Planning for AVs

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WSP USA
MWCOG Transportation Planning Board
Systems Performance, Operations and Technology Subcommittee
June 14, 2017

Attempts at AVs Are Not New

Source: PATH, 1997

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Source: Google, 2014.

Agenda

- **Primer on AVs**

- **Planning for AVs**

- **Key Unknowns**
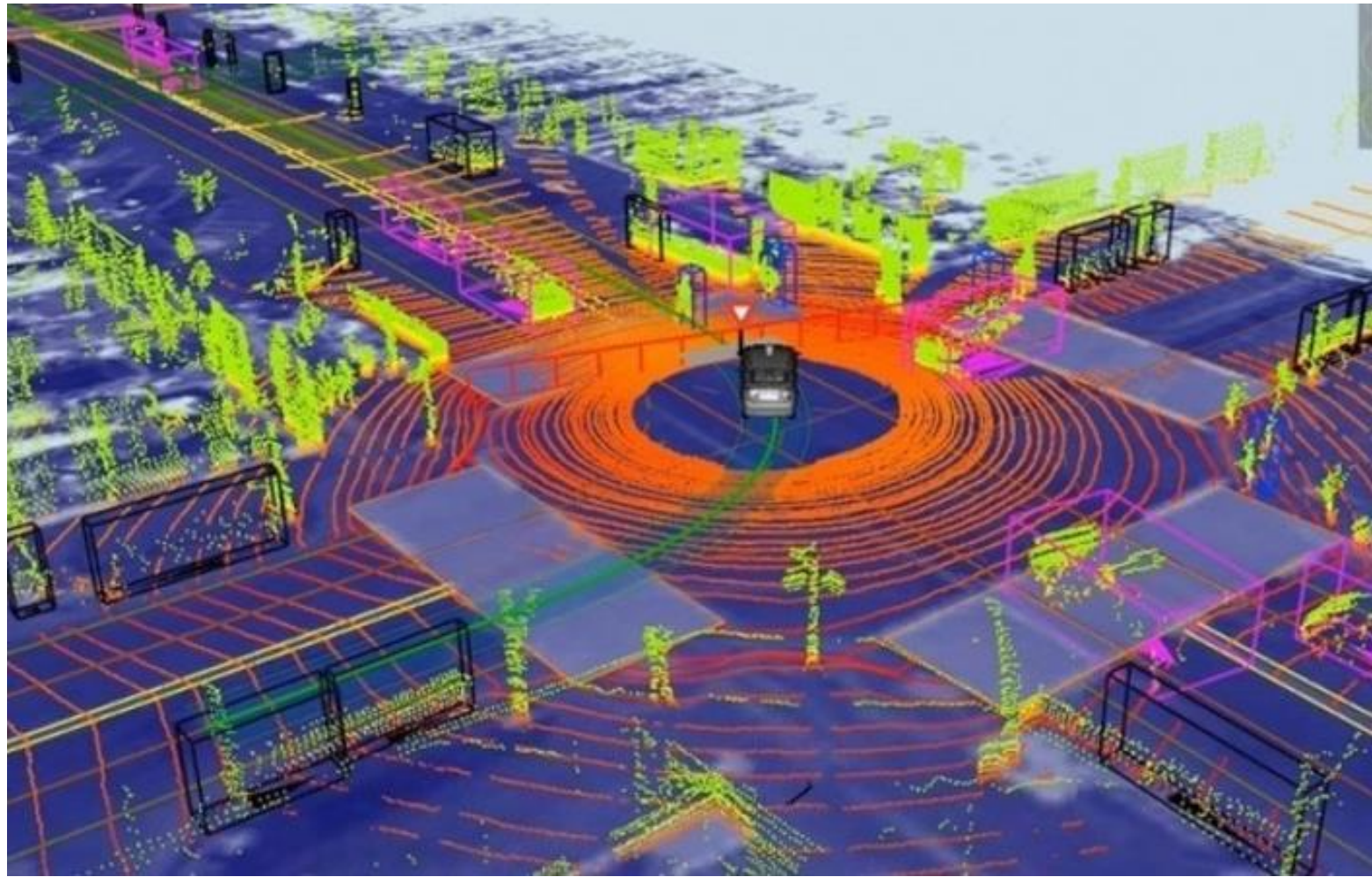
- **Toronto Experience**

- **Scenario Planning**

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Primer on AVs

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NHTSA Levels of Automation

		Steering and acceleration/ deceleration	Monitoring of driving environment	Fallback when automation fails	Automated system is in control
0	NO AUTOMATION				N/A
1	DRIVER ASSISTANCE				SOME DRIVING MODES
2	PARTIAL AUTOMATION				SOME DRIVING MODES
3	CONDITIONAL AUTOMATION				SOME DRIVING MODES
4	HIGH AUTOMATION				SOME DRIVING MODES
5	FULL AUTOMATION				

Human driver monitors the road (Levels 0–2)

Automated driving system monitors the road (Levels 3–5)

Source: SAE

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Self-Contained "Seeing"

Source: Google

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**
- **Reduced collisions, reducing incident-related congestion**
- **_In the future_, potentially greater capacity, reducing recurring congestion**

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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**

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Complexities of AVs

Data

Communications Systems

Technology

Standards

Infrastructure

Ethics

Managing the Transition

Liability

Planning

Consumer Preference

Impact to Jobs

Security

Privacy

Enforcement

Regulation

Human Factors

Safety

Business Models

Economics

Complexities of AVs

Planning

Planning for AVs

Planning for AVs

- It's no longer "if", but "when" and "how"

- It will likely be very, very disruptive

- Over time, it will 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

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Implications for Planning

	Changes
Trip-making	⬆ (red)
Distance of Trip Making	⬆ (red)
Passenger Miles Travelled	⬆ (yellow)
Vehicle Miles Travelled	⬆ (red)
Fixed Route Transit Demand	⬇ (red)
Active Transportation	⬇ (red)
Parking Demand	⬇ (green)
Curbside Demands	⬆ (red)
Congestion	?
Trend of Intensification	?
Right-of-way allocated for vehicles	?

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Key Unknowns

Key Unknowns

Speed of Technological Advancement

Economics

Public Acceptance

Political Support

Market for a Shared Model

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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

Manufacturer	2016	2017	2018	2019	2020-25	2025-30	2030-35	2035-40	2040+
Audi	2		3		3+	4/5			
BMW	2				4/5				
Ford				2	4/5				
Honda	2				3				3-4
KIA					3		4/5		
Mercedes-Benz	2								
Nissan	2		3		4/5				
Tesla	2		4/5						
Volvo Uber	2	4/5							

Source: Mashable, June 2016

Photo Credit: Steve Buckley

California Autonomous Testing Disengagements

Company	Miles Driven	DE*	Miles per DE	Miles per DE in 2015	Common Causes
Waymo (aka Google)	635,868	124	5,128	1,244	Software discrepancy; unwanted vehicle maneuver
BMW	638	1	638	N/A	Lane marking unclear
Nissan	4,099	28	247	14	AV system failure; AV is about to collide with vehicle or obstacle
Ford	590	3	197	N/A	Aborted lane change due to vehicle overtaking at high speed
Delphi	3,125	178	18	42	Completing lane change in heavy traffic; traffic light detection
Cruise (GM)	9,847	414	9.3	N/A	To avoid unexpected behavior
Tesla Motors	550	182	3	N/A	Planner output invalid; follower output invalid
Mercedes-Benz	673	336	2	1.8	Driver discomfort; technology evaluation management
Bosch	983	1,442	0.7	1.5	Planned test of technology
Honda	N/A	N/A	N/A	N/A	N/A
VW/Audi	N/A	N/A	N/A	75	N/A

