Smart Driving Technology: How it can Substantially Enhance the Quality of Life in New Jersey

by

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&

CARTS
Consortium for Autonomous Roadway
&
Transit Systems

Presented at

Choose: New Jersey’s Crashless Vehicle Roundtable Meeting
Princeton, NJ
July 31, 2013
Important Elements of Quality of Life
Quality of Life 101: Important Elements

• Environment
  – Clean air, water, ...

• Employment
  – “High Quality” Jobs
  – Correlated with Crime/Personal Safety

• Mobility
  – Safety, Efficiency, Equity, Comfort, Convenience, ...

• Main Premise:
  – Promoting the Adoption of Smart Driving Technology:
    • Creates “High Quality” Jobs, Improves Personal Safety
    • Improves Safety, Efficiency, Equity, Comfort, Convenience, ...
    • Improves the Environment
Where are We with Mobility?
The Automobile’s 1st 125 Years (1886-2011)

Delivered: Enormous Personal Freedom & Mobility

But...Safe Operation Requires Continuous Vigilance
We Love the Freedom & Mobility

But...**Continuous Vigilance** is an unrealistic requirement for drivers
Txtng while driving is out of control...
TravelTainment Industry Wants Everyone’s Attention
THE RELATIVE FREQUENCY OF UNSAFE
DRIVING ACTS
IN SERIOUS TRAFFIC CRASHES


Summary Technical Report

By D. L. Hendricks, Veridian Engineering, Inc.
J. C. Fell, Star Mountain, Inc.
M. Freedman, Westat, Inc.

"In 717 out of 723 crashes (99%), a driver behavioral error caused or contributed to the crash"

- DRIVER INATTENTION: 22.7%
- VEHICLE SPEED: 18.7%
- ALCOHOL IMPAIRMENT: 18.2%
- PERCEPTUAL ERRORS (e.g. looked, but didn’t see): 15.1%
- DECISION ERRORS (e.g. turned with obstructed view): 10.1%
- INCAPACITATION (e.g. fell asleep): 6.4%
### Early Estimate of Motor Vehicle Traffic Fatalities in 2012

<table>
<thead>
<tr>
<th>Quarter</th>
<th>1st Quarter (Jan-Mar)</th>
<th>2nd Quarter (Apr-Jun)</th>
<th>3rd Quarter (Jul-Sep)</th>
<th>4th Quarter (Oct-Dec)</th>
<th>Total (Full Year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>9,239 [ +3.5%]</td>
<td>11,005</td>
<td>11,897</td>
<td>11,369</td>
<td>43,510</td>
</tr>
<tr>
<td>2006</td>
<td>9,558 [ +3.5%]</td>
<td>10,942 [-0.6%]</td>
<td>11,395 [-4.2%]</td>
<td>10,813 [-4.9%]</td>
<td>42,708 [-1.8%]</td>
</tr>
<tr>
<td>2007</td>
<td>9,354 [-2.1%]</td>
<td>10,611 [-3.0%]</td>
<td>11,056 [-3.0%]</td>
<td>10,238 [-5.3%]</td>
<td>41,259 [-3.4%]</td>
</tr>
<tr>
<td>2008</td>
<td>8,459 [-9.6%]</td>
<td>9,435 [-11.1%]</td>
<td>9,947 [-10.0%]</td>
<td>9,582 [-6.4%]</td>
<td>37,423 [-9.3%]</td>
</tr>
<tr>
<td>2009</td>
<td>7,552 [-10.7%]</td>
<td>8,975 [-4.9%]</td>
<td>9,104 [-8.5%]</td>
<td>8,252 [-13.9%]</td>
<td>33,883 [-9.5%]</td>
</tr>
<tr>
<td>2010</td>
<td>6,755 [-10.6%]</td>
<td>8,522 [-5.0%]</td>
<td>9,226 [+1.3%]</td>
<td>8,496 [+3.0%]</td>
<td>32,999 [-2.6%]</td>
</tr>
<tr>
<td>2011</td>
<td>6,708 [-0.7%]</td>
<td>8,216 [-3.6%]</td>
<td>8,960 [-2.9%]</td>
<td>8,483 [-0.2%]</td>
<td>32,367 [-1.9%]</td>
</tr>
<tr>
<td><strong>2012†</strong></td>
<td><strong>7,550 [+12.6%]</strong></td>
<td><strong>8,650 [+5.3%]</strong></td>
<td><strong>9,250 [+3.2%]</strong></td>
<td><strong>8,630 [+1.7%]</strong></td>
<td><strong>34,080 [+5.3%]</strong></td>
</tr>
</tbody>
</table>
Response is Laudable

