Invest in Automation?

Automated vehicles as an antidote for critical issues facing our urban transportation systems

by Ed Holzwarth

September 16, 2004

1.221 Transportation Systems
Assignment 1
Professor Joe Sussman

automation history

Vehicle automation started in the 1970's with cruise control to allow drivers to maintain a constant speed on the highway. In recent years, automakers have introduced ``adaptive'' cruise control, which automatically adjusts vehicle speed depending on feedback from vehicle sensors[1]. Navigation aids in luxury cars now provide drivers with the directions to reach their chosen destination. In 1995, researchers from Carnegie Mellon's NavLab ``drove'' an automated (or ``autonomous'') vehicle from Pittsburgh, PA to San Diego, CA. More recent research has examined obstacle detection and avoidance[2]. Though still in its early stages now, it seems plausible that vehicle automation will be widespread within the next 20-50 years.

terminology

The National ITS Architecture division of the U.S. Department of Transportation considers a*utomated vehicle operation* as one of the several components of *intelligent transportation system*s *(ITS)*. Automated vehicle operation is an ITS technology categorized under the user service bundle *advanced vehicle safety systems*. Another ITS user service bundle is *travel and traffic management* [3]. For the purposes of this essay, I use simpler, slightly different terminology:

Automated Vehicles have two attributes:

1. They are *driverless*, assumed to utilize advanced vehicle safety systems and able to maneuver anywhere a conventional vehicle can go.
2. They are *intelligent*, providing traveller and traffic management services based on real-time information considering the entire transportation network

These two attributes are independent. A driverless vehicle could theoretically operate without information beyond what it observes and what it is pre-programmed to know. The second attribute, vehicle intelligence, may be just as valuable to a human driver as it is to a computer driver. Some benefits of automated vehicles derive from the fact that they are *driverless*, while other benefits come from the fact that they are *intelligent*. Finally, additional benefits result from the combination of the two attributes working together.

two scenarios

How might the new automated vehicle technology be utilized? The most obvious scenario is that automakers gradually adopt automation technology, until eventually we arrive at a scenario much like today, where most people have their own automobile, only they don't have to drive the car, they just tell it where they want to go, and it takes them there. Such vehicles might be called *personal automated vehicles*. However, automation technology enables another, more interesting scenario. Instead of people having their own vehicles, one could imagine an automated transit network of shared vehicles of varying size that accommodate people's need for transportation. These vehicles work together as a system in what we will call an *automated transit network*. In this essay, when I refer

---

[1] The Economist, 2001.

[2] NavLab, 2004.

[3] National ITS Architecture, 2004.

simply to *automated vehicles*, the term includes both *personal automated vehicles* as well as those which are part of an *automated transit network*.

critical issues

Each year, the Transportation Research Board (TRB) identifies and reports on critical issues in the field of transportation[4]. Among the critical issues cited in 2002, there are several for which automation may offer some compelling answers:

- safety
- congestion
- environmental goals
- mobility of aging population
- class equity

In the following sections each of these critical issues will be examined in more detail.

safety

The numbers are stunning. Each year, more than 40 thousand people are killed in vehicle crashes in the United States. Over 3 million more people are seriously injured[5]. Automation offers great hope to reduce these numbers for the reason that computers do not drink alcohol, get tired, or become distracted. Automated vehicles have no equivalent to the inexperienced driver or the aging driver. Automated vehicles can react faster and more intelligently in an emergency situation to avoid a crash.

To be fair, there are many ``judgement calls'' and pathological cases which will present some difficult technical challenges and ethical issues to automated vehicle engineers. For example, how will the vehicle judge how to avoid a sudden obstacle while protecting the safety of the vehicle occupants? How should the vehicle value safety versus speed? These issues are important to address if society is to trust automated vehicles.

Still, if these issues can be resolved, automated vehicles stand to offer huge safety improvements over human drivers, because computers are not prone to error as humans are. Of course, the humans that program the automated vehicles are also prone to error, but with enough testing and refinement, risks can be controlled to whatever maximum level is considered acceptable.

congestion

Automation offers some interesting possibilities for relieving traffic congestion. *Automated platooning* is a means of doubling or tripling highway capacity by taking advantage of the improved reaction time of automated vehicles over human drivers[6]. Human drivers are typically taught to leave several car-lengths of space between their vehicle and the one ahead of them. This is so that the driver will have time to react if the vehicle in front slows down. Automated vehicles, however, need only a few feet of space between vehicles because they can instantly detect speed changes of the vehicle in front.

---

[4] TRB Executive Committee, 2001.

[5] TRB Executive Committee, 2001.

[6] Mechanical Engineering Magazine, 1998.

Another antidote for traffic congestion is better information. If an automated vehicle can receive real-time information about traffic and route conditions, it can make informed and optimal decisions about the best route to choose.

An automated transit network offers additional possibilities for relieving congestion. Intelligent ride sharing, based on real-time trip demands, could be more attractive than conventional ride sharing. Though many urban areas today offer ride-matching services, shared trips must be still pre-coordinated by individuals to arrange mutually convenient pick-up and drop-off times and locations. An automated system, on the other hand, could offer to share trips on-demand. In an automated transit network, fares could be computed to offer an riders an incentive to allow other riders to share the vehicle (see ``pricing options'' below). Though it depends on the specifics of a city's transportation demand, such a system could have a large impact on the number of people who use ride sharing, which in turn would improve congestion.

environmental goals – air quality and transportation infrastructure

The transportation industry has a major impact on the environment. Motor vehicles degrade air quality, particularly in urban areas. In addition, transportation infrastructure requires a large amount of dedicated space. Automated vehicles may reduce both air quality impacts and infrastructure requirements.