DE* = Disengagements

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Economics

Cost per Person per Mile
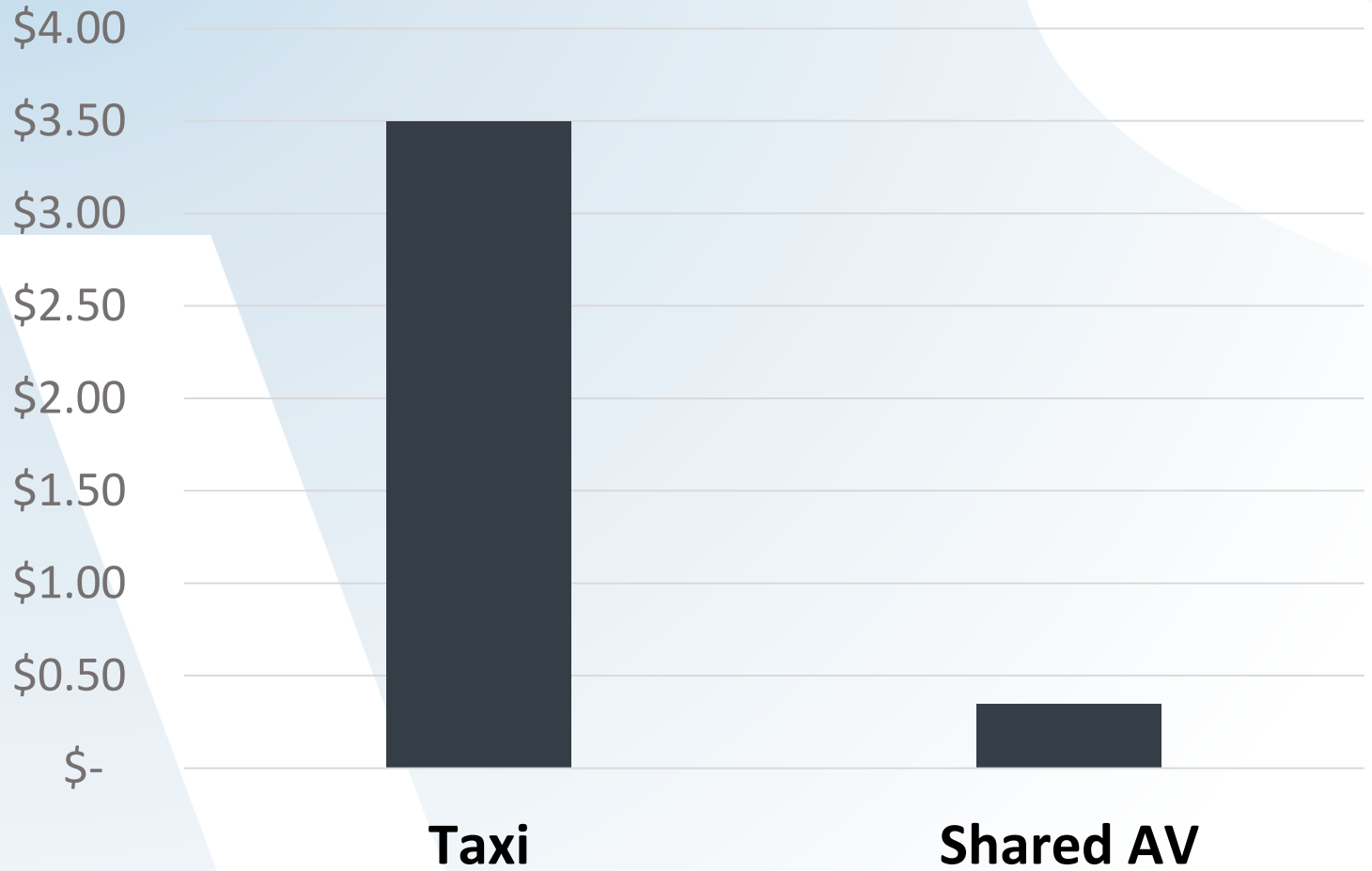
Economics

Cost per Mile: Shared vs. Owned
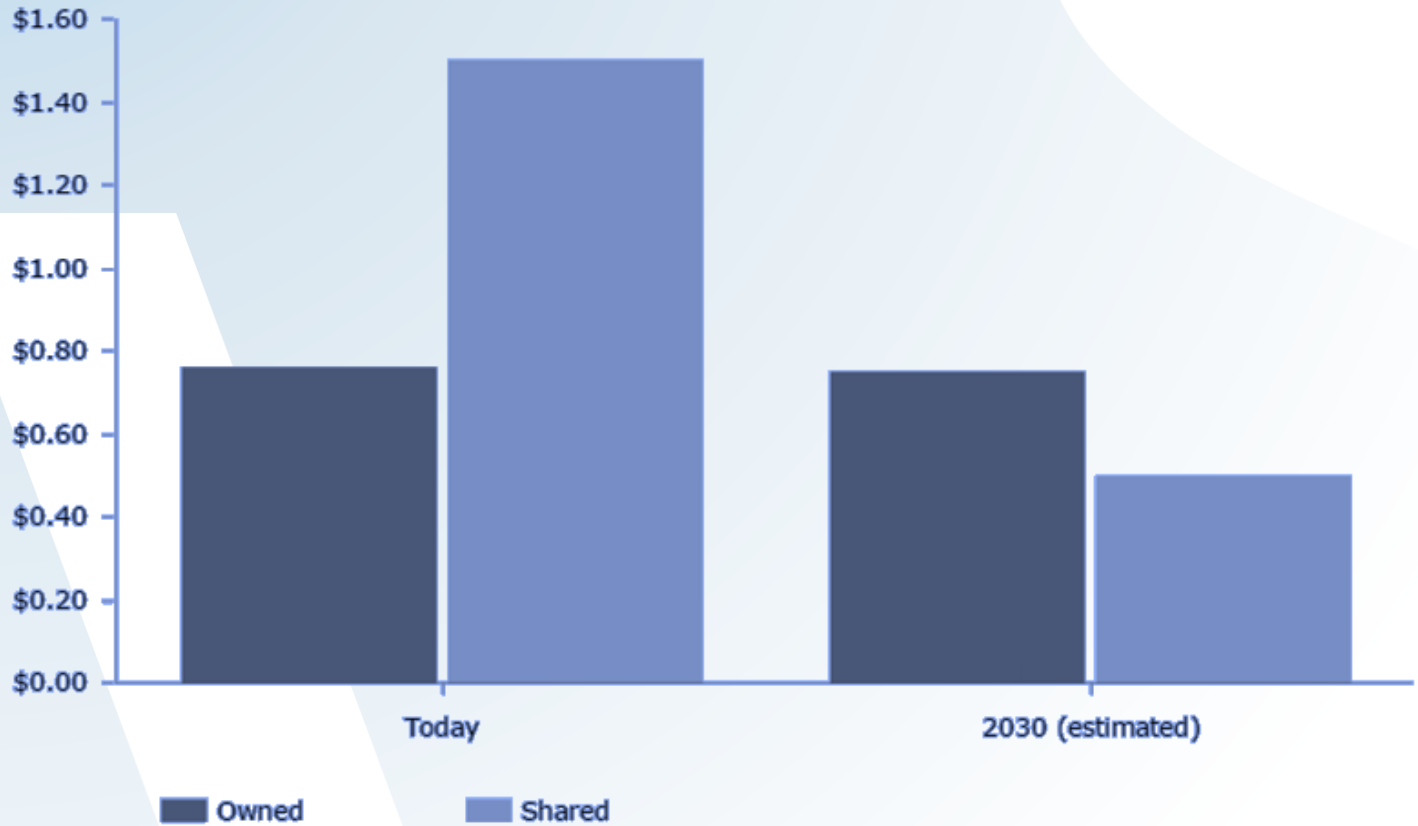
Economics

