Application of Autonomous Vehicle Technology to Public Transit

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Transit and Autonomous Vehicle Technology

- 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 can avoid congestion, use time on transit to read, work or sleep, and can avoid parking costs and hassles at their destinations.

NHTSA Preliminary Policy on Automated Vehicles

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
- Adaptive Cruise Control
- Lane-keeping

- 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
- Drivers safely can do some non-driving activities
- Increases in longer auto commuting trips

Impact of Level 4 Technology - Cars

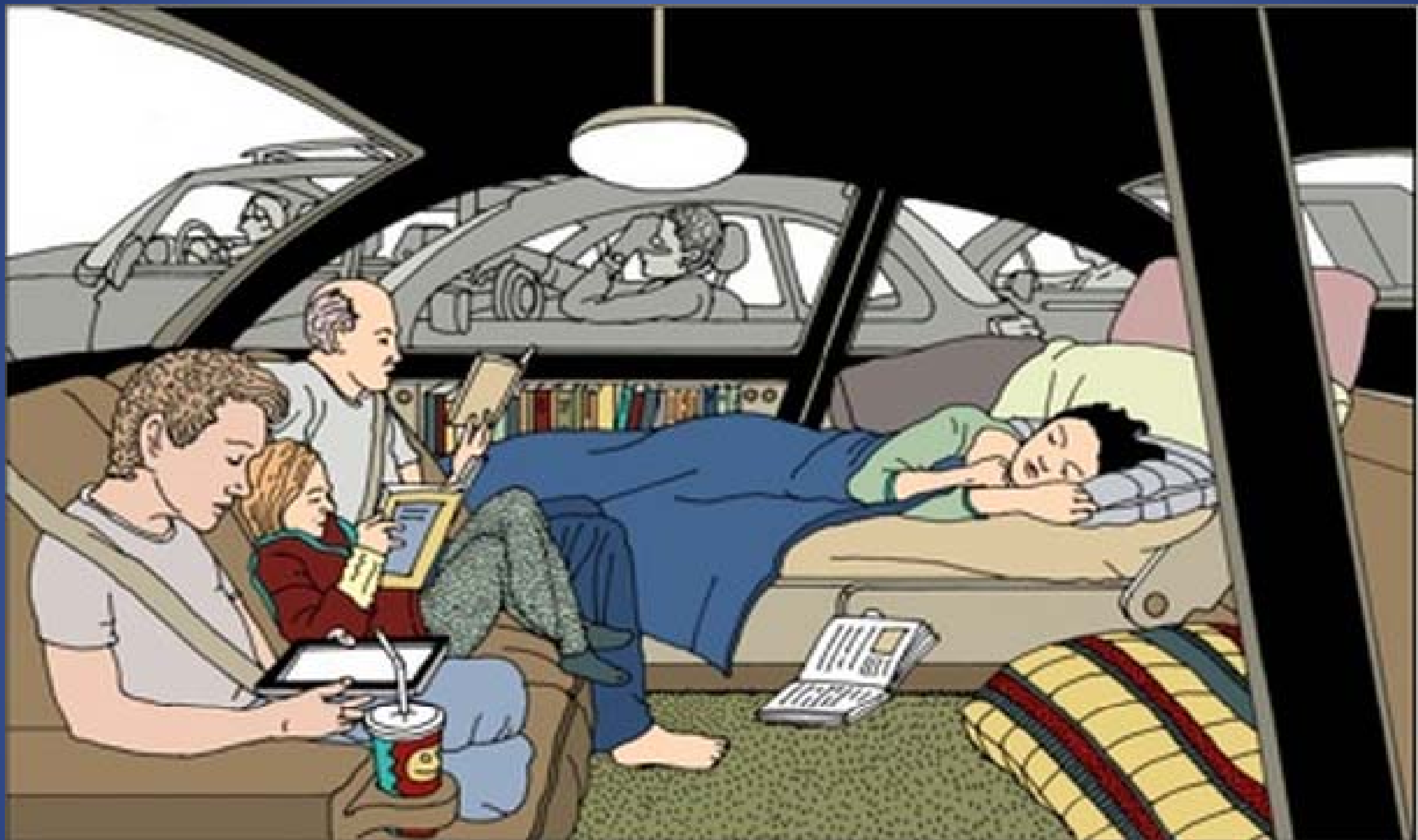
- Unrestricted self-driving
- Empty vehicle movements permitted

- Growth in shared automated 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

Could This be the Future of Self-Driving Cars?

