HAV Systems and Robotics Engineering

Testimony

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"Highly Automated Vehicles (HAV) Testing Legislation"

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by

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Societal Benefits of Vehicle Automation

Automobiles are an integral part of our society and economy. Highly automated vehicle (HAV) technologies are expected to yield major societal benefits.

1. About 42,000 people died from automotive crashes in the US last year, with 94% of these crashes attributable to human error. If vehicles drive themselves, they will not be distracted, and the number of crashes, injuries and fatalities is expected to drop dramatically.
2. The average American commutes to and from work 51 minutes every workday and we are simply stuck in traffic for about 35 hours per year on the average. If our vehicles can be self-driving, we can enjoy the benefits of a virtual chauffeur and be productive during our journeys.
3. The elderly, often living alone, when they lose their driver's licenses, also lose their mobility options, independence and their quality of life. There are also 1.5 million legally blind and more than 5 million physically disabled persons in the US, who cannot drive. These highly disadvantaged groups will benefit significantly from being able to travel independently.

Some of these benefits are many years away. However, highly automated vehicles will reduce the intensity of crashes and their negative outcomes sooner than many of us think.

CMU History and Innovation in Vehicle Automation

Carnegie Mellon University (CMU) has been a birthplace of highly automated vehicles with work dating back to the early 1980s. CMU and Pittsburgh have occupied a special place on this stage since then.

- Our team from CMU won the 2007 **DARPA[1] Urban Challenge**. This global competition required vehicles without *anybody* in them to travel 60 miles in fewer than 6 hours, interacting with other fully autonomous and human-driven vehicles, while following the rules of the road.
- CMU has been working with **General Motors** R&D for the past 17 years on making vehicles smarter and more than 10 years on vehicle automation.
- **Google**'s project on self-driving vehicles literally started when they hired a key person from our CMU team and some experts from other teams.
- **Delphi**, a global Tier-1 automotive supplier, acquired a Pittsburgh startup company I founded named **Ottomatika**, which developed AI software for self-driving vehicles. Ottomatika continues to operate in Pittsburgh.
- **Uber** came to Pittsburgh after recruiting extensively at CMU, and made Pittsburgh the first national testbed for self-driving shared vehicles.
- **Ford** recently announced up to $1B in investments in Pittsburgh's Argo.AI founded by a CMU alumnus and an ex-employee.

Also, thanks to a proposal from CMU, there is now a **Smart Belt Coalition** that has brought together the states of Michigan, Ohio and Pennsylvania with the goal of facilitating and deploying connected and automated vehicles that work seamlessly across state borders. Our collective mission is to change the long-standing narrative of a *Rust Belt* and transform our region into a *Smart Belt*.

We at CMU are also proposing a new **Center of Excellence called CADRE (Connected and Automated Driving Research and Engineering)**. This Center's goal is to develop the next generation of highly

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[1] DARPA, the Defense Advanced Research Projects Agency, is the forward-looking research arm of the US Department of Defense.

automated vehicles that use automotive-grade components with the same degree of safety, quality and reliability that we expect when we buy a car today. Additional research and development along with extensive testing are required to reach this goal. A *Center for the Future of Work* will also study the impact of automation on employment and propose remedies.

Levels of Automation

The Society for Automotive Engineers (SAE in short) has defined 5 levels of degrees of automation.

- **Level 0 is No Automation:** A human driver is responsible for all operations in the vehicle.
- **Level 1 represents some Driver Assistance:** Either acceleration/deceleration or steering in specific driving contexts is performed by a driver assistant in the car. Cruise control is an example of Level 1 operations.
- **Level 2 represents Partial Automation:** Both steering *and* acceleration/deceleration are performed by the vehicle in specific driving contexts. Adaptive cruise control with lane keeping on the highway is an example of this capability. The operator must explicitly intervene when necessary.
- **Level 3 represents Conditional Automation:** The vehicle drives itself completely in specific driving contexts, but the human is expected to intervene when called for. In other words, the human operator must be paying attention and be ready to grab control at any time.
- **Level 4 represents High Automation:** The vehicle drives itself completely in specific driving contexts, even if the human is not paying attention.
- **Level 5 is Full Automation:** The vehicle can drive itself completely from the starting point to the destination on all roads and under environmental conditions that a normal licensed driver can handle. No human intervention or supervision is required.