Robo-Taxis Could Replace Traditional Taxis and Cars in Megacities

New York City case study

Total cost per passenger mile in New York City ($)[a]

Robo-taxis that accommodate at least two people could be cost-competitive with mass transit if capital budgets and government subsidies are taken into account

	Public transport	Vehicle ownership	Taxi	Robo-taxi →			
Value	1.0 (0.7[b] / 0.3[c])	1.2	2.8	1.8	2.2	1.1	0.7	0.6

1.2 (dashed line)

Average number of people per vehicle: NA | 1.6 | 1.2 | 1.2 | 1 | 2 | 3 | 4

Sources: BCG analysis; U.S. Department of Transportation; NYC Metropolitan Transportation Authority; NYC Taxi & Limousine Commission; Kelley Blue Book.
[a]Does not consider the impact of convenience and shorter wait and commute times.
[b]Non-fare-based operating funds received from New York City transit; local, state, and federal sources; and other sources.
[c]Annual fare revenues per passenger mile traveled.

Source: Boston Consulting Group (2016)

Economics
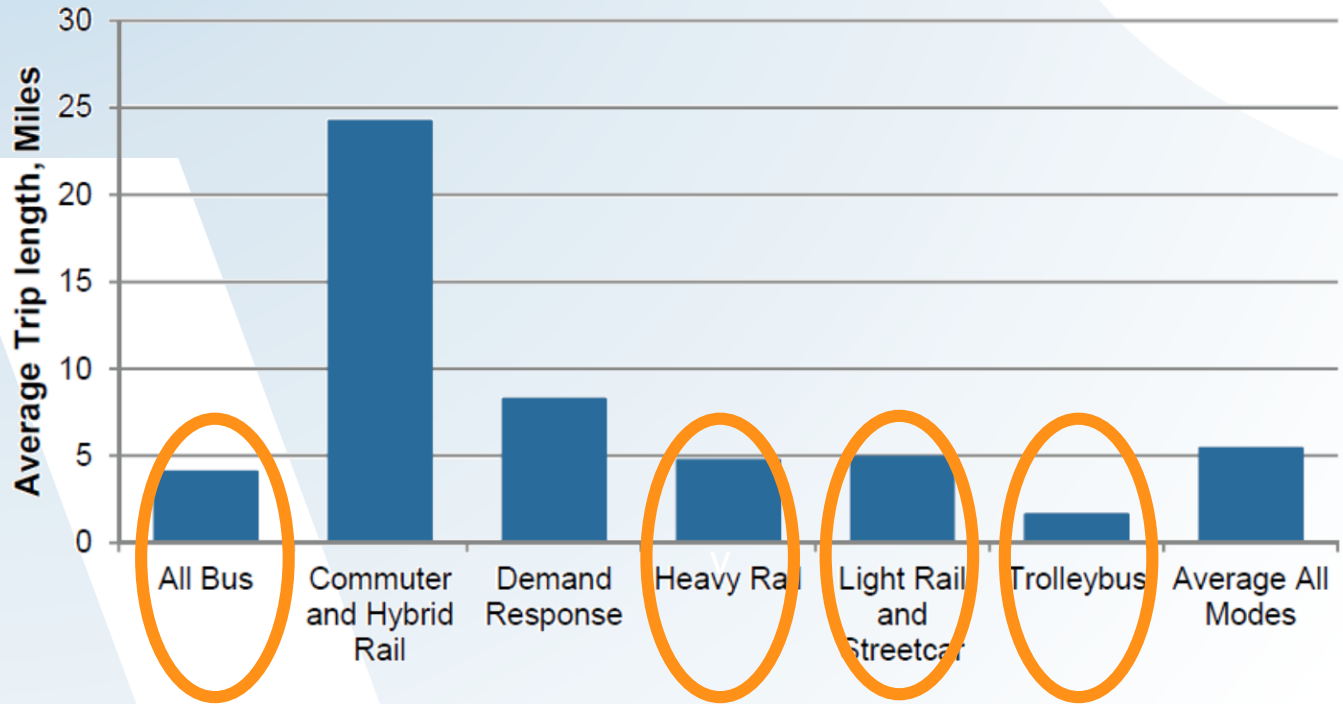

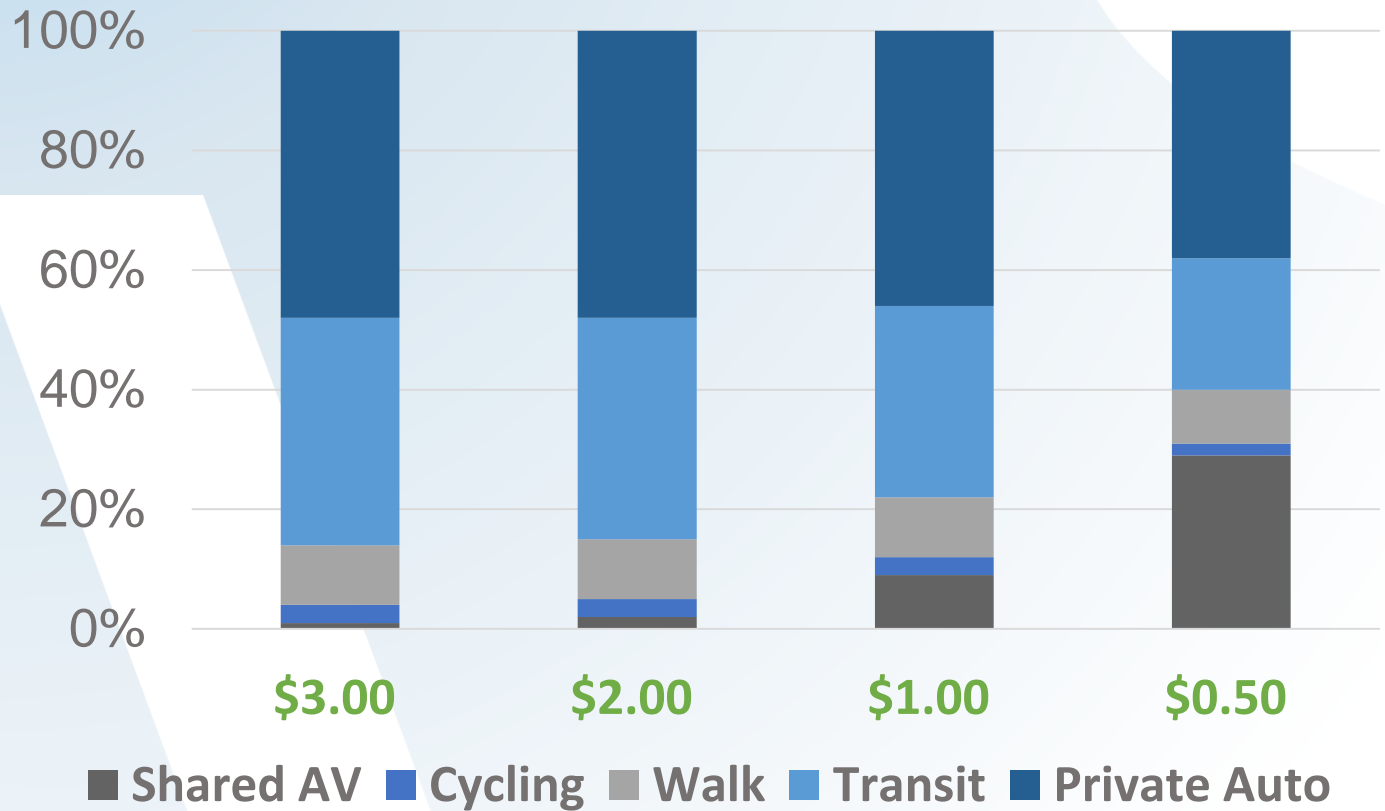Figure 3: Average Unlinked Passenger Trip Length, 2011

Source: APTA 2011 Fact Book

Economics

Illustrative Mode Share in Toronto at Various per Mile Prices

Public Acceptance

"The technology may be ready before society is."