As mentioned earlier automated vehicles could reduce congestion in several ways. Each of the congestion reduction strategies, except for automated platooning, would also reduce air pollution by allowing the transportation network to operate more efficiently. The automated platooning method would probably not reduce air pollution because though it reduces congestion, it also increases highway capacity.

One difficult question to answer is whether an automated transit network would exert any new influences on land use and urban form. Most researchers agree that the personal automobile, as it became ubiquitous, enabled urban forms that are associated with urban sprawl. If in the future automated transit systems become a dominant mode share, what urban form tendencies, if any, would arise?

For starters, one potential benefit is a huge reduction in the number of parking spaces required compared to the current system where most people have their own personal vehicle. Researchers estimate that there are approximately five parking spaces per vehicle in the United States[7]. Combined with the fact that there are more than 1.6 vehicles for every employed person[8], this adds up to a huge amount of space dedicated to parking.

Studies show that Americans spend, on average, between one and two hours per day in their car[9]. This is an interesting statistic for many reasons, but one consequence is that vehicles spend the vast majority of time parked, waiting until the vehicle's driver is ready to go somewhere else. An automated transit network could be designed to allow for accommodating transportation demand with little to no wait time, but when a person does not need transportation, the vehicle can be busy transporting someone else.

---

[7] Litman, 2004.

[8] ``Household Vehicles and Characteristics,'' 2003.

[9] Phillips, 2001.

Finally, to the extent that an automated transit network boosts ride sharing (see previous section), parking requirements can further be reduced because the total number of vehicles to accommodate demand will be less.

mobility of aging population

As noted in the TRB Critical Issues report, as Americans grow older, their driving skills deteriorate. They are more likely to sustain serious or fatal injuries in the event of a crash[10]. Driverless vehicles will potentially be much safer than today's human-driven vehicles (see ``safety'' section above). Automated vehicles will offer safe transportation not only to seniors, but also to other segments of the population who cannot drive.

Many seniors live in areas not well-served by conventional public transit. On_demand ``paratransit'' services are helpful, but most paratransit systems are rather inconvenient, requiring a minimum one-hour notice before scheduling a trip within a 20_minute pickup time window. An automated transit network could offer much higher levels of service. If some customers require, for example, a wheelchair lift, a portion of the vehicles in the automated transit fleet could be outfitted with the necessary equipment. More generally, the fleet of the automated transit system can accommodate whatever the needs are of the urban area.

class equity and pricing options

The TRB report notes that owning and operating a personal automobile is expensive. Because much of the U.S. is highly dependent on the personal automobile, lower-income households spend an alarmingly large fraction of their income – 25 percent – on transportation[11].

At first glance, the relationship between automation and the cost of transportation is not obvious. If anything, the cost of the automation technology would be expected to be higher than conventional vehicles. On the other hand, the economic benefits of the new technology may offset its higher costs. Moreover, there are two reasons why an automated transit network may be able to address class equity issues: 1) as a public system, individual riders need not pay up-front ownership costs, and 2) an intelligent pricing system can individualize prices to fit any public policy goals.

Intelligent pricing could include congestion pricing schemes, ride-sharing incentives, special user services, and discounts for low-income customers. With unique identification for each customer, the options are extensive.

the future

More research is needed to analyze the potential implications of automated vehicles. For example, it would be helpful to quantify the reduction in transportation infrastructure requirements. If we can identify that automated vehicles technology would provide a net social or economic benefit, we can distinguish it as a worthwhile investment of research dollars.

At this early stage, it appears that automation will offer some compelling antidotes to several of transportation's most critical issues. Perhaps one day in the future people will look back on the contemporary era and marvel with incredulity about how we

---

[10] TRB Executive Committee, 2001.

[11] TRB Executive Committee, 2001.

once drove vehicles by hand, crashing into each other at alarming rates, never sure about the best route, typically with only one occupant in a privately owned car that most of the day remains parked!

references

``Beyond Cruise Control," The Economist, 21 Jun 2001.

``Household Vehicles and Characteristics," Transportation Energy Data Book, Chapter 8, 2003. (15 Sep 2004).

Litman, Todd. ``Parking Costs," Transportation Cost and Benefit Analysis, Section 5.4. Victoria Transport Policy Institute, 2 Jan 2004. p. 5.4-5. http://www.vtpi.org/tca/tca0504.pdf (15 Sep 2004).

Phillips, Stephen. ``The future dashboard," Financial Times. 4 Jun 2001. http://specials.ft.com/ftit/june2001/FT3A72I0JNC.html (15 Sep 2004).

``Robotics Institute – NavLab." Robotics Institute, School of Computer Science, Carnegie Mellon Univeristy, 2004. http://www.ri.cmu.edu/labs/lab_28.html (13 Sep 2004).

``Smart cars and automated highways." Mechanical Engineering Magazine, May 1998. http://www.memagazine.org/backissues/may98/features/smarter/smarter.html (13 Sep 2004).

TRB Executive Committee. ``Critical Issues in Transportation 2002," TR News 217, Nov.-Dec. 2001 (pp. 3_11)

``User Service Bundles," National ITS Architecture, U.S. Department of Transportation, April 2004. http://itsarch.iteris.com/itsarch/html/user/userserv.htm (15 Sep 2004).