Human Factors Challenges for Driving Automation Systems

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# SAE J3016 Definitions – Levels of Automation

<table>
<thead>
<tr>
<th>SAE Level</th>
<th>Name</th>
<th>Narrative Definition</th>
<th>Execution of Steering/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>Human driver</td>
<td>Human driver</td>
<td>n/a</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>Human driver</td>
<td>Human driver</td>
<td>Some driving modes</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>Human driver</td>
<td>Human driver</td>
<td>Some driving modes</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>System</td>
<td>Human driver</td>
<td>Some driving modes</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>System</td>
<td>System</td>
<td>Some driving modes</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>System</td>
<td>System</td>
<td>All driving modes</td>
</tr>
</tbody>
</table>
# Example Systems at Each Automation Level

<table>
<thead>
<tr>
<th>Level</th>
<th>Example Systems</th>
<th>Driver Roles</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Adaptive Cruise Control OR Lane Keeping Assistance</td>
<td>Must drive other function and monitor driving environment</td>
</tr>
<tr>
<td>2</td>
<td>Adaptive Cruise Control AND Lane Keeping Assistance Traffic Jam Assist (Mercedes, Volvo, Infiniti)</td>
<td>Must monitor driving environment (system nags driver to try to ensure it)</td>
</tr>
<tr>
<td>3</td>
<td>Traffic Jam Pilot Automated parking with supervision</td>
<td>May read a book, text, or web surf, but be prepared to intervene when needed</td>
</tr>
<tr>
<td>4</td>
<td>Highway driving pilot Closed campus driverless shuttle Driverless valet parking in garage</td>
<td>May sleep, and system can revert to minimum risk condition if needed</td>
</tr>
<tr>
<td>5</td>
<td>Automated taxi (even for children) Car-share repositioning system</td>
<td>No driver needed</td>
</tr>
</tbody>
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Level 1 Driver Assistance

- Full attention needed to execute “other” driving task → no loss of driver vigilance
- Warning systems (using same sensors as automation systems) augment driver vigilance
- Reduced effort on steering in tight curves frees up driver attention to monitor external hazards:
Level 2 Partial Automation

- Drivers could be misled to assume higher capability than system has
- Drivers will lose vigilance when system does steering and speed/spacing control
- Drivers will be tempted to abuse the system so they can do other things:
Level 3 Conditional Automation

• Serious doubts about feasibility of capturing driver’s attention to provide fallback within a few seconds, considering:
  – Inattention
  – Distraction
  – Sleep

• Can these driver states be avoided?
• Fallback will be needed under the most challenging emergency driving conditions
→ Doubts about feasibility (safety) of Level 3
Broader Human Factors Issues for Automation

• User acceptance based on perceived safety (especially after crashes are reported)
• Interactions with vulnerable road users (bikes and pedestrians), who depend on eye contact with drivers today
• Interactions with other drivers, especially for overly-timid AV driving styles
• Societal risk tolerance determining “how safe is safe enough?” to be different by country
Regulatory Needs

• California legislation specified that new rules apply to “technology that has the capability to drive a vehicle without the active physical control or monitoring by a human operator”

• What rules are needed to:
  – Ensure users are informed/educated about capabilities and limitations of systems
  – Require some minimum system safety level
  – Reassure other road users that their safety has not been compromised by AVs
  – Deter abuses of systems by drivers
Public Policy Choices

• How to balance protecting public safety with encouraging new technological innovations?
  – Immature technology will not be safe at first
• How to gain societal consensus on acceptable safety level for automated driving systems?
• How to balance “new economy” jobs creating more advanced automation systems with driving jobs that could be lost eventually?
• How to assess mixed impacts on energy use and traffic, based on increased levels of travel but more efficient unit travel?