

Autonomous and Connected Vehicle Technology: Effects on the Motor Carrier Industry with Implications for National Freight Policy

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Research Question

- What are the impacts that Autonomous Vehicle (AV) and Connected Vehicle (CV) technologies have on the future of freight mode split between rail and motor carrier and the relevant transportation infrastructure policies.

Outline

- Brief Overview
- Potential Impacts on Freight Industry
- Policy Concerns
- Infrastructure Requirements for AV/CV

SAE level	Name	Narrative Definition	Execution of Steering and 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 <i>human driver</i> of all aspects of the <i>dynamic driving task</i> , even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a
1	Driver Assistance	the <i>driving mode</i> -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 <i>human driver</i> perform all remaining aspects of the <i>dynamic driving task</i>	Human driver and system	Human driver	Human driver	Some driving modes
2	Partial Automation	the <i>driving mode</i> -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 <i>human driver</i> perform all remaining aspects of the <i>dynamic driving task</i>	System	Human driver	Human driver	Some driving modes
Automated driving system (“system”) monitors the driving environment						
3	Conditional Automation	the <i>driving mode</i> -specific performance by an <i>automated driving system</i> of all aspects of the dynamic driving task with the expectation that the <i>human driver</i> will respond appropriately to a <i>request to intervene</i>	System	System	Human driver	Some driving modes
4	High Automation	the <i>driving mode</i> -specific performance by an automated driving system of all aspects of the <i>dynamic driving task</i> , even if a <i>human driver</i> does not respond appropriately to a <i>request to intervene</i>	System	System	System	Some driving modes
5	Full Automation	the full-time performance by an <i>automated driving system</i> of all aspects of the <i>dynamic driving task</i> under all roadway and environmental conditions that can be managed by a <i>human driver</i>	System	System	System	All driving modes

Overview – AV

AV – broken down into 6 distinct levels of autonomy defined by SAE

Overview – CV

- CV – “enable safe, interoperable networked wireless communications among vehicles, the infrastructure, and passengers’ personal communications devices.” – USDOT
 - Our concern – truck platooning and its evolution.

Potential Impacts

- Significantly lower operating cost of long distance truck hauls
- Trucking industry will be one of the first adopters
- Rail and intermodal rail will see decreases in demand

Impacts on Long Distance Trucking

- Platooning depends on a multitude of factors
- Most important determinant → technological capabilities and cost savings
- Three possible phases of technological availability
- Cost impacts analyzed for each phase

Phase 1

- SAE level 2 or lower
- All trucks in a platoon must have a driver
- Only cost savings from AV/CV use is from fuel savings
- Can save anywhere from 5% to 12% of fuel costs (or 1% to 3% per mile cost)

Phase 2

- SAE level 3 or higher
- Platoons can have a driver to truck ratio of less than 1 but more than 0
 - CV technology allows full vehicle synchronization
- For a 2 truck platoon, cost per mile can decrease by 22.3%.

Phase 3

- SAE level 3 or higher
- Platoons do not require drivers for some portion of route
- For a 2 truck platoon, cost per mile can decrease by 40.8%

Impacts on Rail and Intermodal Rail

- 2 methods used:
 - Apply cross price elasticity estimates from Abdelwahab (1998)
 - Use an ad hoc method which relies on more current data (see paper for details)

Abdelwahab (1998)

Phases	Percent Decrease in Q (Max Fuel Savings)	Percent Decrease in Q (Min Fuel Savings)
Phase1 (SAE level ≤ 2 , driver-truck ratio = 1)	2.91%	1.56%
Phase2 (SAE level ≥ 3 , $0 < \text{drive truck ratio} < 1$)	23.89%	22.54%
Phase3 (SAE level ≥ 4 , driver truck ratio = 0)	45.34%	43.99%

Ad Hoc Method

Phases	Percent Decrease in Q Max Fuel Savings	Percent Decrease in Q Min Fuel Savings
Phase1 (SAE level ≤ 2 , driver-truck ratio = 1)	0.51%	0.2%
Phase2 (SAE level ≥ 3 , $0 < \text{drive truck ratio} < 1$)	5.93%	5.44%
Phase3 (SAE level ≥ 4 , driver truck ratio = 0)	20.4%	18.59%

National Freight Policy Concerns

- The U.S. National Freight Strategic Plan's pro-inter-modalism stance may need to be revisited
- Railroad intermodal freight will not be competitive with autonomous trucks
- Infrastructure spending may be better directed towards AV/CV infrastructure

Required Infrastructure for AV and CV

- Better lane markings
- Infrastructure capable of vehicle to infrastructure (V2I) communication
- Dedicated highway lanes and exits
- Refueling and/or recharging stations

Potential Cost of Dedicated Lane

- Expanding an interstate from 4 lanes to 6 lanes
→ \$4 million / mile – American Road and Transportation Builders Association
- 227,225 miles of highway and interstate within the U.S.
- Dedicated lane would cost roughly \$9.1 billion

Possible Source of Funding

- In 2015, the trucking industry made about \$726.4 billion in revenue
 - Estimated \$43 billion in profits (avg. profit margin of 6%) – National Trucking Services 2016
 - If AV/CV can decrease costs by 1/3 and constant prices, then profits would be \$442 billion (**Very Hypothetical**)
- This potential is a viable source of funding

Concluding Observations

- New technologies stand to cut almost a third of motor carrier's operating costs
- Rail and intermodal rail will lose competitiveness
- Such a drop in trucking costs will create pressure for faster adoption of new technologies for lower transport costs
- There will be pressure for National Transportation Policy to facilitate this modal shift and invest in AV/CV infrastructure.
- Rail's only potential to be competitive is to have the Federal Government purchase rail roadways and lease their use back to the carriers – lowering fixed costs.