000,000 hours of travel delay
• $80,000,000,000 cost of urban congestion

Environment
• 2,900,000,000 gallons of wasted fuel
Fatalities in Motor Vehicle Traffic Crashes 2009

Human Error is Critical Reason for 93% of Crashes
### Crash Avoidance

<table>
<thead>
<tr>
<th>Normal Driving</th>
<th>Crash Imminent</th>
<th>Crash Event</th>
<th>Post-Crash</th>
</tr>
</thead>
</table>
| **Passenger Cars/Trucks** | • Driver Distraction  
 • Driver Support Systems  
 • Blind Spot Detection  
 • Alcohol Detection  
 • Drowsy Driver Detection  
 • V2V & V2I  
 • Human Factors/HMI  
 • Electronics Reliability and Cybersecurity  
 • Automation | • Forward Crash Warning  
 • Lane Departure Warning  
 • Lane Keeping  
 • Lane Change/Blind Spot  
 • Automatic Braking  
 • Connected Vehicles [Vehicle-to-Vehicle (V2V) Communication] | • Dynamic Rollover  
 • Oblique/Off-set Frontal  
 • Adaptive Restraints  
 • Child Side Impact  
 • Elderly Occupants  
 • ... | • Auto Crash Notification  
 • Advanced ACN  
 • Medical Outcome (CIREN)  
 • First Responder Safety |
| **Heavy Vehicles - Truck/Bus** | • Driver Distraction  
 • Drowsy Driver Detection  
 • Enhanced Vision Systems  
 • Blind Spot Detection  
 • V2V & V2I  
 • Human Factors/HMI  
 • Automation | • ESC/RSC  
 • Forward Collision Warning  
 • Lane Change Warning  
 • Automatic Braking  
 • Lane Keeping  
 • V2V | • Underride |
| **Motorcycles** | • Conspicuity  
 • Automation | • ABS/CBS  
 • V2V | • Helmet Use  
 • Airbags | • ACN |
| **Pedestrians** | • Quiet Car Detection  
 • Lighting Systems for Peds  
 • Automation | • Pedestrian Warning  
 • Automatic Braking  
 • V2P | • GTR – Hoods / Bumpers | • ACN |
## Crash Avoidance

### Normal Driving
- Driver Distraction
- Driver Support Systems
- Blind Spot Detection
- Alcohol Detection
- Drowsy Driver Detection
- V2V & V2I
- Human Factors/HMI
- Electronics Reliability and Cybersecurity
  - **Automation**

### Crash Imminent
- **Forward Crash Warning**
- **Lane Departure Warning**
- **Automatic Braking**
- **Blind Spot Detection**
- V2V & V2I

### Crash Event
- Dynamic Rollover
- Oblique/Off-set Frontal
- Adaptive Restraints
- Child Side Impact
- Elderly Occupants
- 

### Post-Crash
- Auto Crash Notification
- Advanced ACN
- Medical Outcome (CIREN)
- First Responder Safety

## Crashworthiness

### Heavy Vehicles - Truck/Bus
- Driver Distraction
- Drowsy Driver Detection
- Enhanced Vision Systems
- Blind Spot Detection
- V2V & V2I
- Human Factors/HMI
- **Automation**

### ESC/RSC
- **Forward Collision Warning**
- Lane Change Warning
- Automatic Braking
- V2V & V2I

### Underride

### Motorcycles
- Conspicuity
  - **Automation**

### ADB/CBS
- V2V

### Helmet Use
- Airbags

### Pedestrians
- Quiet Car Detection
- Lighting Systems for Peds
  - **Automation**

### Pedestrian Warning
- Automatic Braking
- V2P

### GTR – Hoods / Bumpers

### ACN
Focus on Safety

- Automation should be focused first on safety
- Not enough to be “as safe” as human drivers
- Automated car goal: “crash-less”
Definitions are Important

- **Autonomous**
  - “not subject to control from outside; independent” *
  - “undertaken or carried on without outside control” #

- **Automated**
  - “automatically controlled operation of an apparatus, process or system by mechanical or electronic devices that take the place of human labor” #

- **Cooperative**
  - “acting together for a common purpose or benefit” *

Sources: * http://dictionary.reference.com
# http://www.merriam-webster.com/dictionary
# Levels of Automation (NHTSA Draft)

