Attempts at AVs Are Not New
Agenda

• Brief Primer on AVs

• Planning for AVs

• Work in Toronto

• Moving Forward
NHTSA Levels of Automation

<table>
<thead>
<tr>
<th>Levels of Automation</th>
<th>Human Driver Monitors Environment</th>
<th>System Monitors Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 No Automation</td>
<td>0: The absence of any assistive features such as adaptive cruise control.</td>
<td>0: The true electronic chauffeur: retains full vehicle control, needs no human backup and drives in all conditions.</td>
</tr>
<tr>
<td>1 Driver Assistance</td>
<td>1: Systems that help drivers maintain speed or stay in lane but leave the driver in control.</td>
<td>1: Automated systems that drive and monitor the environment but rely on a human driver for backup.</td>
</tr>
<tr>
<td>2 Partial Automation</td>
<td>2: The combination of automatic speed and steering control—for example, cruise control and lane keeping.</td>
<td>2: Automated systems that do everything—no human backup required—but only in limited circumstances.</td>
</tr>
</tbody>
</table>

- **Who steers, accelerates and decelerates**
  - 0: Human driver
  - 1: Human driver
  - 2: System
  - 3: System
  - 4: System
  - 5: System

- **Who monitors the driving environment**
  - 0: Human driver
  - 1: Human driver
  - 2: Human driver
  - 3: System
  - 4: System
  - 5: System

- **Who takes control when something goes wrong**
  - 0: Human driver
  - 1: Human driver
  - 2: Human driver
  - 3: System
  - 4: System
  - 5: System

- **How much driving, overall, is assisted or automated**
  - 0: None
  - 1: Some driving modes
  - 2: Some driving modes
  - 3: Some driving modes
  - 4: Some driving modes
  - 5: All driving modes
Self-Contained “Seeing”
The Promise of AVs

- Improved road safety
- Economic benefits of less lost productivity
- More equitable access for all
- Increased travel options
- Reduced stress of driving
- Reduced fuel consumption and emissions
- In the future, greater throughput, reducing congestion
Two Paths

Private Ownership Model

- Driven by Auto Industry
- Incremental Moves in Functionalities
- Mostly Privately Owned
- Here Today

Shared Mobility Model
(MaaS/TaaS/Robo-taxis)

- Driven by Tech and TNCs
- Jump to Fully Automated
- Transportation-as-a-Service
- A few (or many, many) years away
## Roles and Responsibilities

<table>
<thead>
<tr>
<th>Topic</th>
<th>Federal</th>
<th>State</th>
<th>Regions</th>
<th>Industry</th>
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<tr>
<td>Business Models</td>
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<td>Business Regulations</td>
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<tr>
<td>Alignment with Planning</td>
<td>●</td>
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<td>Public Transit Applications</td>
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<td>○</td>
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</tbody>
</table>
Complexities of AVs

- Technology
- Standards
- Ethics
- Liability
- Planning
- Impact to Jobs
- Security
- Safety
- Economics
- Data
- Communications Systems
- Infrastructure
- Managing the Transition
- Consumer Preference
- Regulation
- Enforcement
- Privacy
- Human Factors
- Business Models
Complexities of AVs

Planning
Planning for AVs

• It’s no longer “if”, but “when” and “how”

• It will likely be very, very disruptive

• Over time, will likely transform mobility as we know it

• Will impact how we design, build and operate not only roads, but likely all aspects of our transportation system
Questions on Planning for AVs

- Will they increase or decrease trip-making?
- Will they increase or decrease the distance of trip-making?
- What will be their impact to transit?
- Will it be complementary or supplementary?
- Will we see more VMT or less VMT?
- Will we see more congestion or less congestion?
- Will they support or undermine land use polices?
- Will they impact locational choices of residents and employers?
- How will they impact the economy, industries and goods movement?
Key Unknowns

- Speed of Technological Advancement
- Economics
- Public Acceptance
- Political Support
- Market for a Shared Model
Speed of Technological Advancement

‘What we’ve got will blow people’s minds, it blows my mind… it’ll come sooner than people think’

– Elon Musk on Tesla Fully Autonomous Car, Electrek, August 4, 2016

Uber starts self-driving car pickups in Pittsburgh

– Tech Crunch, September 14, 2016

Google starts deploying its self-driving Chrysler Pacifica minivans: first prototypes spotted

