Application of Autonomous Driving Technology to Transit

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Transit and SmartDrivingCars

- Impact of Self-Driving Cars on Transit
- Opportunities for Autonomous Driving Technology in Transit
The Market for Transit

Transit riders generally fall into two categories, captive and choice

• Captive riders – cannot drive or do not have access to a car

• Choice riders - generally do own cars, but choose transit when it can offer a faster, cheaper or more convenient trip.
  – Choice riders who own cars really appreciate the ability to “text” while traveling.
NHTSA Preliminary Policy on SmartDrivingCars

Level 2 (Combined function automation)
• Automation of at least two control functions designed to work in harmony (e.g., adaptive cruise control and lane centering) in certain driving situations.

Level 3 (Limited self-driving)
• Vehicle controls all safety functions under certain traffic and environmental conditions.
• Driver expected to be available for occasional control.
Example: Google car

Level 4 (Full self-driving automation)
• Vehicle controls all safety functions and monitors conditions for the entire trip.
• Vehicle may operate while unoccupied.
Impact of Level 2 Technology - Cars

- Jam assist; Active Collision avoidance
- Adaptive Cruise Control
- Lane-Centering
- Fewer crashes
- Lower Stress
- Some increase in auto commuting trips
Impact of Level 3 Technology - Cars

• Automatic Valet Parking
• Limited Self-driving – freeways, pre-mapped or programmed routes, good weather
• Significant reduction in center city parking time and cost

• **Driver can now “text”**
  (on certain roads at certain times)

• **Increases in longer auto commuting trips**
Impact of Level 4 Technology - Cars

• Unrestricted self-driving
• Autonomous Empty Vehicle Repositioning

• Emergence of **shared-ride**
  Autonomous Taxi services
  – Non-drivers can make low-cost individual trips
  – Time spent in motion no longer wasted – in-vehicle experience is transformed

• Vehicle trips may exceed person trips *(unless rides are shared)*
Could This be the Future of SmartDrivingCars?
The self-driving car as an extension of living or working space
You could live in this.
Impact of SmartDrivingCars on Transit

- Self-driving cars will offer mobility to those transit captives who cannot drive, and, in conjunction with car-sharing, can offer mobility to those who do not have ready access to a car.

- For choice riders, self-driving cars can offer amenities similar to those of transit in terms of how one can use time while traveling, to read, sleep or work.

- According to studies, automated cars could double highway capacity. Couple that with the ability to self-park, and the transit advantage could melt away.

- So the impact on many transit systems could be huge.
Potential Applications of SmartDriving Technology to Bus Transit

How can transit benefit?
Use Autonomous Collision Avoidance Technology to Address a BIG CURRENT Problem
Good News! Travel by Bus is getting safer!

Injuries per Million Bus Passenger Miles
Source: Federal Transit Administration National Transit Database
Good News! Injuries have been trending down!

**US Bus Transit Industry Annual Reported Injuries 2002-2011**

Source: Federal Transit Administration National Transit Database
Terrible News! Claims are going through the roof!

Figure 2 US Bus Transit Industry Reported Casualty and Liability Expense 2002-2011
Average Increase 2.8% per Year
Source: Federal Transit Administration National Transit Database
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Casualty and Liability Amount</strong></td>
<td><strong>Vehicle-related</strong></td>
<td><strong>$483,076,010.</strong></td>
</tr>
<tr>
<td><strong>Total Buses</strong></td>
<td></td>
<td><strong>59,871</strong></td>
</tr>
<tr>
<td><strong>Sub-Total Casualty and Liability Amount Per Bus</strong></td>
<td></td>
<td><strong>$8,069/Bus/Year</strong></td>
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</table>
Casualty and Liability Claims are a Huge Drain on the Industry

- For the 10 year period 2002-2011, more than $4.1 Billion was spent on casualty and liability claims
- For many self-insured transit agencies these expenses are direct “out-of-pocket”
- Large reserves for claims must be budgeted
- Claims experience also is reflected in insurance premiums
- There are gaps in data reporting
Potential Impact for Transit – Level 2 Automation – Claims Reduction

- Pedestrian and Bicycle Detection
- Autonomous Emergency Braking
- Lane-centering
- Blind-spot Monitoring
- Adaptive Cruise Control
The **Cost** of Installing an Active Collision Avoidance System on a Bus Could be Recovered in as Little as **One Year** Through Reductions in Casualty and Liability Claims
Potential Impact for Transit – Level 3 Automation

- Co-operative Adaptive Cruise Control
- Lane-centering
- Precision docking
- **Increased capacity in high-volume bus corridors**
A Capacity Bonus for NJ TRANSIT
Exclusive Bus Lane (XBL) to New York City