Interstate EXT in Jet Black

The self-driving car as an extension of living or working space



2013: The driverless car can become a family living room. “Driving Sideways,” Allison Arieff, *NY Times*.

Impact of Self-Driving Cars 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. (30.9 million in US, includes 24.8 million age 10-15 and 6.1 million visually impaired adults)

- 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.

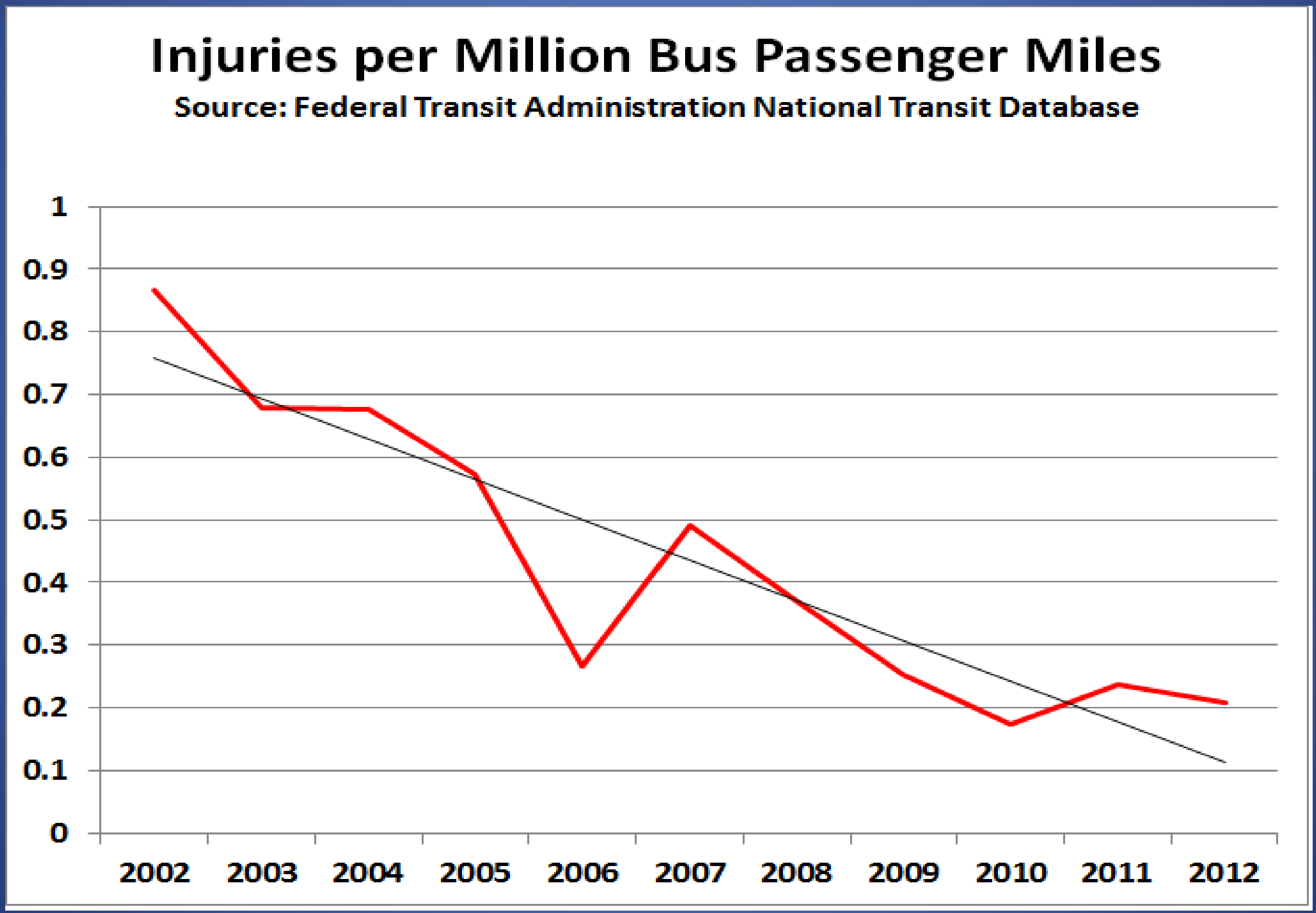
- So the impact on many transit systems could be huge.