But... Not Likely to be Effective
What About Buses?
### NTD 2011 Bus Casualty and Liability Expense for All Transit Agencies

<table>
<thead>
<tr>
<th>Casualty and Liability Amount</th>
<th>General Administration</th>
<th>$432,228,288</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle Maintenance</td>
<td></td>
<td>$50,847,722</td>
</tr>
<tr>
<td>Sub-Total Casualty and Liability</td>
<td></td>
<td>$483,076,010</td>
</tr>
</tbody>
</table>

| Maximum Available Buses       | 59,871                  |
| Sub-Total Casualty and Liability Amount Per Bus | $8,069                  |

Credit to: Dr. Jerome Lutin
## 2002-2012 Safety and Claims Data for Service Directly Operated by NJ TRANSIT Bus Operations

<table>
<thead>
<tr>
<th>Category</th>
<th>Total for Period 2002-2012</th>
<th>Annual Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incidents</td>
<td>3,077</td>
<td>280</td>
</tr>
<tr>
<td>Collisions</td>
<td>1,753</td>
<td>159</td>
</tr>
<tr>
<td>Injuries</td>
<td>4,417</td>
<td>402</td>
</tr>
<tr>
<td>Fatalities</td>
<td>25</td>
<td>2.3</td>
</tr>
<tr>
<td>Estimated Bus Claims</td>
<td>$112,400,000</td>
<td>$10,220,000</td>
</tr>
<tr>
<td>Peak Buses</td>
<td>n/a</td>
<td>1,769</td>
</tr>
<tr>
<td>Total Buses Operated</td>
<td>n/a</td>
<td>2,106</td>
</tr>
<tr>
<td>Estimated Bus Claims/Total Buses Operated</td>
<td>$53,305</td>
<td>$4,846</td>
</tr>
</tbody>
</table>

Credit to: Dr. Jerome Lutin
What About Automation?
Up to today:
Primarily concerned with safety standards associated with Crash Mitigation
(air bags, seat belts, crash worthiness, ...)

Click image to view video
Preliminary Statement of Policy Concerning Automated Vehicles

Extending its vehicle safety standards from **Crash Mitigation** to **Crash Avoidance** with Aim at Full Self-Driving Automation

**Level 0 (No automation)**
The human is in complete and sole control of safety-critical functions (brake, throttle, steering) at all times.

**Level 1 (Function-specific automation)**
The human has complete authority, but cedes limited control of certain functions to the vehicle in certain normal driving or crash imminent situations. Example: electronic stability control

**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.
Enables hands-off-wheel and foot-off-pedal operation.
**Driver still responsible for monitoring and safe operation and expected to be available at all times to resume control of the vehicle.**
Example: adaptive cruise control in conjunction with lane centering

**Level 3 (Limited self-driving)**
Vehicle controls all safety functions under certain traffic and environmental conditions.
Human can cede monitoring authority to vehicle, which must alert driver if conditions require transition to driver control.
**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.
The human provides destination or navigation input but is not expected to be available for control during the trip. **Vehicle may operate while unoccupied.**
Responsibility for safe operation rests solely on the automated system
Preliminary Statement of Policy Concerning Automated Vehicles

What the Levels Deliver:

