TREND ANALYSIS SUMMARY

TECHNOLOGY

Autonomous Vehicles, Mobile Technology, Sensors, Monitors & Big Data, Electrification & Alternative Fuels, Unmanned Aircraft Systems

The intersection of technological innovation and transportation has peaked people's interests throughout history. From the Futurama exhibit depicting an interconnected network of expressways at the 1939 New York World's Fair to flying vehicles in *The Jetsons*, future visions of transportation draw people in and lead us to imagine how we might get from place to place beyond the means that we have today. Change in transportation technology is happening so quickly that it sometimes seems as though advances occur overnight. Planning a transportation system that can adapt to changing technologies is vital to ensure that Minnesota doesn't fall behind in the face of technological advances.

Autonomous Vehicles

Autonomous vehicles are one of the most rapidly emerging transportation technologies, and have the potential to significantly change the way people think about trips, vehicle ownership, and places of residence. Vehicles are classified into one of five levels of automation based on their features and capabilities:

Type	Year[1]	Description
No-automation	Now	The driver is in complete and sole control of the primary vehicle controls at all times.
Function-specific automation	Now	Automation involving one or more specific control functions. (ex. electronic stability control)
Combined-function automation	2017	Automation of at least two primary control functions that work in unison. (ex. adaptive cruise control in combination with lane centering)
Limited self-driving automation	2020	These vehicles enable the driver to cede full control of all safety-critical functions under certain conditions. The driver is expected to be available for occasional control.
Full self-driving automation	2025	The vehicle is designed to perform all safety critical driving functions and monitor roadway conditions for an entire trip.

ROLLOUT

Early versions of vehicles that fall between the combined-function automation and limited self-driving automation categories are anticipated to be available sometime in 2017.[2] Tesla recently released a software update that included Autopilot features falling into the limited self-driving

automation category.[3] The amount of testing conducted using these systems has been extensive; Google's autonomous vehicle system drove its one-millionth mile in May of 2015.[4] The rapid development of this technology is not expected to slow. By 2020, it is likely that vehicles meeting the description of limited self-driving automation will be available on the market.[5] Given the safety record of early autonomous vehicle prototypes, it is not unreasonable to envision a future where self-driving technology is required in all new cars and is eventually required for all cars on public roads. In Minnesota the rollout of autonomous vehicles may be slowed by concerns about performance in winter conditions.

IMPLICATIONS OF AUTONOMOUS VEHICLES

The implications of autonomous vehicles are far-reaching. Safety improvements may be one of the most important implications of autonomous vehicle adoption – unlike human drivers autonomous vehicles seldom get distracted or tired and have almost instantaneous perception. It is possible that a full deployment of autonomous vehicles could prevent thousands of deaths that happen in the United States. As a result of lower safety risks car insurance rates may decrease for people who use autonomous vehicles. Autonomous vehicles will be able to follow each other at closer distances, increasing the capacity of our existing roadways, and potentially allowing for changes in traditional vehicle form. This is largely dependent on the emergence of connected vehicles that are able to communicate location and route with other vehicles around them. Larger vehicles may be able to carry more passengers in lighter vehicles, increasing fuel efficiency and boosting roadway capacity. Automated pick-up and delivery of people and goods may be possible if drivers are not required to be in vehicles at all times. Finally, autonomous vehicles offer vast improvements in mobility for those who are unable to drive for one reason or another. It is conceivable that an autonomous vehicle may be able to pick meet someone in a given location and bring them to their destination before embarking on another trip. This may also decrease the need for parking in many parts of the country.

Mobile Technology

We live in a world where not having the ability to communicate instantly with others or access the internet is the exception, not the rule. This has significant implications for transportation now and as technologies like autonomous vehicles continue to develop.

DISTRACTED DRIVING

The always-on nature of smartphones, internet-enabled vehicle interfaces, and other technologies make it easy to be distracted from focusing on the road while driving. Each year, distracted driving is a factor in 1 in 4 crashes in Minnesota resulting in at least 70 deaths and 350 serious injuries.[6] It is likely that these numbers are vastly underreported due to the difficulty in determining distraction as a factor in crashes.