– Electrek, October 9, 2016
## Speed of Technological Advancement

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<tr>
<td>Audi</td>
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<td>3</td>
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<td>3+</td>
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<td>Ford</td>
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<td>4/5</td>
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<td>Honda</td>
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<td>KIA</td>
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<td>3</td>
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<tr>
<td>Uber</td>
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<td>4/5</td>
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</table>

Source: Mashable
Economics

Cost per Mile

Taxi

Shared AV

Source: ARK Investment Management
Economics

Cost per Mile: Shared vs. Owned

Source: Morgan Stanley (2016)
Economics

Robo-Taxis Could Replace Traditional Taxis and Cars in Megacities

New York City case study

<table>
<thead>
<tr>
<th>Mode</th>
<th>Average number of people per vehicle</th>
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</thead>
<tbody>
<tr>
<td>Public transport</td>
<td>NA</td>
</tr>
<tr>
<td>Vehicle ownership</td>
<td>1.6</td>
</tr>
<tr>
<td>Taxi</td>
<td>1.2</td>
</tr>
<tr>
<td>Robo-taxi</td>
<td>1</td>
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</table>

Sources: BCG analysis; U.S. Department of Transportation; NYC Metropolitan Transportation Authority; NYC Taxi & Limousine Commission; Kelley Blue Book.

- Does not consider the impact of convenience and shorter wait and commute times.
- Non-fare-based operating funds received from New York City transit; local, state, and federal sources; and other sources.
- Annual fare revenues per passenger mile traveled.

Source: Boston Consulting Group (2016)
Economics

Figure 3: Average Unlinked Passenger Trip Length, 2011

Source: APTA 2011 Fact Book
Economics

Illustrative Mode Share at Various per Mile Prices

<table>
<thead>
<tr>
<th>Price</th>
<th>Mode Share</th>
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<td>$1.00</td>
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</table>

- Shared AV
- Cycling
- Walk
- Transit
- Private Auto
Public Acceptance – Trust of AVs

58% say they would take a ride in a fully self-driving car

<table>
<thead>
<tr>
<th>Country</th>
<th>Very likely</th>
<th>Likely</th>
<th>Neutral</th>
<th>Unlikely</th>
<th>Very unlikely</th>
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<tbody>
<tr>
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<td>19%</td>
<td>11%</td>
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<tr>
<td>China</td>
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<td>43%</td>
<td>16%</td>
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<td>France</td>
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<tr>
<td>India</td>
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<td>3%</td>
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<tr>
<td>Japan</td>
<td>12%</td>
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<tr>
<td>Netherlands</td>
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<td>16%</td>
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<tr>
<td>Singapore</td>
<td>31%</td>
<td>31%</td>
<td>24%</td>
<td>8%</td>
<td>7%</td>
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<tr>
<td>UAE</td>
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<td>UK</td>
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<tr>
<td>US</td>
<td>27%</td>
<td>17%</td>
<td>12%</td>
<td>18%</td>
<td></td>
</tr>
</tbody>
</table>

... but only 35% of parents would let their children ride alone in one

<table>
<thead>
<tr>
<th>Country</th>
<th>Very likely</th>
<th>Likely</th>
<th>Neutral</th>
<th>Unlikely</th>
<th>Very unlikely</th>
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<tbody>
<tr>
<td>Global</td>
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<td>22%</td>
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<tr>
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<td>12%</td>
<td>15%</td>
<td>22%</td>
<td>21%</td>
<td>30%</td>
</tr>
</tbody>
</table>

Public Acceptance – Shared Use

Political Support

Helsinki “announced plans to transform its existing public transport network into a comprehensive, point-to-point "mobility on demand" system by 2025”

– July 10, 2014 • theguardian.com

L.A. Mayor Eric Garcetti:
We Will Be the First City to Do Autonomous Vehicles Right

– September 29, 2014 • citylab.com

Regulations force Uber, Lyft out of Austin...

– May 15, 2016 • Cointelegraph.com
Political Support
Will a Shared Model Work?