Levels 1 -> 3: Increased Safety, Comfort & Convenience

Level 4 (Driverless Opportunity): Efficiency, Equity
Revolutionizes “Mass Transit” by enabling the provision of mobility without incurring a Labor Cost
Where Are We Now?
Available in ShowRooms for Consumers
“Level 2- Combined Automation with Constant Vigilance”
Driver Assistance Package

- Active Blind Spot Assist
- Active Lane Keeping Assist
- DISTRONIC PLUS® with Steering Assist
- PRE-SAFE® Brake with Cross-Traffic Assist
- PRE-SAFE® PLUS

$2,800

Introduction dates vary. See your dealer for availability.

BAS-Plus

Active Lane-Keeping Assist (braking not steering 😎)

Intelligent Drive (active steering 😎)

Volvo Truck Emergency braking
History and Development of DISTRONIC:
Price reduction, intelligent packaging and availability cross-carline

**MY 2000**
Introduce DISTRONIC Adaptive Cruise Control
In package for **+$3,700**
Only available on S/CL

**MY 2006 - Current**
DISTRONIC PLUS
Autonomous Braking Intervention
In “Driver Assistance Package” with Blind Spot Assist/Lane Keeping Assist **$2,950**
Available Cross-Carline on almost every model

**MY 2014 - Future**
Enhancements to Driver Asst. Package
• Steering Assist
• BAS with Cross-Traffic Assist
• PRE-SAFE Brake with Pedestrian Detection
• PRE-SAFE PLUS – protection during rear collisions

In “Driver Assistance Package” with Blind Spot Assist/Lane Keeping Assist **+$2,800**
Only available on S/E
Estimated Safety Benefits

- Analysis based on NHTSA
- For Highway relevant scenarios
  - 71% fewer crashes
  - 65% fewer injuries
  - 81% fewer fatalities

### Liabilities Associated with Road Accidents Involving Fatalities and Injuries:

<table>
<thead>
<tr>
<th>Incident</th>
<th>Av Liability ('000$)</th>
<th>Number: (2011)</th>
<th>Annual Liability ('000$)</th>
<th>Liability Per Driver - Human Driver (5.729M drivers)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>x1,000</td>
<td>xBillion</td>
<td>5.729M</td>
<td>Annual</td>
</tr>
<tr>
<td>Fatalities</td>
<td>$3,200.0</td>
<td>627</td>
<td>$2.01</td>
<td>$350</td>
</tr>
<tr>
<td>Injuries</td>
<td>$68.2</td>
<td>43,329</td>
<td>$2.96</td>
<td>$516</td>
</tr>
<tr>
<td>Total</td>
<td>$4.96</td>
<td></td>
<td></td>
<td>$866</td>
</tr>
</tbody>
</table>

### Liabilities New Jersey Google Cars

<table>
<thead>
<tr>
<th>Incident</th>
<th>Av Liability ('000$)</th>
<th>Number: (2011)</th>
<th>Annual Liability ('000$)</th>
<th>Liability Per Driver - Google Car Driver (5.729M drivers)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Annual</td>
</tr>
<tr>
<td>Fatalities</td>
<td>$3,200.0</td>
<td>119</td>
<td>$0.38</td>
<td>$67</td>
</tr>
<tr>
<td>Injuries</td>
<td>$68.2</td>
<td>15,165</td>
<td>$1.03</td>
<td>$181</td>
</tr>
<tr>
<td>Total</td>
<td>$1.42</td>
<td></td>
<td></td>
<td>$247</td>
</tr>
</tbody>
</table>