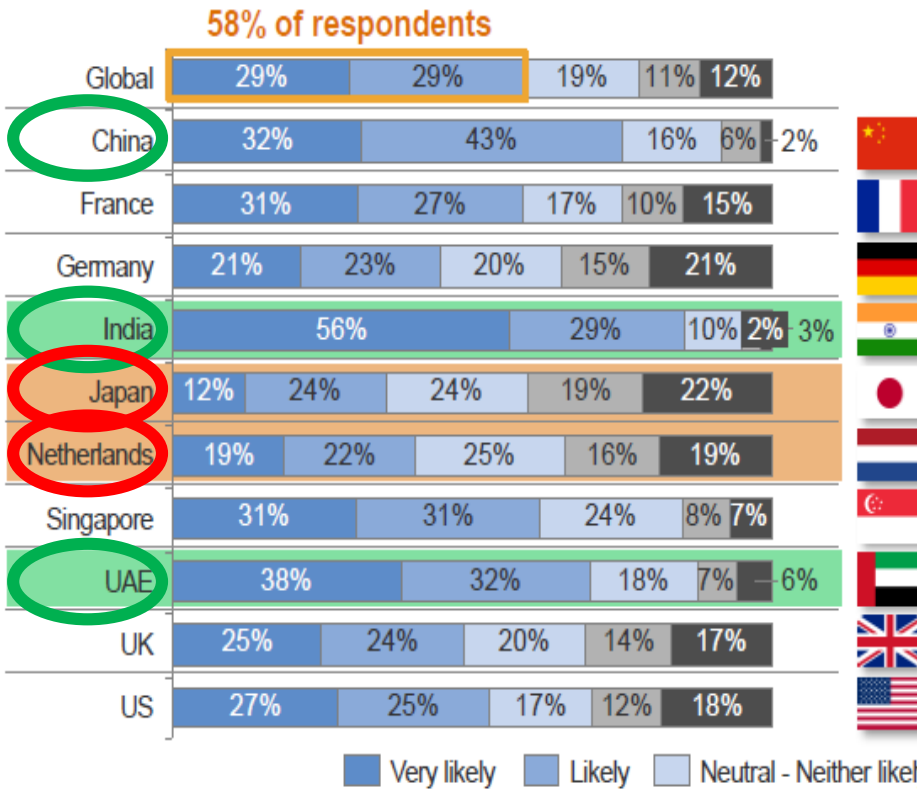*- Bill Ford, Jr., Chairman,*
Ford Motor Company
December, 2015
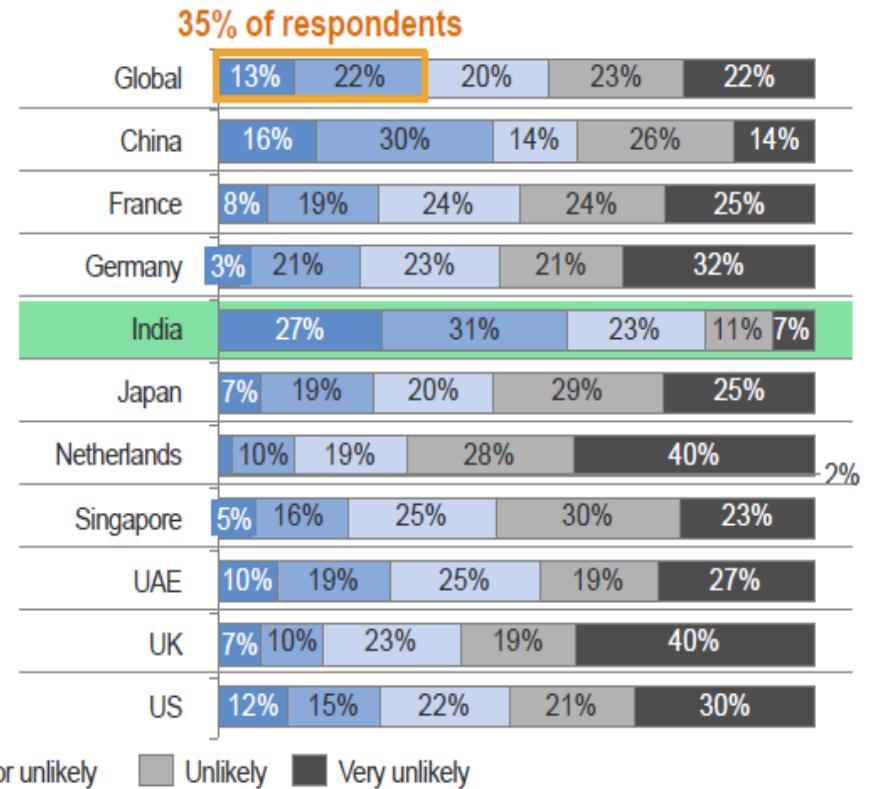
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Public Acceptance – Trust of AVs

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

In % of respondents per country

58% of respondents

	Very likely	Likely	Neutral	Unlikely	Very unlikely
Global	29%	29%	19%	11%	12%
China	32%	43%	16%	6%	2%
France	31%	27%	17%	10%	15%
Germany	21%	23%	20%	15%	21%
India	56%	29%	10%	2%	3%
Japan	12%	24%	24%	19%	22%
Netherlands	19%	22%	25%	16%	19%
Singapore	31%	31%	24%	8%	7%
UAE	38%	32%	18%	7%	6%
UK	25%	24%	20%	14%	17%
US	27%	25%	17%	12%	18%

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

In % of respondents per country

35% of respondents

	Very likely	Likely	Neutral	Unlikely	Very unlikely
Global	13%	22%	20%	23%	22%
China	16%	30%	14%	26%	14%
France	8%	19%	24%	24%	25%
Germany	3%	21%	23%	21%	32%
India	27%	31%	23%	11%	7%
Japan	7%	19%	20%	29%	25%
Netherlands	10%	19%	28%	40%	2%
Singapore	5%	16%	25%	30%	23%
UAE	10%	19%	25%	19%	27%
UK	7%	10%	23%	19%	40%
US	12%	15%	22%	21%	30%