MULTITASKING DURING TRAVEL

Improvements in mobile technology have increased the range of activities that people can engage in when traveling away from home. Airport waiting areas, public transit vehicles, and the back seats of cars are filled with people using electronic devices.[7] The increasing use of telecommunications devices while traveling tends to lead people to see travel time as being more useful or enjoyable, and might increase people's willingness to travel longer distances.[8] The impact of mobile technologies on how people spend their travel time are likely dependent on the age and socioeconomic status of a person, in addition to trip distance, duration, the space available to complete activities, and vehicle preferences.

Sensors, Monitors & Big Data

The emergence of so many mobile technologies has created vast demands for data that keep tabs on people's health, homes, movement, and more. We are increasingly reliant on internet-connected devices to organize our calendars, gauge the best route or mode for a trip, and track our calorie consumption, in addition to many other activities. Data collected through these methods tell a story about us and our behaviors; understanding how this data is used and for what purposes is an important issue.

SMARTPHONES & TRANSPORTATION

Smartphones offer a vast array of transportation information and services at the touch of a button, leading some people to believe that they are the most important transportation innovation of the decade. Apps like Google Maps offer the ability to compare routes with real-time traffic information to determine what path is the quickest to your destination, all while updating in real time. Apps available in the Twin Cities like OMG Transit, and RideScout offer the ability to compare transit service, taxi and ridesharing options, carsharing, bike, driving, and walking directions all from one screen to help travelers make informed decisions about their routes and modes. Many of these mobile apps rely on location-tracking to help determine potential routes and trips, leading to potential concerns about data privacy and storage.

TRANSPORTATION SYSTEM DATA

Transportation stewards rely on data to ensure that transportation systems meet the needs of people who use them. Transportation agencies rely on roadway sensors to gauge environmental conditions for maintenance and research, and also track the number of vehicles who pass specific points on the roadway to better understand travel patterns. Emerging technologies can also use cell phone and smartphone signals to track travel patterns for cars, bikes, and walkers. This data, while useful, also raises significant privacy concerns regarding identifying information and safe storage.

Electrification & Alternative Fuels

Concerns about dependency on foreign oil and environmental damage have led to the development and use of alternative fuels in Minnesota. These include biofuels like ethanol and biodiesel, compressed natural gas, and electricity. Each alternative fuel that has been used in Minnesota comes with advantages and disadvantages. It is also important to remember that subsidies matter when it comes to alternative fuels – any new fuel faces an entrenched gasoline/diesel distribution and delivery system that is familiar and works with virtually every automobile on the road meaning that subsidies are often necessary to even make an alternative fuel available to consumers.