Potential Applications of Autonomous Driving Technology to Bus Transit

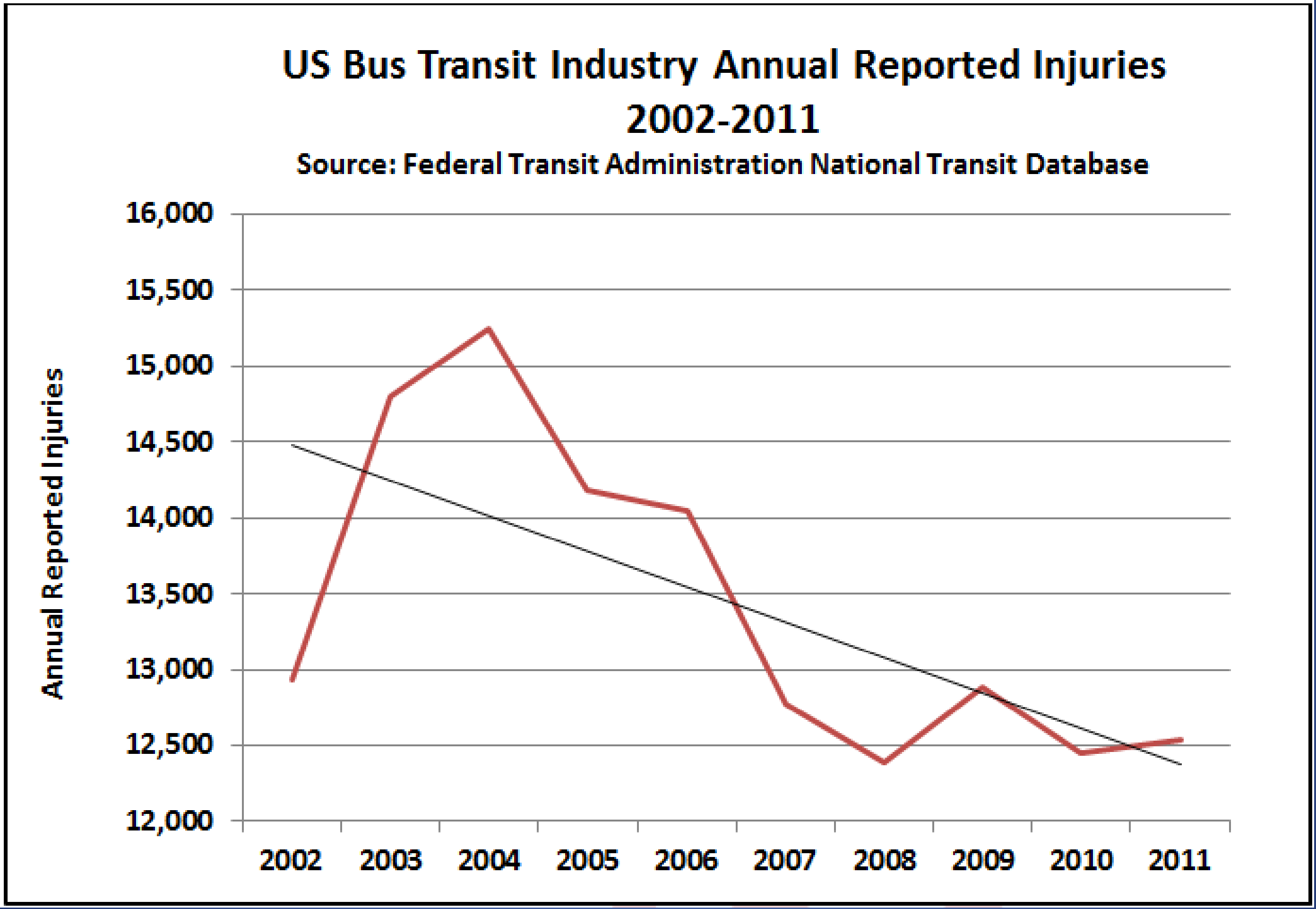
How can transit benefit?