Source: Port Authority of New York and New Jersey
Port Authority Bus Terminal (PABT)
New York City

Source: Google Maps 2013
Potential Increased Capacity of Exclusive Bus Lane (XBL) Using Cooperative Adaptive Cruise Control (CACC) (Assumes 45 toot (13.7 m) buses @ with 57 seats)

<table>
<thead>
<tr>
<th>Average Interval Between Buses (seconds)</th>
<th>Average Spacing Between Buses (ft)</th>
<th>Average Spacing Between Buses (m)</th>
<th>Buses Per Hour</th>
<th>Additional Buses per Hour</th>
<th>Seated Passengers Per Hour</th>
<th>Increase in Seated Passengers per Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6</td>
<td>2</td>
<td>3,600</td>
<td>2,880</td>
<td>205,200</td>
<td>164,160</td>
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<tr>
<td>2</td>
<td>47</td>
<td>14</td>
<td>1,800</td>
<td>1,080</td>
<td>102,600</td>
<td>61,560</td>
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<tr>
<td>3</td>
<td>109</td>
<td>33</td>
<td>1,200</td>
<td>480</td>
<td>68,400</td>
<td>27,360</td>
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<tr>
<td>4</td>
<td>150</td>
<td>46</td>
<td>900</td>
<td>180</td>
<td>51,300</td>
<td>10,260</td>
</tr>
<tr>
<td>5 (Base)</td>
<td>212</td>
<td>64</td>
<td>720</td>
<td>-</td>
<td>41,040</td>
<td>-</td>
</tr>
</tbody>
</table>
Potential Impact for Transit – Level 4 Automation

• Bus capable of fully automated operation
• Paired or bus “train” operation possible
• BRT systems can emulate rail in capacity at less cost
Connected Vehicle and Autonomous Driving Technology for Bus Platooning – Leader/Close-Follower Concept

Schematic – Wireless Short-Range Connections Between Busses Interface with Automated Driving and Passenger Systems Functions
Peak Period Operation of Two-Bus Platoon – One Operator Controls Two Buses for Added Capacity

Off-Peak – When Extra Capacity Is Not Needed, Follower Bus Can Be Parked to Save Fuel Cost
Opportunities for Autonomous Driving Technology in Transit - Recommendations

• Institutional Response

• Technological Response
Recommendation - Transit Institutional Response

• Promote shared-use autonomous cars as a replacement for transit on many bus routes and for service to persons with disabilities

• Exit markets where transit load factors are too low to justify operating a transit vehicle

• Concentrate transit resources in corridors where more traffic and parking will be too costly and too congested, and where transit can increase the people carrying capacity of a lane beyond that of a general traffic lane
Recommendation - Transit Institutional Response- Continued

• Focus attention on land use – work with partners to create Transit-Oriented Development that limits the need for driving and where trip-end density will provide enough riders

  – Create compact activity centers
  – Allow higher density
  – Promote mixed use development
  – Make streets pedestrian and bike friendly
  – Manage parking ratios and configuration
Recommendations - Transit
Technological Response

What do we need to do?
Prepare for Technological Evolution and Obsolescence

• Buses last from 12 to 18 years or more
• Computer technology becomes obsolete in 18 months to two years
• Expect to replace components and systems several times during the life of a bus
• Do not expect replacement parts to still be available
• Sometimes stuff does not work as expected
Federal Transit Administration Notice of Funding Availability

- Federal Register October 1, 2013
- Seeking Research Development Demonstration & Deployment Projects – 3 Categories
  - Operational Safety
  - Resiliency
  - All Hazards Emergency Response & Recovery
- $29 million available
- Grants from $500k to $5 million
- Open to anyone
- Deadline December 2, 2013
Proposal Title:
Application of Autonomous Collision Avoidance Technology to Transit Buses to Reduce Claims, Injuries and Fatalities

Submitted by
Princeton University
Alain L. Kornhauser, PhD, Principal Investigator

In association with:
Jerome M. Lutin, PhD, LLC
American Public Transportation Association
Greater Cleveland Regional Transit Authority
Washington State Transit Insurance Pool
1. Create a broad, inclusive stakeholder group from the transit industry to achieve a comprehensive view of the problem and potential solutions,

2. Conduct a research assessment to determine the potential for automated collision avoidance systems to reduce fatalities, injuries and claims

3. Develop functional requirements and standards to allow installation of autonomous collision avoidance technology (ACAT) and driver assist technology on new transit buses and **retrofit** of existing buses

4. Develop a prototype test bed that would allow developers of innovative collision avoidance and driver assist technologies to work with transit agencies and researchers to expedite development and deployment
Thank You

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