Human Factors Challenges for Driving Automation Systems

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SIP – adus Workshop

Tokyo, October 28, 2015

SAE J3016 Definitions – Levels of Automation

SAE Level	Name	Narrative Definition	Execution of Steering/ Acceleration/ Deceleration	*Monitoring* of Driving Environment	Fallback Performance of *Dynamic Driving Task*	System Capability (*Driving Modes*)
Human driver monitors the driving environment						
0	No Automation	the full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a
1	Driver Assistance	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*	Human driver and system	Human driver	Human driver	Some driving modes
2	Partial Automation	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*	**System**	Human driver	Human driver	Some driving modes
Automated driving system ("system") monitors the driving environment						
3	Conditional Automation	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*	System	**System**	Human driver	Some driving modes
4	High Automation	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*	System	System	**System**	Some driving modes
5	Full Automation	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*	System	System	System	**All driving modes**

Example Systems at Each Automation Level

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

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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:**

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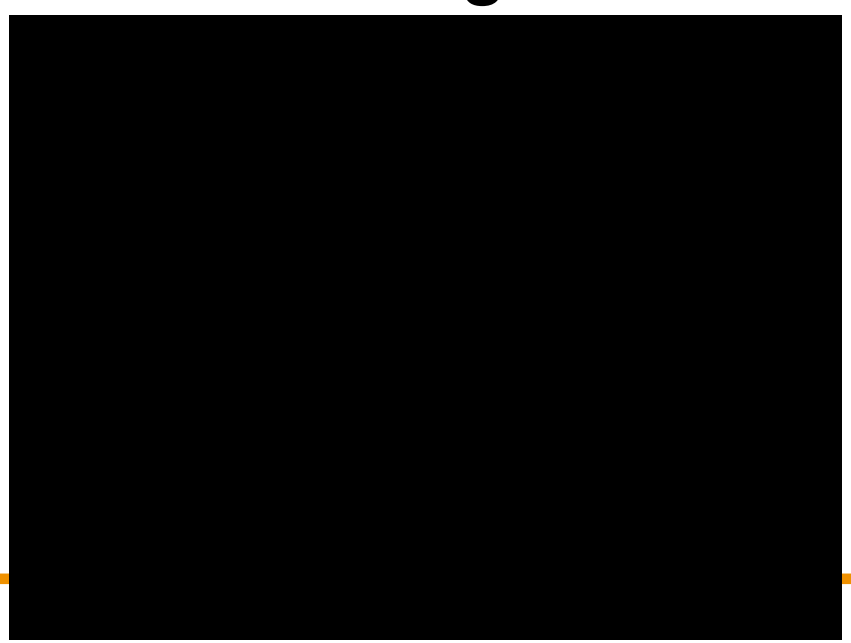
Level 2 Partial Automation

- **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:**



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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**

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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**

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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**

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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?**

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