### Safety Savings New Jersey

<table>
<thead>
<tr>
<th>Incident</th>
<th>Av Liability ('000$)</th>
<th>Number: (2011)</th>
<th>Annual Liability ('000$)</th>
<th>Liability Savings Per Google Car Driver</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Annual</td>
</tr>
<tr>
<td>Fatalities</td>
<td>$3,200.0</td>
<td>508</td>
<td>$1.63</td>
<td>$284</td>
</tr>
<tr>
<td>Injuries</td>
<td>$68.2</td>
<td>28,164</td>
<td>$1.92</td>
<td>$335</td>
</tr>
<tr>
<td>Total</td>
<td>$3.55</td>
<td></td>
<td></td>
<td>$619</td>
</tr>
</tbody>
</table>
With Mercedes the Market Leader in “Level 2-” and an incremental price tag that can be absorbed by a Price Leading Insurance Company, then other automakers will be enticed to follow which should lead to:

- Viral adoption by the car buying public
- “Moore’s Law type of price/performance improvement
- Market-driven Transition to “Level 2” and “Level 3” at same or even lower price structure
- Adoption and enhancement rates that are comparable to that enjoyed by airbags
Action Item

• Observation: New Jersey is the home of NAHQ of:
  – Mercedes, BMW & Subaru

• Action Item:
  – Create an environment that is conducive for these companies (and others) to successfully enhance, test and accelerate the adoption of SmartDriving Technologies
Action Item

• Observation: In 2 Years, NJ Transit will initiate a new Bus Replacement Cycle (That will extend for about 15 years)

• Action Item:
  – Ensure that the Procurement Specifications include “Level 2” SmartDriving Technologies
Where Are We Now?  
R&D  

“Level 3 Semi Self-Driving Automation”
Has drive ~ 500,000 miles with “Level 3: Limited Self-Driving Automation”

But...Hardware too expensive and Reliance on 3D Google Maps is “non-elegant”

http://www.youtube.com/watch?v=cdgQpa1pUUE
Where Are We Now?

Operational in Exclusive Environments

“Level 4 Full Self-Driving Automation”
Now exist in essentially every **Major Airport**
and a growing number of Driverless Metros
Today...
Remains a critical mobility system & expansion being planned

> 25M Driverless VMT
Zero serious accidents
And Today...

• Masdar & Heathrow are operational

> 1M Driverless VMT
Zero accidents
• **Autonomous Buses at La Rochelle** (CyberCars/Cybus/INRIA) [http://www.youtube.com/watch?v=72-PISFwP5Y](http://www.youtube.com/watch?v=72-PISFwP5Y)
  
  – Simple virtual non-exclusive roadway
  
  • Virtual vehicle-based longitudinal (collision avoidance) and lateral (lane keeping) systems

This is actually “Level 4 Full Self-Driving Automation”

Very Slow Speed (~ 10 mph); “Limited Pedestrian Environment”
– Driverless Trucks in Australian & Chilean Mines
Where Are We Committed to Go?

“Level 4 Driverless in Mixed Environment”

Google has stated* that by 2018 Google will make available to the public “Level 4” technology in a mixed environment.

*Anthony Levandowski reaffirmed last week @ Stanford TRB Workshop Sergie Brin’s statement last year.
• Observation: Ft Monmouth may well be one of the most hospitable sites for Google to implement its intention
Near-term Opportunity for a Substantive Extension of Autonomous Transit

• Specific: General Mobility for Fort Monmouth Redevelopment
  – Currently: Decommissioned Ft. Monmouth is vacant.
    • Ft. Monmouth Economic Revitalization Authority (FMERA) is redeveloping the 3 sq. mile “city”
    • Focus is on attracting high-tech industry
    • The “Fort” needs a mobility system.
    • FMEDA is receptive to incorporating an innovative mobility system
    • Because it is being redeveloped as a “new town” it can accommodate itself to be an ideal site for testing more advanced driverless systems.
Action Item

• Observation: “Level 4” may well be upon us in less than 5 years and our planning, operational and maintenance entities are largely unaware

• Action Item: Ensure that NJTPA, DVRPC, PANYNJ, DRPA, NJTP, NJDoT, NJTransit, etc. are all aligned to the Opportunities and Challenges associated with the rapid evolution of these technologies
Discussion!

Thank You

alaink@princeton.edu

www.SmartDrivingCar.com