Automated Vehicle Impacts

• “Big picture” of automation impacts
• Direct and Indirect
• A framework breaks a complex problem into (somewhat) manageable pieces

Source: US DOT Benefits Estimation Model report and poster from 2017 Automated Vehicles Symposium
<table>
<thead>
<tr>
<th>Impact Area</th>
<th>Potential Benefit</th>
<th>Potential Dis-Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety</td>
<td>Reduction in crashes</td>
<td>New types of crashes</td>
</tr>
<tr>
<td>Vehicle Operations</td>
<td>More precise vehicle following and lane keeping</td>
<td>Longer following distances</td>
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<tr>
<td>Personal Mobility</td>
<td>More options, especially for those unable/unwilling to drive</td>
<td>Can <em>everyone</em> access the automated vehicles?</td>
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<tr>
<td></td>
<td>Potentially cheaper</td>
<td></td>
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<tr>
<td>Energy Use and Emissions</td>
<td>Smoother speed profiles, platooning, light-weighting could improve efficiency</td>
<td>Increases in VMT could increase fuel use/pollution</td>
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<tr>
<td>Network Efficiency</td>
<td>May increase throughput</td>
<td>May increase congestion, via increased trips</td>
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<tr>
<td>Public Health</td>
<td>Improved access to medical care, work and recreation for non-motorists</td>
<td>May reduce use of active modes</td>
</tr>
<tr>
<td>Travel Behavior and Vehicle</td>
<td>May decrease need for ownership, potentially reducing fleet size</td>
<td>May lead to more trips, with ability to safely multi-task enroute</td>
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<tr>
<td>Ownership</td>
<td></td>
<td></td>
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<tr>
<td>Land Use</td>
<td>May encourage density by freeing up space currently devoted to parking</td>
<td>May encourage sprawl</td>
</tr>
</tbody>
</table>
Safety - a significant potential improvement

- Automated vehicles that accurately detect, recognize, anticipate, and respond to the movements of all transportation system users could lead to breakthrough gains in transportation safety - Automated Vehicles 3.0
- Most motor vehicle crashes involve driver related factors
- Some evidence of benefit from currently available crash avoidance technologies
- But, while automation may reduce many human-caused crashes, it may contribute to other crashes

Sources:
NHTSA (2015), Critical Reasons for Crashes Investigated in the National Motor Vehicle Crash Causation Survey
Insurance Institute for Highway Safety (2019), Real-world benefits of crash avoidance technologies
Safety – cautions in analysis

How is safety being measured and normalized? What is the baseline?

- Make sure the operational design domain for automated systems and the baseline is the same
- Accounting for under-reporting of crashes
- How safe is safe enough?
  - Compare to the “average” human driver?
  - Or, to a “reference driver” (an attentive, skilled and experienced driver)?
  - Expectations of automation vs. human driving
- Crashes are rare events
  - Would need to drive many miles to demonstrate a statistically significant lower crash rate per mile

Measuring safety

Direct measures:
- Fatalities, injuries, crashes

Proxy measures:
- Near-misses
- Disengagements
- False positives

Sources:
“...would need to drive many miles...” from RAND Driving to Safety: How Many Miles of Driving Would It take to Demonstrate Autonomous Vehicle Reliability (2016)
Safety – what you can do

• Become familiar with the evolving best practices in safe AV testing
• Educate and collaborate with the public and law enforcement
• Facilitate safe testing and operation of automated vehicles on local streets
• Understand the near-term opportunities that automation may provide
  • Automatic Emergency Braking and pedestrian detection may improve safety for your own fleets

*Automated Driving Systems 2.0: A Vision for Safety* (2017) introduces Voluntary Safety Self Assessments and safety elements that should be considered
Vehicle operations – unclear effect on road capacity

• Automated systems can affect road and intersection capacity
  • Following distance
  • Gap acceptance
  • Required lane width

• Simulation studies and field tests suggest different following distances for manual driving, adaptive cruise control (ACC) and cooperative adaptive cruise control (CACC)

• What happens in different operational design domains?

Source for the chart: Eilbert, Berg and Smith (2019) poster and report
Vehicle operations – cautions in analysis

• Choices (e.g., for acceleration) will involve tradeoffs
  • Safety
  • Comfort
  • Energy consumption

• Connectivity may have a significant effect
  • V2V for car following
  • V2I for intersections

• Need to consider effect on other road users
  • For example, manually driven vehicles operating on a freeway with platoons

Measuring vehicle operations
• Speed variation and jerk
• Lateral position variation and jerk
• Headway to lead vehicle
• Gap acceptance
Energy/emissions – complex impacts

• Vehicle fuel consumption per mile
  • Vehicle / powertrain resizing
  • Smoother traffic flow
  • Faster travel
  • Power load of automation hardware and software

• Vehicle-miles traveled
  • Increased travel
  • Shared or not shared
  • Zero-occupant vehicles

• Self-repositioning of AVs can facilitate electric vehicle use

References: There are many papers and reports on this topic. Examples include Stephens et al (2016); Eilbert et al (2017), Lee and Kockelman (2019)
“Automation has the potential to improve our quality of life and enhance the mobility and independence of millions of Americans, especially older Americans and people with disabilities.” – Automated Vehicles 3.0

• Personal mobility for non-motorists
• First / last mile services for transit
• “Complete Trip” to enable independent and spontaneous travel for those who are underserved now
  • Planning the trip
  • Getting to the vehicle
  • Using the vehicle
  • Getting to the final destination

Source: USDOT
Indirect impacts – network efficiency

• Primarily from changes in vehicle operations
  • Car following
  • Intersection
  • Needed lane widths

• Are vehicles also connected?

• Interactions with other road users
  • Non-automated vehicles
  • Bicyclists, pedestrians
Indirect impacts – travel behavior

Privately owned vehicles (POV)

- Level 4, for part of the journey
- Lower value-of-time, with automated driving

Shared automated vehicles, with single occupant trips

- Self-delivery makes this option more convenient than car-sharing today
- Provides improved accessibility for non-motorists
- Less need for POVs
- Zero-occupant trips

Shared automated vehicle, with pooled trips

- Fixed route transit or demand-responsive routing
Indirect impacts – public health

Public health is the science of protecting and improving the health of families and communities through promotion of healthy lifestyles, research for disease and injury prevention and detection and control of infectious diseases.
– CDC Foundation

Elements of automation that affect public health

• Safety: vehicle occupants and non-occupants

• Effect of automation on active transportation

• Air pollution

• Access to opportunities for healthy lifestyles

Source: US DOT Volpe Center
Indirect impacts – land use

• Parking
  • POVs are parked most of the time
  • Less need for parking for shared vehicles, because of their higher utilization
  • Option of self-repositioning to remote parking?

• Sprawl
  • Ability to engage in other tasks enroute may make long commutes more attractive