Use Autonomous Collision Avoidance Technology to Address a BIG CURRENT Problem

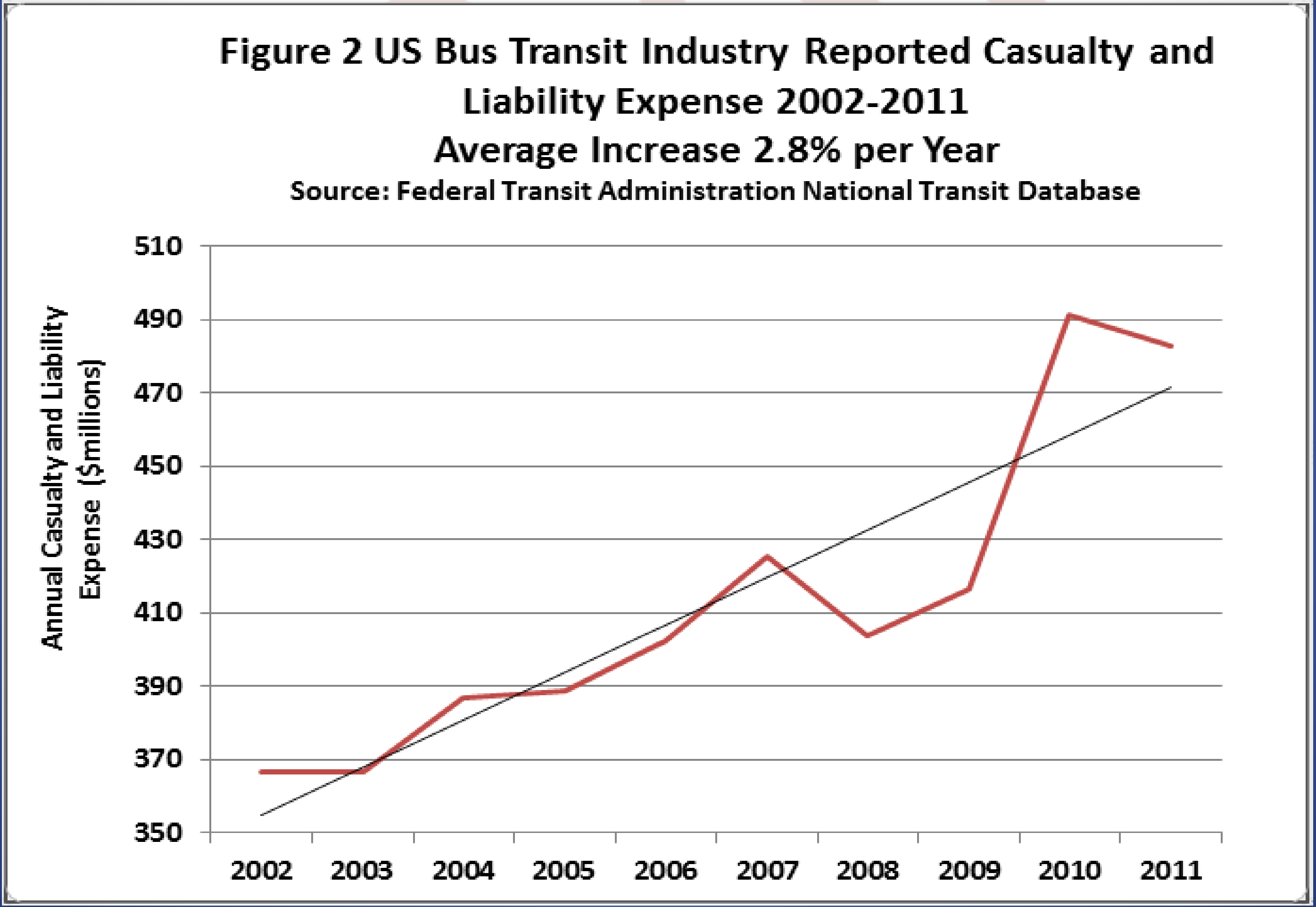
Good News! Travel by Bus is getting safer!



Good News! Injuries have been trending down!



Terrible News! Claims are going through the roof!



NTD 2011 Bus Casualty and Liability Expense for All Transit Agencies		
Casualty and Liability Amount	General Administration	**$432,228,288**
	Vehicle Maintenance	**$50,847,722**
	Sub-Total Casualty and Liability	**$483,076,010**
Maximum Available Buses		**59,871**
Sub-Total Casualty and Liability Amount Per Bus		**$8,069**

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

- Blind spot monitoring (for vehicles and pedestrians)
- Driver fatigue and attentiveness monitoring
- Adaptive Cruise Control
- Autonomous emergency braking
- Lane keeping assistance
- Collision warning and mitigation
- Obstacle detection

The Cost of Installing an Autonomous 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 keeping
- Precision docking