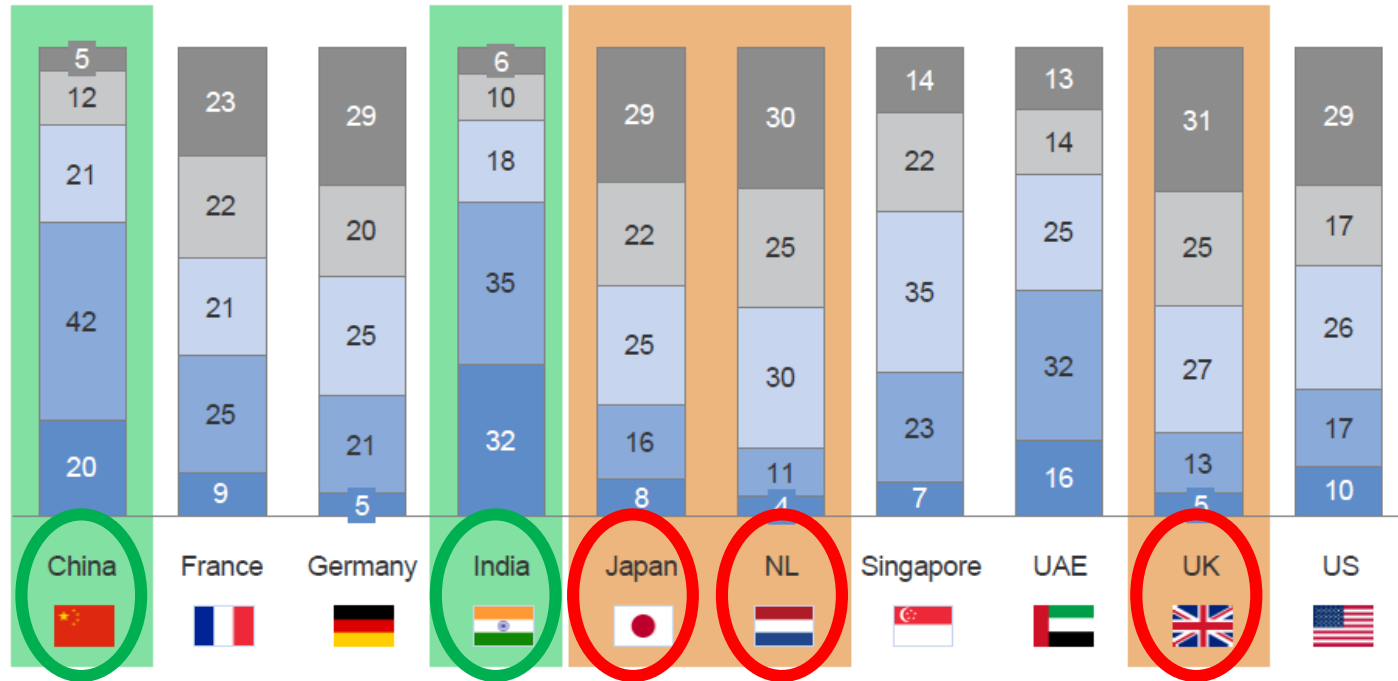Legend: Very likely | Likely | Neutral - Neither likely nor unlikely | Unlikely | Very unlikely

Source: World Economic Forum/Boston Consulting Group, 2015.

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Public Acceptance – Shared Use

In % of respondents per country

	China	France	Germany	India	Japan	NL	Singapore	UAE	UK	US
	5	23	29	6	29	30	14	13	31	29
	12	22	20	10	22	25	22	14	25	17
	21	21	25	18	25	30	35	25	27	26
	42	25	21	35	16	11	23	32	13	17
	20	9	5	32	8	4	7	16	5	10

Source: World Economic Forum/Boston Consulting Group, 2015.

Political Support

Political Support

"**Helsinki announces 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

Uber stops San Francisco self-driving pilot as DMV revoked registrations

– December 21, 2016 Techcrunch.com

Gov. Doug Ducey welcomes Uber self-driving cars with open arms

– December 23, 2016 · The Arizona Republic

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Influencing a Shared Model

- **Economics will strongly influence viability**

- **Unless we see quick, definitive actions by cities or transit agencies, this WILL be driven by consumer preference and pricing**

- **Shared use will likely not work in all areas or for all needs, so there will likely still be a strong market for privately-owned AVs**

- **Public acceptance will likely not only vary regionally, but even within regions**

- **AV–only facilities or zones will be needed to permit smaller, lighter vehicles**

Factors Driving Where Shared Mobility Will Land First
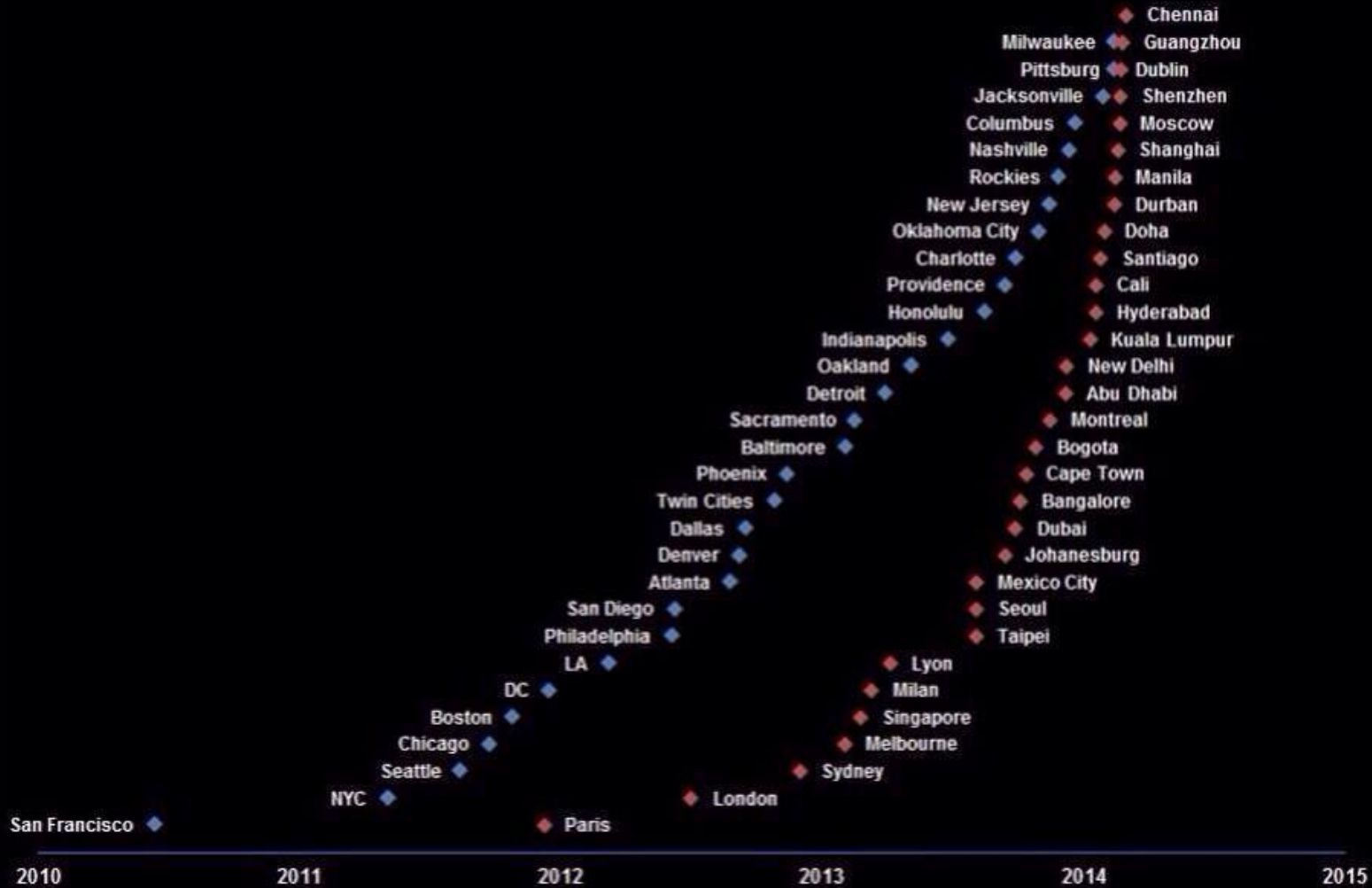
- **Weather**

- **Economics**

- **Market**
  - **Density**
  - **Accustomed to Sharing**
  - **Tech-savvy**
  - **Wealth**

- **Political Support**
  - **Infrastructure**
  - **Proactive Deployment**

Influencing a Shared Model

Uber Expansion

Key Unknowns

Speed of Technological Advancement

Economics

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Market for a Shared Model

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Without a clear understanding of the future,
how do we plan?