The Economics need to create a market

- This will influence speed of privates and extent of coverage

There Needs to be a Willing Client Base

- If for cultural, demographic purposes there is reluctance
- Likely wealthy, tech-supportive, tech-savvy, public-transit friendly cities and regions

Political Support

- Barriers could be created if opposed
- Economics will improve if vehicle size and weight can come down. This will likely only happen in AV-only environments – facilities or zones
Key Unknowns

- Speed of Technological Advancement
- Economics
- Public Acceptance
- Political Support
- Market for a Shared Model
Key Unknowns

Without a clear understanding of the future, how do we plan?
Driving Changes: Automated Vehicles in Toronto

Discussion paper

David Ticoll
Distinguished Research Fellow
Innovation Policy Lab
Munk School of Global Affairs
University of Toronto

October 15, 2015
Three Scenarios

Ownership Leads

Mixed

Shared Leads
## Impacts of Private vs. Mixed vs. Shared

<table>
<thead>
<tr>
<th>Impact</th>
<th>Private</th>
<th>Mixed</th>
<th>Shared</th>
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<tbody>
<tr>
<td>Collisions</td>
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<td>Congestion</td>
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<tr>
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<td>Equitable Mobility</td>
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<td>🔺</td>
<td>?</td>
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<tr>
<td>Cost of Private/Semi-private Vehicular Travel</td>
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<td>🔻</td>
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<tr>
<td>Carpooling</td>
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<td>?</td>
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<td>Trend of Intensification</td>
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<td>?</td>
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<td>Parking Demand</td>
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<td>🔻</td>
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<tr>
<td>Right-of-way allocated for vehicles</td>
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<td>🔻</td>
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<td>Residential Building/Lot Size</td>
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<td>🔻</td>
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<tr>
<td>Impervious Areas</td>
<td>?</td>
<td>🔻</td>
<td>🔻</td>
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</tbody>
</table>
How is this Unfolding?

• Discussions are happening primarily at the federal and state levels

• Economic development considerations have seemed to be a significant driver of the policy discussions

• Because of the potential “winner take all”, stakes are high, companies are moving fast…. 
Goals of Cities and Regions

• Safety
• Accessibility
• Mobility
• Economic Opportunity
• Quality of Life
• High-Quality Natural and Built Form
• Environmental Sustainability
• Social Inclusion
• Financial Sustainability
Toronto Working Group

- Transportation
- Economic Development
- City Planning
- Toronto Transit Commission

- Licensing & Standards
- Police Services
- Parking Authority
- Parking Enforcement
- Revenue

- Employment Services
- Fleet
- Budget
- City IT
- Privacy Commission
Approaches Cities Could Take

- Actively Discourage
  - Prohibit or Restrict AVs or TaaS

- Passive
  - Wait and See

- Actively Encourage
  - Outfit signals with transmitters
  - Map curbside regulations
  - Conduct a pilot or demonstration
  - Tax credits
  - Create AV-only zones
  - Create AV-only facilities
Toronto’s Draft Vision Statement

Toronto needs to harness the potential of AVs to help us create the City that we want.
### GOAL 2

**PREPARATION**

To prepare for the arrival of AVs no matter when and how they are introduced and adopted.

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<tr>
<th>Objectives</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
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<tbody>
<tr>
<td><strong>2.1 Improve Understanding and Clarity</strong></td>
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<tr>
<td>2.1.1 Create and maintain a common lexicon of terms and concepts for consistent understanding.</td>
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<tr>
<td>2.1.2 Identify and understand the broad range of potential implications of AVs.</td>
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<tr>
<td>2.1.3 Define the interests of Transportation Services in vehicle automation across all sections and districts.</td>
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<tr>
<td>2.1.4 Undertake public opinion research to assess and establish baseline attitudes toward AVs, expectations of government, and how AVs may influence travel behaviour and modal choice in the Greater Toronto and Hamilton Area.</td>
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<tr>
<td>2.1.5 Develop detailed scenarios – ranging from no change, to a completely new transportation paradigm – for consistent forecasting and planning pathways; use these scenarios on a scale of possible to probable.</td>
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<tr>
<td>2.1.5.1 In partnership with the Organization for Economic Cooperation and Development's International Transportation Forum, undertake a modelling exercise to further develop and refine potential scenarios.</td>
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<tr>
<td><strong>2.2 Prepare a Foundation</strong></td>
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<tr>
<td>2.2.1 Improve the management and current function of traffic control devices, particularly signage and pavement markings.</td>
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</tr>
<tr>
<td>2.2.1.1 Increase asset management and lifecycle analysis of traffic control devices, particularly signage and pavement markings.</td>
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<tr>
<td>2.2.1.2 Review and consider the need for pavement markings on local streets.</td>
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<td>2.2.1.3 Improve the visibility of traffic control devices under all weather conditions.</td>
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<tr>
<td>2.2.2 Work with mapping providers to investigate the potential for AV-supportive mapping to be conducted in Toronto, and determine the appropriate role for Transportation Services and the City.</td>
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<tr>
<td>2.2.3 Begin to engage with technology providers, automobile manufacturers, and transportation network companies to discuss municipal preparations and potential pathways.</td>
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Are GTHA Residents Ready for Autonomous Vehicles?

