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Preparing a nation for autonomous vehicles: opportunities, barriers and policy recommendations

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ABSTRACT

Autonomous vehicles (AVs) represent a potentially disruptive yet beneficial change to our transportation system. This new technology has the potential to impact vehicle safety, congestion, and travel behavior. All told, major social AV impacts in the form of crash savings, travel time reduction, fuel efficiency and parking benefits are estimated to approach $2000 to per year per AV, and may eventually approach nearly $4000 when comprehensive crash costs are accounted for. Yet barriers to implementation and mass-market penetration remain. Initial costs will likely be unaffordable. Licensing and testing standards in the U.S. are being developed at the state level, rather than nationally, which may lead to inconsistencies across states. Liability details remain undefined, security concerns linger, and without new privacy standards, a default lack of privacy for personal travel may become the norm. The impacts and interactions with other components of the transportation system, as well as implementation details, remain uncertain. To address these concerns, the federal government should expand research in these areas and create a nationally recognized licensing framework for AVs, determining appropriate standards for liability, security, and data privacy.

1. Introduction

Over the past few years the automobile and technology industries have made significant leaps in bringing computerization into what has, for over a century, been exclusively a human function: driving. New car models increasingly include features such as adaptive cruise control and parking assist systems that allow cars to steer themselves into parking spaces. Some companies have pushed the envelope further by creating autonomous vehicles (AVs, also called automated or self-driving vehicles) that can drive themselves on existing roads and can navigate many types of roadways and environmental contexts with almost no direct human input. Assuming that these technologies become successful and available to the mass market, AVs have the potential to dramatically change the transportation network. This paper serves as an introduction to AV technology, its potential impacts, and hurdles for transportation professionals and policymakers.

AVs have the potential to fundamentally alter transportation systems by averting deadly crashes, providing critical mobility to the elderly and disabled, increasing road capacity, saving fuel, and lowering emissions. Complementary trends in shared rides and vehicles may lead us from vehicles as an owned product to an on-demand service. Infrastructure investments and operational improvements, travel choices and parking needs, land use patterns, and trucking and other activities

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may be affected. Additionally, the passenger compartment may be transformed: former drivers may be working on their laptops, eating meals, reading books, watching movies, and/or calling friends – safely.

Yet, the proliferation of autonomous vehicles is far from guaranteed. High costs hamper large-scale production and mass consumer availability (KPMG and CAR, 2012; Economist Technology Quarterly, 2012; Grau, 2012; Hickey, 2012). Complex questions remain relating to legal, liability, privacy, licensing, security, and insurance regulation. While individual U.S. states have been advancing AV legislation through incremental measures (Center for Information and Society, 2012), federal guidance has not yet been issued for either fully, or partially, autonomous vehicles beyond testing purposes on public roads. This being noted, NHTSA has identified research needs that need to be addressed before states should begin AV licensing to the general public, indicating that data to establish proper regulatory frameworks are not yet ready (National Highway Traffic Safety Administration, 2013).

At the September 2012 signing of California's law enabling AV licensure (SB 1298), Google founder Sergey Brin predicted that Americans could experience AVs within five years (O'Brien, 2012). Nissan (Nissan, 2013) Volvo (Carter, 2012) and other manufacturers have announced their intentions to have commercially viable autonomous-driving capabilities by 2020 in multiple vehicle models. Assuming an additional five years for prices to drop to allow for some degree of mass-market penetration, AVs may be available on the mass market by 2022 or 2025, approximately two decades after the DARPA (Defense Advanced Research Projects Agency) Grand Challenge's first successful tests. Policymakers need to begin to address the unprecedented issues that AVs could surface, and could potentially aid the introduction of incremental improvements in the meantime.

1.1. AVs today

In 2004, DARPA's Grand Challenge was launched with the goal of demonstrating AV technical feasibility by navigating a 150-mile route. While the best team completed just over seven miles, one year later five driverless cars successfully navigated the route. In 2007, six teams finished the new Urban Challenge, with AVs required to obey traffic rules, deal with blocked routes, and maneuver around fixed and moving obstacles, together providing realistic, every-day-driving scenarios (Defense Advanced Research Projects Agency, 2012). As of April 2014, Google's self-driving cars have driven over 700,000 miles on California public roads (Anthony, 2014), and numerous manufacturers – including Audi, BMW, Cadillac, Ford, GM, Mercedes-Benz, Nissan, Toyota, Volkswagen, and Volvo – have begun testing driverless systems (Wikipedia, 2013). Semi-autonomous features are now commercially available, including adaptive cruise control (ACC), lane departure warnings, collision avoidance, parking assist systems, and on-board navigation. Europe's CityMobil2 project is currently demonstrating low-speed fully autonomous transit applications in five cities. Additionally, AVs are becoming increasingly common in other sectors including military, mining, and agricultural (Economist Technology Quarterly, 2012). While urban environments pose much greater challenges, these environments can be helpful testing grounds for AV innovation.

States are proceeding with AV-enabling legislation: California, Florida, Nevada, Michigan and Washington, D.C. have enacted bills to regulate AV licensing and operation, with instructions to their respective Department of Motor Vehicles (DMV) for fleshing out details. Yet some of these efforts are in direct conflict with federal guidance. NHTSA (The National Highway and Traffic Safety Administration) has issued a statement advocating that states should begin establishing procedures for allowing testing on public roads, though should not yet begin licensing AV sales to the general public (National Highway Traffic Safety Administration, 2013). In contrast, California has directed its DMV to provide AV certification requirements by 2015 (Center for Information and Society, 2012).

1.2. Paper organization

This paper seeks to explore the feasible aspects of AVs and discuss their potential impacts on the transportation system. This research explores the remaining barriers to well-managed, large-scale AV market penetration and suggests federal-level policy recommendations for an intelligently planned transition, as AVs become a growing share of our transportation system. The paper contains three major sections:

- Potential benefits of autonomous vehicles.
- Barriers to implementation.
- Policy recommendations.

The first section reviews existing literature to ascertain system benefits and impacts with respect to traffic safety, congestion, and travel behaviors. The information is used to estimate and monetize traveler benefits in the form of crash and congestion reduction as well as parking savings across multiple levels of market penetration. The analysis reflects not only autonomous capabilities for individual vehicles, but also increasingly connected and cooperative vehicles and infrastructure systems. The second section investigates barriers to AV adoption and implementation, primarily from a consumer and regulatory standpoint, rather than technical feasibility. These barriers were largely identified in the literature and in discussions with experts. The final section proposes concrete policy recommendations to directly address potential barriers flagged in the second section.