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Key Short-term Challenges in Shaping Policy

- **This is currently being driven by the market**

- **Most regions, cities and transit agencies aren't at the table**

- **Complex issue with lots of moving parts and unknowns, making it difficult to educate or advise leadership and elected officials**

- **Currently lacking the methods and tools to help us better inform the discussion**

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Roles and Responsibilities

Topic	Federal	State	Regions	Industry	Academic
Safety	●	○		○	
Testing	●	○		○	
Communications and Security	●			●	
Vehicle Licensing		●			
Liability and Insurance		●		●	
Supporting Infrastructure		●	●	○	
Business Models		○	○	●	
Business Regulations		●	●		
Alignment with Planning		○	●		
Public Transit Applications		○	●		
Enforcement			●		
Ethics					●
Privacy	○	○			●

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Approaches Regions Could Take

Actively Discourage

Passive

Actively Encourage

- **Prohibit or Restrict AVs or TaaS**

- **Wait and See**

- **Outfit signals with transmitters**

- **Map curbside regulations**

- **Conduct a pilot or demonstration**

- **Tax credits**

- **Create AV-only zones**

- **Create AV-only facilities**

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Approaches Transit Agencies Could Take

Resist

Passive

Embrace

- Attempt to Prohibit or Restrict Shared AVs

- Laissez-faire

- Partner

- Own and Operate

- Partner and Fund

Toronto Experience

Toronto Experience

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

UTTRI

Three Scenarios

Ownership Leads

Mixed

Shared Leads

Impacts of Private vs. Mixed vs. Shared

|	Private	Mixed	Shared
Collisions	↓	↓	↓
Congestion	↓?	↓?	↓?
Vehicular Mobility	↑	↑	↑
Equitable Mobility	?	↑?	↑?
Cost of Private/Semi-private Vehicular Travel	?	↓	↓
Carpooling	?	↑	↑
Passenger Kilometers Travelled	↑	↑?	↑?
Vehicle Kilometers Travelled	↑	?	↓?
Fixed Route Transit Demand	↓	↓	↓
Active Transportation	↓	?	?
Trend of Intensification	↓	?	?
Parking Demand	?	↓	↓
Right-of-way allocated for vehicles	↓	↓	↓
Residential Building/Lot Size	?	↓	↓
Impervious Areas	?	↓	↓

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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**

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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

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Most Common Job (2014)
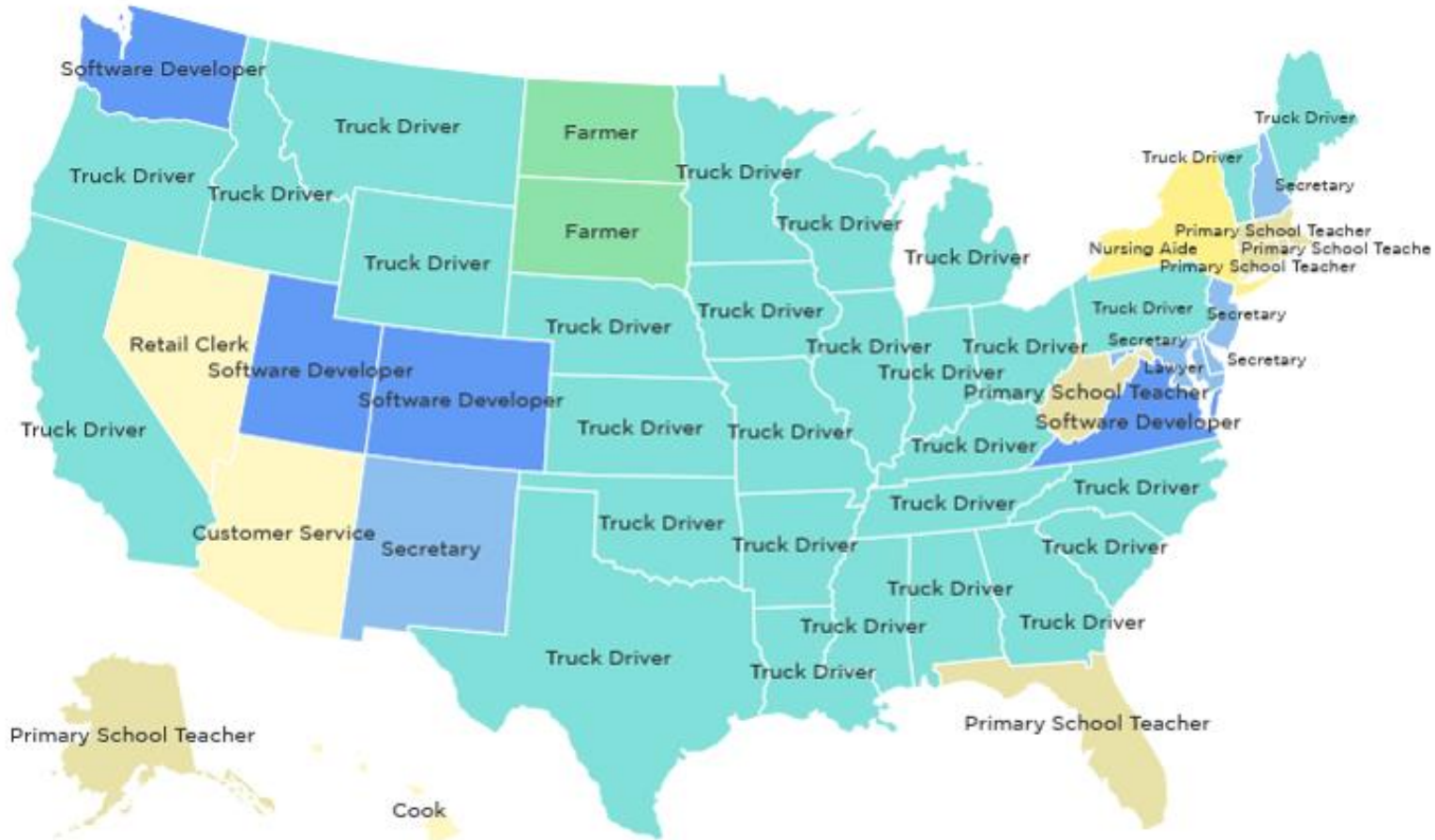
Approaches Cities Could Take

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- **Create AV-only zones**

- **Create AV-only facilities**

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Toronto's Draft Vision Statement

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

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Toronto Transportation Services Work Plan

PREPARING FOR AUTONOMOUS VEHICLES

Divisional Workplan 2016-2018

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Toronto Transportation Services Work Plan

GOAL 2

PREPARATION

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

Objectives	2016	2017	2018
2.1 Improve Understanding and Clarity			
2.1.1 Create and maintain a common lexicon of terms and concepts for consistent understanding.			
2.1.2 Identify and understand the broad range of potential implications of AVs.			
2.1.3 Define the interests of Transportation Services in vehicle automation across all sections and districts.			
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.			
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.			
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.			
2.2 Prepare a Foundation			
2.2.1 Improve the management and current function of traffic control devices, particularly signage and pavement markings.			
2.2.1.1 Increase asset management and lifecycle analysis of traffic control devices, particularly signage and pavement markings.			
2.2.1.2 Review and consider the need for pavement markings on local streets.			
2.2.1.3 Improve the visibility of traffic control devices under all weather conditions.			
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.			
2.2.3 Begin to engage with technology providers, automobile manufacturers, and transportation network companies to discuss municipal preparations and potential pathways.			