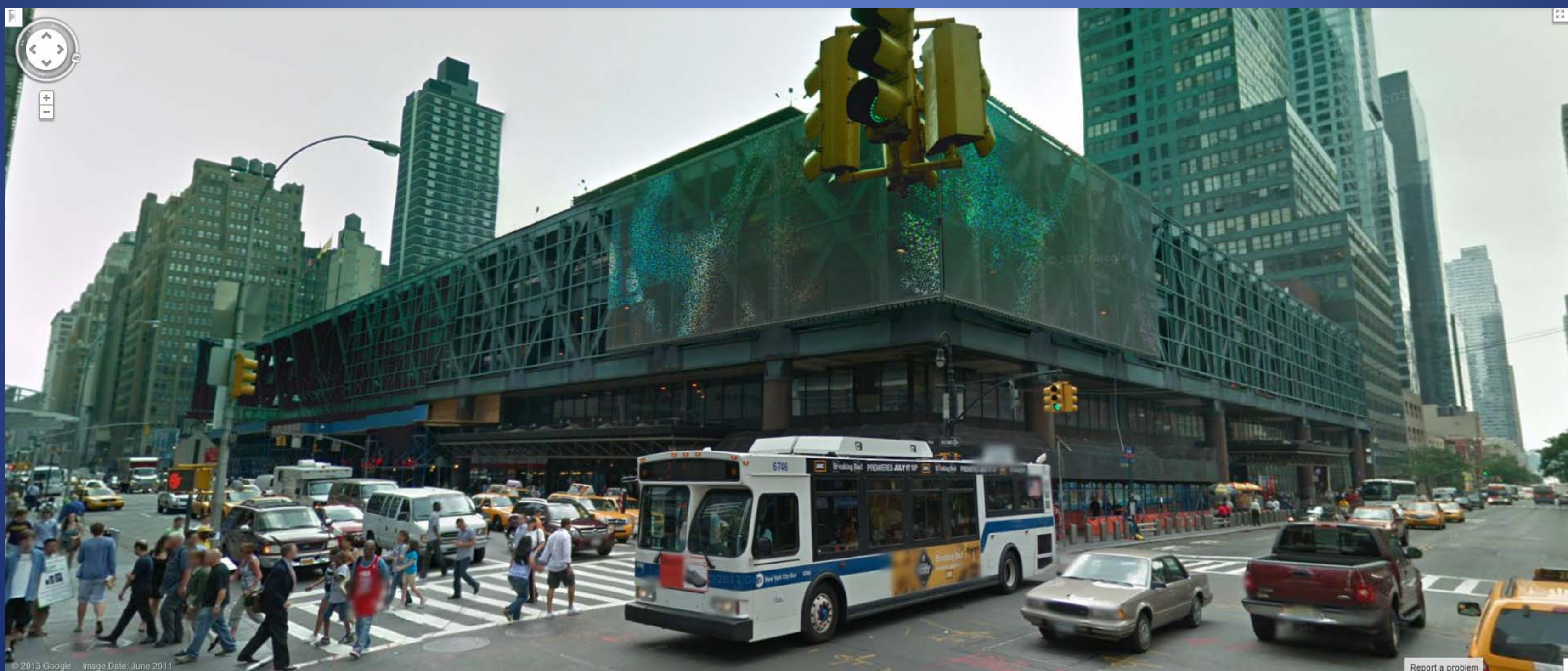
- Increased capacity in high volume bus corridors

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)

Average Interval Between Buses (seconds)	Average Spacing Between Buses (ft)	Average Spacing Between Buses (m)	Buses Per Hour	Additional Buses per Hour	Seated Passengers Per Hour	Increase in Seated Passengers per Hour
1	6	2	3,600	2,880	205,200	164,160
2	47	14	1,800	1,080	102,600	61,560
3	109	33	1,200	480	68,400	27,360
4	150	46	900	180	51,300	10,260
5 (Base)	212	64	720	-	41,040	-

Light Rail is great, but can be $$ expensive

Bus Rapid Transit is much less expensive to build but has less capacity

Potential Impact for Transit – Level 4 Automation

- Bus capable of fully automated operation
- Unstaffed non-revenue 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

< connected>

Bus #2 Follower - No Operator on Board

Bus #1 Leader – Operator on Board

Peak Period Operation of Two-Bus Platoon – One Operator Controls Two Buses for Added Capacity

Bus 2 Parked

Bus 1 Operates as Single Unit

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 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

Need Open Architectures and Standards

- Avoid problems of legacy systems and sole source procurements
- Modular systems and components
- Standard interfaces between systems and components
- Multiple sources and innovation from vendors
- “Plug and play”

Proposal Title:
Application of Autonomous Collision Avoidance Technology to Transit Buses to Reduce Claims, Injuries and Fatalities

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Thank You

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