



Highly Automated Commercial Vehicles (HACVs)

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Amina Fisher and Luke Loy,
Office of Vehicle and Roadside Operations

Brian Routhier, Office of Technology

FMCSA



SAE LEVELS OF AUTOMATION



Level 0: No Automation

Who or what is driving?		Fallback	Are there limitations on the Operational Design Domain (ODD)?
Sustained control	Detection and response		
		None	N/A

- No automation
- Driver remains in complete control




Level 1: Assistive Automation

Who or what is driving?		Fallback	Are there limitations on the Operational Design Domain (ODD)?
Sustained control	Detection and response		
			Limited
<p>The automated system can <i>sometimes assist</i> the human driver conduct <i>some parts</i> of the driving task.</p>			

- HACV controls **EITHER** speed **OR** lane keeping but not both
- Driver must monitor HACV at all times






Level 2: Partial Automation

Who or what is driving?		Fallback	Are there limitations on the Operational Design Domain (ODD)?
Sustained control	Detection and response		
			Limited
The automated system can <i>actually conduct</i> some parts of the driving task, while the human continues to monitor the driving environment and performs the rest of the driving task.			

- HACV controls BOTH speed AND lane keeping
- Driver must monitor HACV at all times







Level 3: Conditional Automation

Who or what is driving?		Fallback	Are there limitations on the Operational Design Domain (ODD)?
Sustained control	Detection and response		
			Limited
<p>The automated system can both actually conduct some parts of the driving task and monitor the driving environment <i>in some instances</i>, but the human driver must be ready to take back control when the automated system requests.</p>			




- HACV in full control in some situations
- HACV alerts when driver must regain manual control

Level 4: Highly Automated

Who or what is driving?		Fallback	Are there limitations on the Operational Design Domain (ODD)?
Sustained control	Detection and response		
		 OR 	Limited
<p>The automated system can conduct the driving task and monitor the driving environment, and the human need not take back control, but the automated system can only operate in certain environments and under certain Operational Design Domains (ODDs).</p>			

- HACV in full control in some situations
- HACV will NEVER request the driver to regain manual control

Level 5: Fully Automated

Who or what is driving?		Fallback	Are there limitations on the Operational Design Domain (ODD)?
Sustained control	Detection and response		
			Unlimited
The automated system can perform all driving tasks, under all conditions that the human driver could perform them.			

- HACV in full control in all situations
- HACV will NEVER request the driver to regain manual control



SAE Levels 4 and 5

HIGHLY AUTOMATED COMMERCIAL VEHICLES (HACVs)



Methods for Automation

METHOD ONE

- Vehicle-to-Vehicle (V2V)
 - Outfitted vehicles communicate with one another and provide alerts to their drivers
- Vehicle-to-Infrastructure (V2I)
 - Outfitted vehicles communicate with compatible infrastructure and provide alerts to their drivers
- Higher Level 2 Technologies
 - Adaptive Cruise Control (ACC)
 - Lane Keeping Assist (LKA)
 - Crash Imminent Braking (CIB)
 - Automatic Emergency Braking (AEB)

METHOD TWO

- Mapping, Lidar, advanced cameras, and AI technologies

Industry Demonstrations of HACVs

- Freightliner
 - Testing in Nevada
- Uber ATG (Otto)
 - Over-the-road demonstrations
 - Promotional video
- Mobile Eye / Delphi
 - AV package for OEMs
- Google
 - Patent for self-delivery truck
- Starsky Robotics
 - Testing in Nevada
 - Promotional video
- Embark
 - Testing in Nevada
 - Promotional video



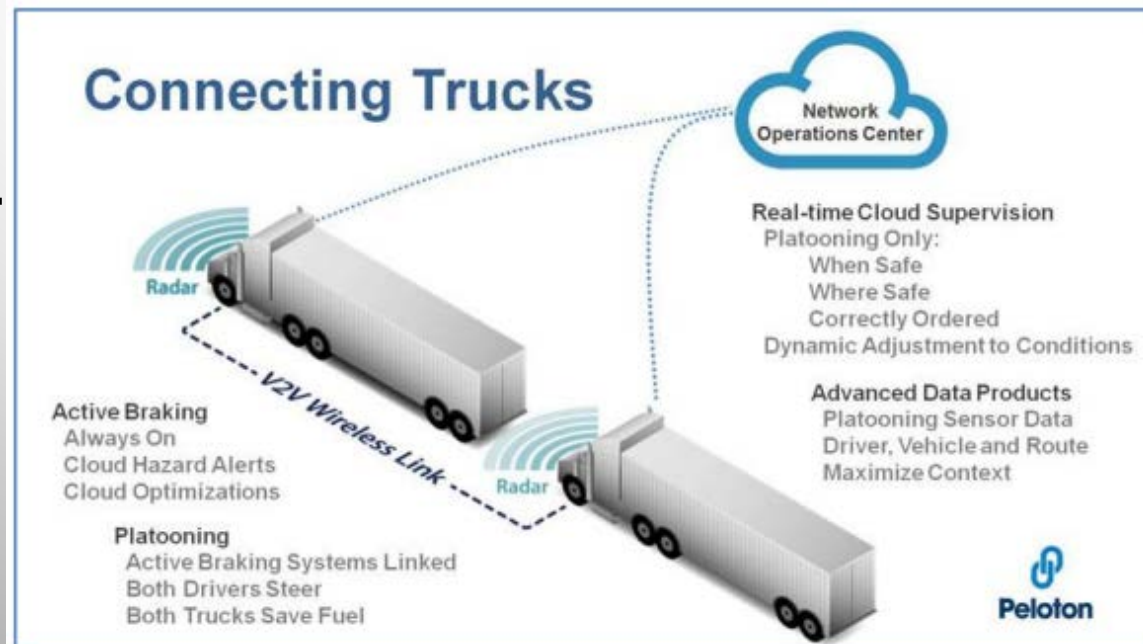


SAE Level 2 | Connected Vehicles (CVs)

TRUCK PLATOONING

Components of Platooning

- Vehicle-to-Vehicle (V2V) connection
- Vehicles are driver-operated
- Following drivers are under longitudinal control
- Hazard alerts
- Active braking



Industry Demonstrations of Connected Vehicle Platooning

- Daimler
 - Truck platooning in live traffic
- Smart Columbus
 - Driver assisted truck platooning



RESEARCH ACTIVITIES

Ongoing/Completed Research

- Advanced driver fatigue research
- Human factors evaluations of automated commercial vehicle concepts
- Volpe FMCSR Review

Planned Research

- Development of brake performance specifications for safe truck platoons
- HACV sensor performance guidelines
- HACV monitor/operator fatigue study

Amina Fisher, Mechanical Engineer

Vehicle and Roadside Operations Division, FMCSA

Amina.Fisher@dot.gov

Luke Loy, Mechanical Engineer

Vehicle and Roadside Operations Division, FMCSA

Luke.Loy@dot.gov

Brian Routhier, Transportation Specialist

Office of Analysis, Research, and Technology, FMCSA

Brian.Routhier@dot.gov