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Are GTHA Residents Ready for Autonomous Vehicles?

Survey Overview
November 24, 2016

Sweet, Matthias; Laidlaw, Kailey; Olsen, Tyler

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Scenario Planning

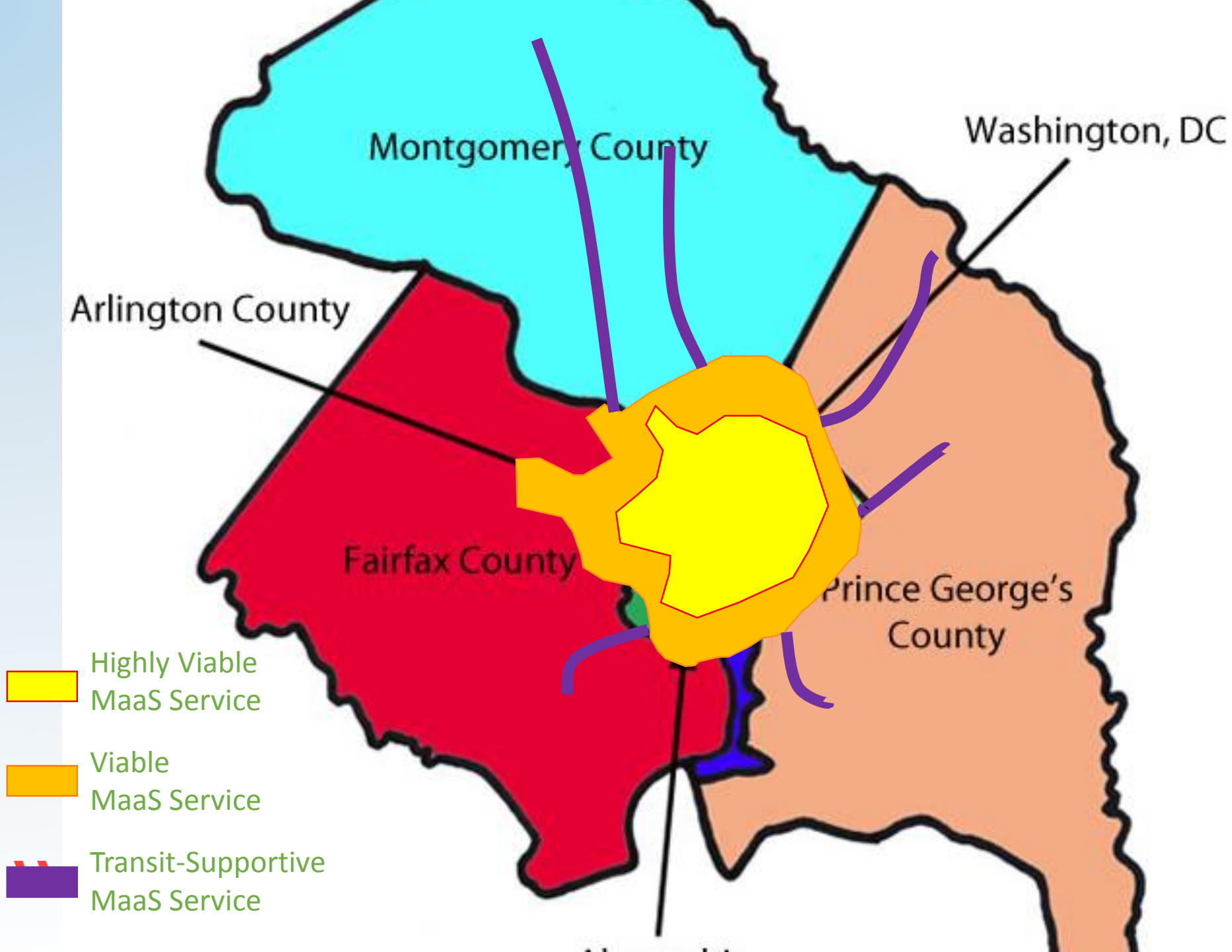# Scenario Planning

Speed of Technological Advancement
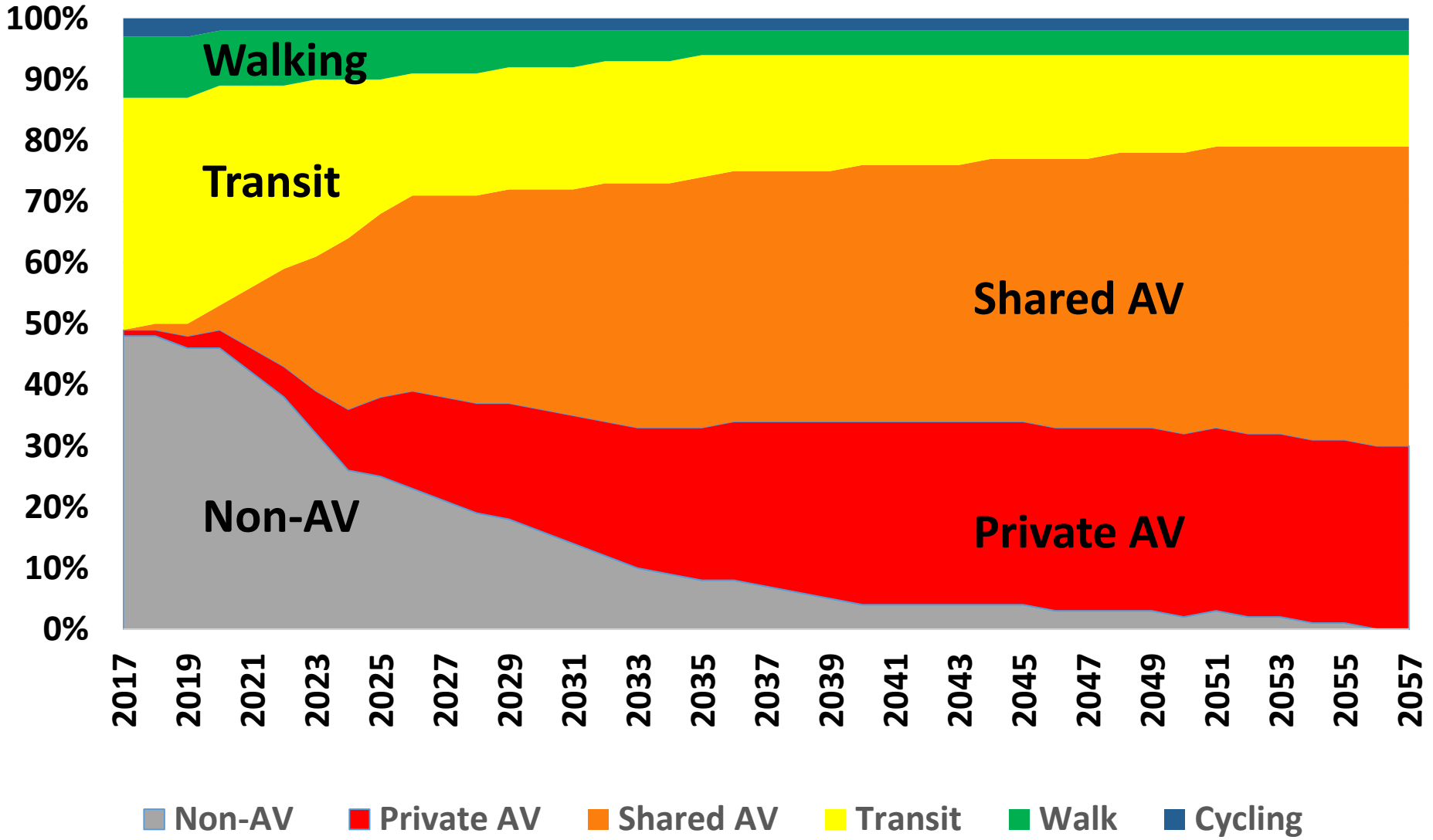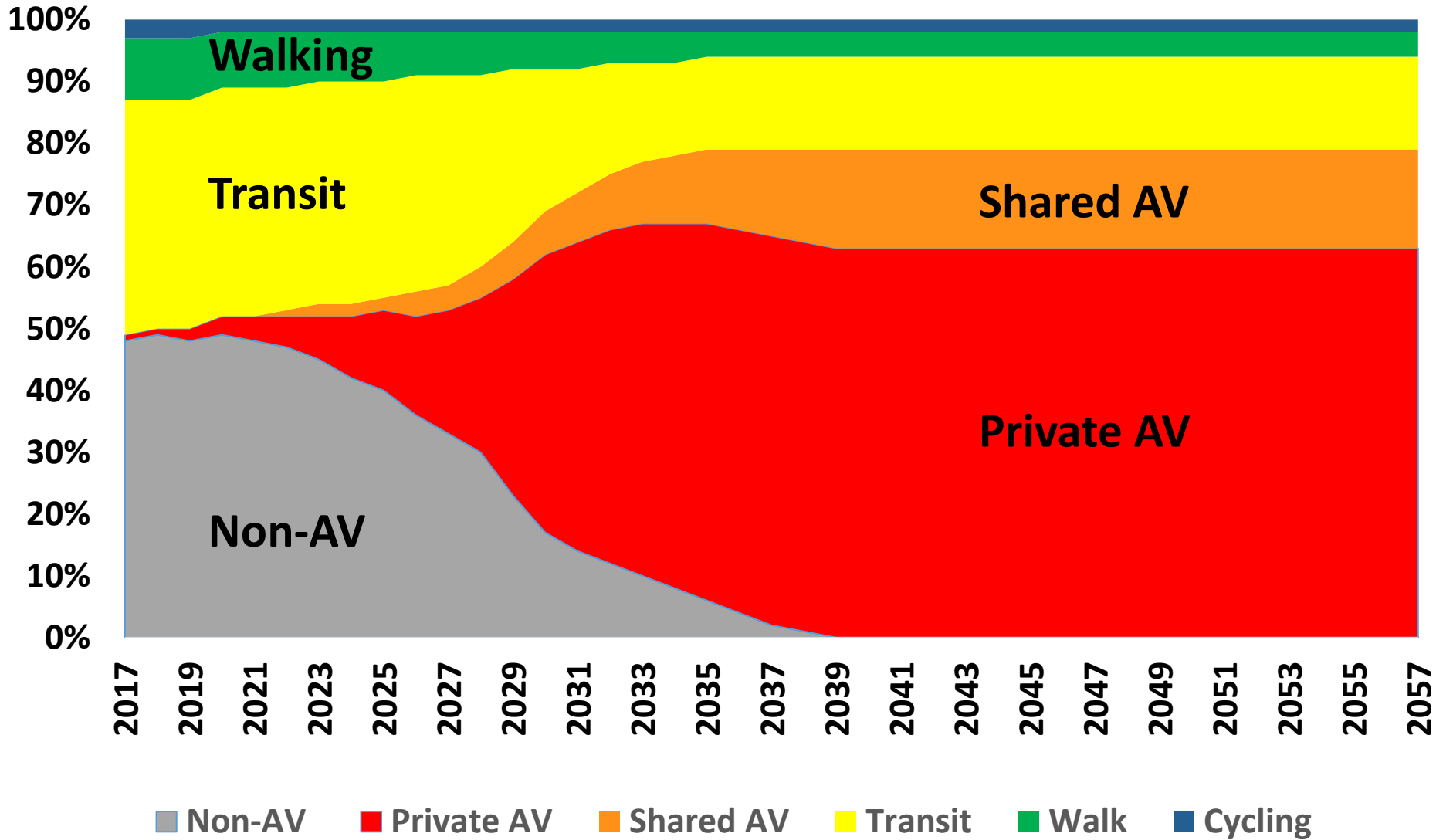
Economics

Public Acceptance

Political Support

Market for a Shared Model

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Washington, DC

Montgomery County

Arlington County

Fairfax County

Prince George's County

Highly Viable
MaaS Service

Viable
MaaS Service

Transit-Supportive
MaaS Service

Scenarios – Shared Leads

Scenarios – Private Leads

Wildcards

Catastrophic Event

Public Backlash Regarding Data and Privacy

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Realities

- **Many planners believe that this will unfold in a thoughtful and controlled way**

- **Unless we see quick, definitive actions by states, transit agencies, and cities this WILL be market-driven by consumer preference and pricing**

- **Conversation is currently being driven by politically-active industries that have HUNDREDS of BILLIONS at stake**

- **Some companies in this space appear to be driven entirely by profit motivations**

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What This May Mean for Transit

- **Agencies need to begin to prepare**

- **Expect that major investments will be questioned**

- **Some will advocate that AVs will make transit obsolete**

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What this May Mean for MPOs

- **Investment plans may be challenged**

- **Review your goals and tie discussions back to those goals**