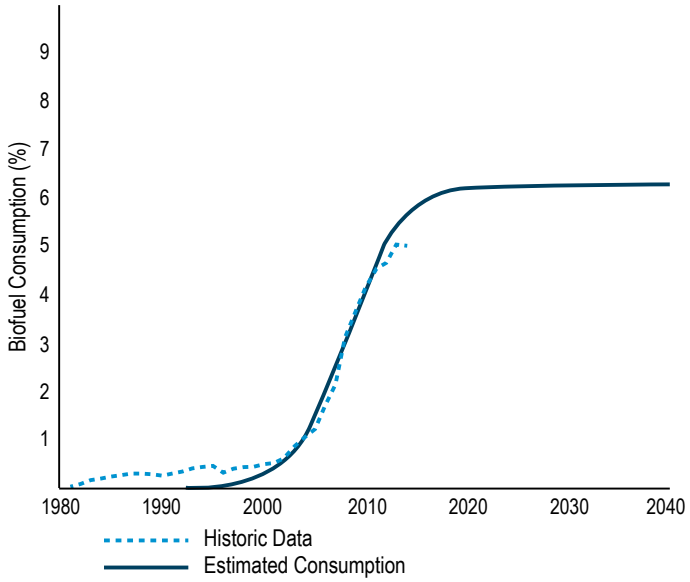
DROP-IN BIOFUELS

The use of drop-in biofuels (meaning that they can be used in existing vehicles without modifications and can utilize existing distribution systems)[9] has increased rapidly since their initial adoption in the 1990s. A law passed in Minnesota requires that all gasoline is either 20% ethanol or has the maximum allotment of ethanol allowed by the EPA.[10] As a result of this law, nearly 20% of Minnesota's corn crop is devoted to ethanol production each year, making Minnesota the leading user of biofuels in the United States. Nationally, biofuel consumption is likely to plateau near current levels, as is shown in Figure 1. As technology continues to develop it is likely that incentives for fuels from non-food sources may emerge to shift the focus away from corn- and soy-based biofuels.

ELECTRIC VEHICLES

The adoption of electric vehicles in Minnesota has lagged behind the national average; roughly 2.5 percent of new cars sold are some kind of electric or hybrid-electric vehicle.[11] This includes hybridized electric vehicles like the Toyota Prius, fully electric vehicles like the Nissan Leaf, and plug-in hybrid electric vehicles like the Chevrolet Volt. Four key issues emerge when considering electric vehicle systems in Minnesota. These include vehicle cost, the range of vehicles available, the effects of winter and cold temperatures on battery systems, and for fully-electric vehicles, the availability of charging stations. The potential development of dynamic charging systems that are able to wirelessly transmit electricity to cars and other vehicles could eliminate "range-anxiety" and greatly expand the potential applications for electric vehicles.

Figure 1: Use of biofuels in the United States



COMPRESSED NATURAL GAS

Compressed natural gas (CNG) has emerged primarily as an alternative fuel for heavy-duty vehicles. The use of CNG results in fewer carbon dioxide emissions, fewer particulate matter emissions, and is 20 to 40 percent cheaper in comparison to diesel fuel. Despite these advantages CNG has a lower energy density than diesel fuel and emits significant amounts of methane when burned. By 2040 it is projected that CNG will make up approximately 7 percent of total energy use for the heavy-duty vehicle sector.

OTHER ALTERNATIVE FUELS

Other alternative fuels are likely to emerge in the future as people search for ways to improve efficiency and reduce the environmental impacts of transportation systems. One emerging alternative fuel that is used extensively in Sweden is dimethyl ether (DME). DME is a propane-like alternative to diesel fuel, primarily intended for use in heavy-duty vehicles.[12] DME is potentially renewable and can be sourced from feedstocks, biogas and natural gas. Additional research is likely to lead to additional alternative fuel solutions, including improvements in existing alternative fuels.

Unmanned Aircraft Systems (Drones)

The use and regulation of Unmanned Aircraft Systems (UAS), also known as drones (shown in image below), is rapidly evolving and this trend is expected to continue over the next several years.

Sales of UAS are on the rise as they become less expensive and easier to get. Also on the rise are reports of unsafe or illegal UAS operations around airports, near manned aircraft, at major sporting events, among others. Educating users of the rules that must be followed when operating a UAS will be one of the biggest challenges into the foreseeable future.

Just a few of the uses for UAS include:

- Crop monitoring
- Precision agricultural spraying
- Aerial photography
- Infrastructure and utility inspection
- Law enforcement
- Search and rescue
- Recreation

CONCLUSION

Transportation is changing the way that people travel and the ways that they think about travel time in ways that could not have been anticipated in the recent past. Monitoring new developments is an essential step to ensuring that Minnesota's transportation systems are able to keep up with the rapid pace of technological change. Autonomous vehicles, mobile communications systems, and new types of fuels all have the potential to significantly change how people think about their relationship with the transportation system on a number of different levels. The emergence of UAS technologies offer a wide variety of potential applications that limit potential risks for people while collecting and transmitting data that may not have been readily-available in the past.

CITATIONS

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8. Goldwyn, 2014
9. U.S. Department of Energy
10. MN House, The Ethanol Industry in Minnesota, 2012
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12. Oberon Fuels, What is DME?

For more information about the the Statewide Multimodal Transportation Plan update please visit our website: www.minnesotago.org