Public Safety, Technological Innovations and Economic Development

There are three fundamental considerations for this legislature:

The first is **public safety.** Driving is a very complex activity where drivers consume and process enormous amounts of sensory information, make decisions, and actuate the steering wheel and the pedals. We use experience, common sense, instincts and planning. But we are also conditioned to be distracted. Technology can more than make up for our distractions, but cannot match our other strengths for quite some time to come. The real-world complexity of different weather, lighting, and road conditions, as well as the dynamic chaos of urban traffic can and does overwhelm today's technological capabilities.

The second is **technological innovation.** While there is still quite some distance to reach full automation, we have come a long way since 2007's Urban Challenge. With the breadth and depth of activities at companies and universities like ours and in locations like Pittsburgh, innovation is progressing rapidly. PennDOT, for example, has been a strong leader in deploying smart traffic light technologies around the Capitol here and in Pittsburgh. These traffic lights can talk to HAVs, making traversal of accident-prone intersections safer and more reliable. This is referred to as vehicle-to-infrastructure technology, V2I in short. Just like our phones and laptop computers can talk to each other wirelessly, vehicles can also talk to one another using Vehicle-to-Vehicle communications (or V2V). Up to 80 % of automotive crashes can be prevented or mitigated using this technology. Vehicles will also be able to talk to pedestrians, bicyclists and their smartphones improving safety for all. PennDOT is at this leading edge. Their continued deployments will make our transportation infrastructure smarter and safer.

The third is **economic development.** The market size for highly automated vehicles is conservatively estimated at several hundreds of billions of dollars per year. Pittsburgh was a birthplace of the technology, and we need to invest in and leverage this innovation culture to continue our renaissance. If the HAV ecosystem is not allowed to develop here, it *will* happen elsewhere. In fact, Singapore became the first country to have the public ride self-driven taxis. Highly automated vehicles require myriad components, sensors, computers, and software. These components need to be built, tested, diagnosed and repaired creating many new higher-paying jobs. HAVs can also provide access to transportation in disadvantaged neighborhoods and rural communities, making our Commonwealth's cities smarter and communities more connected to opportunities. Better access to health care and higher safety would also be major benefits.

Recommendations on Legislation

First, we need to **move in an enabling direction.** PA laws have enabled us to test our self-driving Cadillac in Pittsburgh, Allegheny County and in Harrisburg since 2011. It has been legal to do such testing as long as there is a licensed operator in the driver's seat. Without this framework, our development and testing would have been significantly hampered. Any new legislation that you pass must, in the very least, not take away this feature. The question for the legislation is which *additional* new testing and deployment modalities should be permitted. On-road testing under real-world traffic conditions is absolutely essential to gaining experience and fixing problems.

Secondly, our Commonwealth and institutions like CMU have been **globally recognized leaders in HAVs and must continue to be.** We can hold back, and make testing and eventual deployment onerous or prohibited in our Commonwealth. Unfortunately, this will not stall the technology. There is intense competition from states like California, Nevada and Michigan. California is actively considering allowing fully automated vehicles without *any* operator in the driver's seat. We will merely end up losing jobs and a large market. Conversely, we can be forward-looking and be open to innovation. We must open up new markets, create new jobs and emerge as winners in the aggregate.

Thirdly, and perhaps most importantly, HAV legislation would benefit tremendously from **built-in flexibility**. Since the technology is progressing rapidly, we will gain by not cornering ourselves into a rigid and inflexible position. We need to be able to relax constraints when the technology proves itself to be reliable. At the same time, if mishaps and harmful incidents occur more frequently than imagined, we may need to impose some restrictions. The regulatory guidance issued by the USDOT[2] in 2016 called for the federal regulatory framework to be updated *every* year! This was a conscious and deliberate attempt to be responsive to future developments. Similar flexibility here in Pennsylvania will be priceless.

In conclusion, HAV technology that our Commonwealth played a major role in creating and nurturing is expected to carve big new markets. Any legislation must continue to enable this technology to be tested on public roads. A path can also be laid out for how the technology can be deployed in the due course of time. However, public safety cannot and should not be compromised. Rules, instead of being set in stone, can build in evolutionary flexibility so that any restrictions can either be relaxed or strengthened, as developments warrant.

I thank you for this opportunity and will be happy to answer any questions.

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[2] US Department of Transportation.