- **Begin to develop scenarios that are likely for your region**

- **Investigate the use of modelling tools**

- **Plan, act, assess, tack…..Plan, act, assess, tack……**

- **Develop a work plan and follow it**

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Signs of Promise

- **Regions, transit agencies and cities are becoming engaged**

- **Tools are being developed**

- **Discussion of new funding (and pricing models)**

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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**

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"The best way to predict the future is to create it."

Resources

Resources

Resources

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

NHTSA 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

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Resources

nuTonomy is testing its vehicles in Michigan and UK
January 2017

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 advancements in Canada on the AV front. The report uses a significant amount of source material from the report CAVCOE and the Conference Board of Canada published a year earlier.

Here in Canada, we remain concerned that our very occasional adverse weather (our tongue firmly in cheek) will slow the deployment of AVs on our roads. However, it seems that Tesla's Autopilot is already accomplished at steering in the snow, even without visible lane lines or a

Resources

Adam Jonas, Morgan Stanley

http://linkback.morganstanley.com/web/sendlink/webapp/BM Servlet?file=e72626n0-3pka-g002-b8c7-005056013600&store=0&d=1&user=ded82hm7bu07c-2&__gda__=1601757194_55d7b23ee93236041c022c4c70eacd f9#0001&ded82hm7bu07c-0&1601757194_c1c3530231514a8ac2e1c78bdf76871f&0011&ded82hm7bu07c-1&1601757194_45a5104d280513428eb57e473a5220c0

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