Survey Overview

November 24, 2016

Sweet, Matthias; Laidlaw, Kailey; Olsen, Tyler
Learning Objectives

• How likely are individuals to adopt Driverless Cars?

• How are individuals likely to change their travel behavior?

• How are different neighborhoods and demographic groups likely to respond differently?

• What role can public policy play in managing the future of driverless cars?
Population and Geographic Location

• 3,201 individuals surveyed, aged 18-75

• Greater Toronto-Hamilton Area Residences:
  • Toronto
    • Downtown
    • Etobicoke
    • Scarborough
    • North York
  • Hamilton
  • Peel Region
  • York Region
  • Durham Region
  • Halton Region
Survey Overview

- Household and Individual Demographics
- Employment and Commuting
- Residence & Household
- Vehicles Ownership and Daily Travel
- General Attitudes
- Driverless Car Attitudes
- Driverless Cars and Public Policy
Challenges in Shaping Policy

• Companies don’t want to deal with municipalities, and are engaging at the only the most superficial level....

• Complex issue, lots of moving unknowns, we don’t have a clear understanding, so it’s difficult to advise our elected officials and boards

• Currently lacking the methods and tools to help us better inform the discussion
Scenario Planning

Speed of Technological Advancement

Economics

Public Acceptance

Political Support

Market for a Shared Model
Scenarios – Shared Leads

- Walking
- Transit
- Shared AV
- Non-AV
- Private AV

Legend:
- Non-AV
- Private AV
- Shared AV
- Transit
- Walk
- Cycling
Scenarios – Private Leads

Over time, the percentage of private autonomous vehicles (AV) is projected to increase, while the percentages of non-AV, shared AV, transit, and walking decrease. The chart shows a gradual shift towards private AVs from 2017 to 2057.

Key categories:
- **Non-AV**
- **Private AV**
- **Shared AV**
- **Transit**
- **Walking**
- **Cycling**

Years: 2017 to 2057
Potential MaaS Markets

- Highly Viable MaaS Service
- Viable MaaS Service
- Transit-Supportive MaaS Service
Wildcards

Catastrophic Event

Public Backlash Regarding Data and Privacy
Takeaways

• This is coming fast – guide it or respond to it

• Cities, regions and transit agencies have a chance to shape this, but need to move

• While still many unknowns, we need to start factoring AVs into long-range planning

• Don’t let the unknowns and complexities paralyze us
“The best way to predict the future is to create it.”
Resources

DRIVING TOWARDS DRIVERLESS:
A GUIDE FOR GOVERNMENT AGENCIES

LAUREN ISAAC
Resources

http://smartdrivingcar.com/GreenLight-092316
Friday, September 23, 2016

Federal Automated Vehicles Policy: Accelerating the Next Revolution In Roadway Safety
September 2016, "Executive Summary...For DOT, the excitement around highly automated vehicles (HAVs) starts with safety. (p5)

...The development of advanced automated vehicle safety technologies, including fully self-driving cars, may prove to be the greatest personal transportation revolution since the popularization of the personal automobile nearly a century ago. (p5)

...The benefits don’t stop with safety. Innovations have the potential to transform personal...
From the Editors
Wishing all our readers and AV Subscribers a very happy and prosperous New Year.

Earlier this month, the Ottawa AV Summit 2017 was held in Kanata, Ontario, hosted by the Kanata North Business Association, CAVCOE and the Conference Board of Canada. The objective was to help the local technology industry better understand the business opportunities and technologies in the AV space and to network with each other. The event was very successful and we had twice as many attendees as we expected.

The Canadian Parliamentary research report "Automated and Connected Vehicles: Status of the Technology and Key Policy Issues for Canadian Governments" reads very well for the