<table>
<thead>
<tr>
<th>Level</th>
<th>Monitoring Roadway</th>
<th>Active Control</th>
<th>Responsibility for Safe Operation</th>
<th>Driver/Occupant Availability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 0 - Non-Automated</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>Y</td>
</tr>
<tr>
<td>Level 1 – Single Function Automation</td>
<td>D</td>
<td>D and R</td>
<td>D</td>
<td>Y</td>
</tr>
<tr>
<td>Level 2 – Combined Function Automation</td>
<td>D</td>
<td>R</td>
<td>D</td>
<td>Y</td>
</tr>
<tr>
<td>Level 3 – Limited Self-Driving Automation</td>
<td>R</td>
<td>R</td>
<td>R?</td>
<td>Y</td>
</tr>
<tr>
<td>Level 4 - Full Self Driving Automation</td>
<td>R</td>
<td>R</td>
<td>R?</td>
<td>N</td>
</tr>
</tbody>
</table>

D= Driver  
R= Robot
Automation Challenges Include:

- Human Factors (Driver Engagement/Re-engagement)
- Sensor Performance
- Artificial Intelligence Decision-Making Capability
- Electronic Control Systems Safety
- Cybersecurity
- Testing and Evaluation Methodology
- Regulatory Approaches:
  - Performance requirements/objective testing for various levels of automation.
  - Standardization - Are different concepts for achieving automation compatible on the roadway?
- Operating environment - operating in mixed traffic and on public roads?
- Infrastructure modifications
- Liability
Goal: to improve motor vehicle safety by investigating the requirements for automated driving that is:

- Operational only to the extent granted by the driver
  - Including override capability
- Electronically Reliable and Secure
  - Functionally safe w/appropriate data storage/diagnostics/prognostics
  - Secure from malicious external control and tampering
- Operationally intuitive for drivers
  - under diverse driving conditions
  - within limits understood by the driver
- **Focused on reducing crashes!**
Objectives

1. **Support policy decisions on emerging system concepts (Level 2 and Level 3 systems)**
   - Near production concepts are already here

2. **Facilitate development/deployment of safety enhancing automated systems**
   - Defining concepts of automated operation including the integration of safety systems [safety enhancing concepts]
   - Developing technical requirements and associated performance tests
   - Assess safety benefits & system performance
Motor Vehicle Automation Research Roadmap

**Support Policy Decisions**
- Complete human factors studies to evaluate emerging concepts

**Program Planning/Knowledge Base**
- Evaluate critical issues. Synthesize findings to define critical research gaps

**Develop System Performance Requirements**
- Performance requirements for automation levels and associated system concepts

**Address Electronic Control Systems Safety**
- Reliability and cybersecurity requirements

**Improve Driver Awareness & Response**
- Driver-Vehicle Interface (DVI) criteria and guidelines
  - Driver Training & Licensing req’ts

**Evaluate System Operability**
- Develop obj. tests
- Define safety and perf. metrics
- Complete Evaluation studies
- Estimate Benefits

**Outcomes**
Project 1: Human Factors Study

Purpose: Study the human factors needs for automated driving Levels 2 and 3.

Research questions

- Can drivers safely interact with and operate vehicles that offer Level 2 and 3 systems
- What are the risks from driver involvement with and interruptions from secondary tasks when operating L2/L3 systems.
- What are effective handoff strategies between system & driver including failure mode response
Key research questions (con’d)

- How do drivers engage, disengage reengage with the driving task in response to the various states of L2 & L3 automation?
- How do drivers perform under various operational concepts (mixed traffic, dedicated lanes, etc.) within L2 and L3 automation?
- What are the most effective human-machine interface concepts which optimize safe operation of L2 and L3 systems?

Phase 1 – project planning; Phase 2 – project execution
Project 2 - Feasibility Study of Automated Driving

- Multi-modal (NHTSA, FHWA, FMCSA, FTA, RITA)
- Lead: Volpe Transportation Systems Center
- Look at a broad array of key issues that could impact feasibility of automated driving/automated highway concepts
- Output: Evaluation of key issues resulting in a multi-modal roadmap for future research needs
Automation Challenges Can be Met

- The goal is a worthy one
- Potential for improving vehicle safety
  - And other transportation goals
- NHTSA/USDOT initiating research
- Will require collaboration
  - product developers,
  - insurers,
  - academia,
  - state and federal governments,
  - and many others.....
THANK YOU!

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