Planning for Automated Vehicles

Stephen Buckley, P.E.

February 8, 2017

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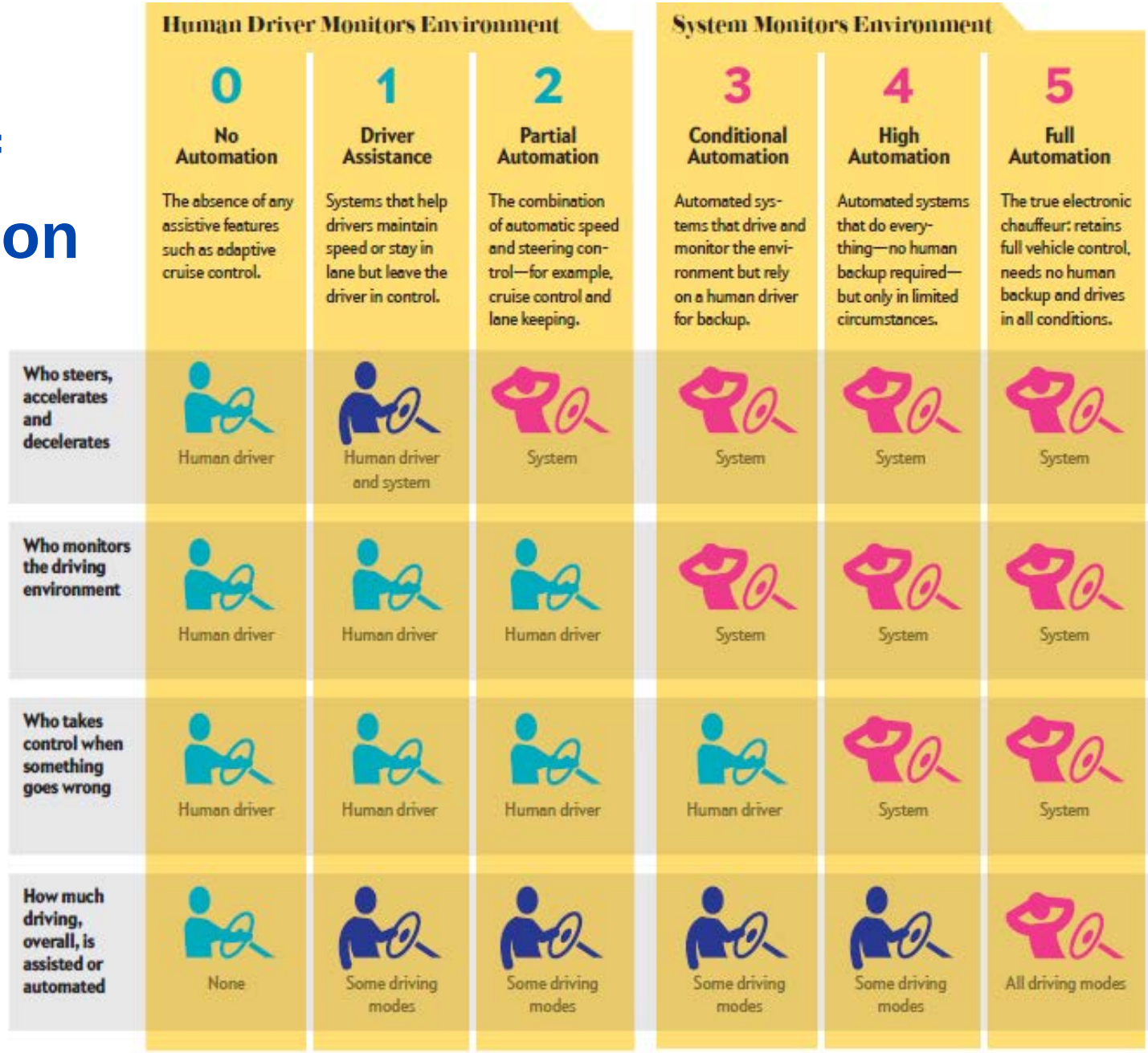
Attempts at AVs Are Not New

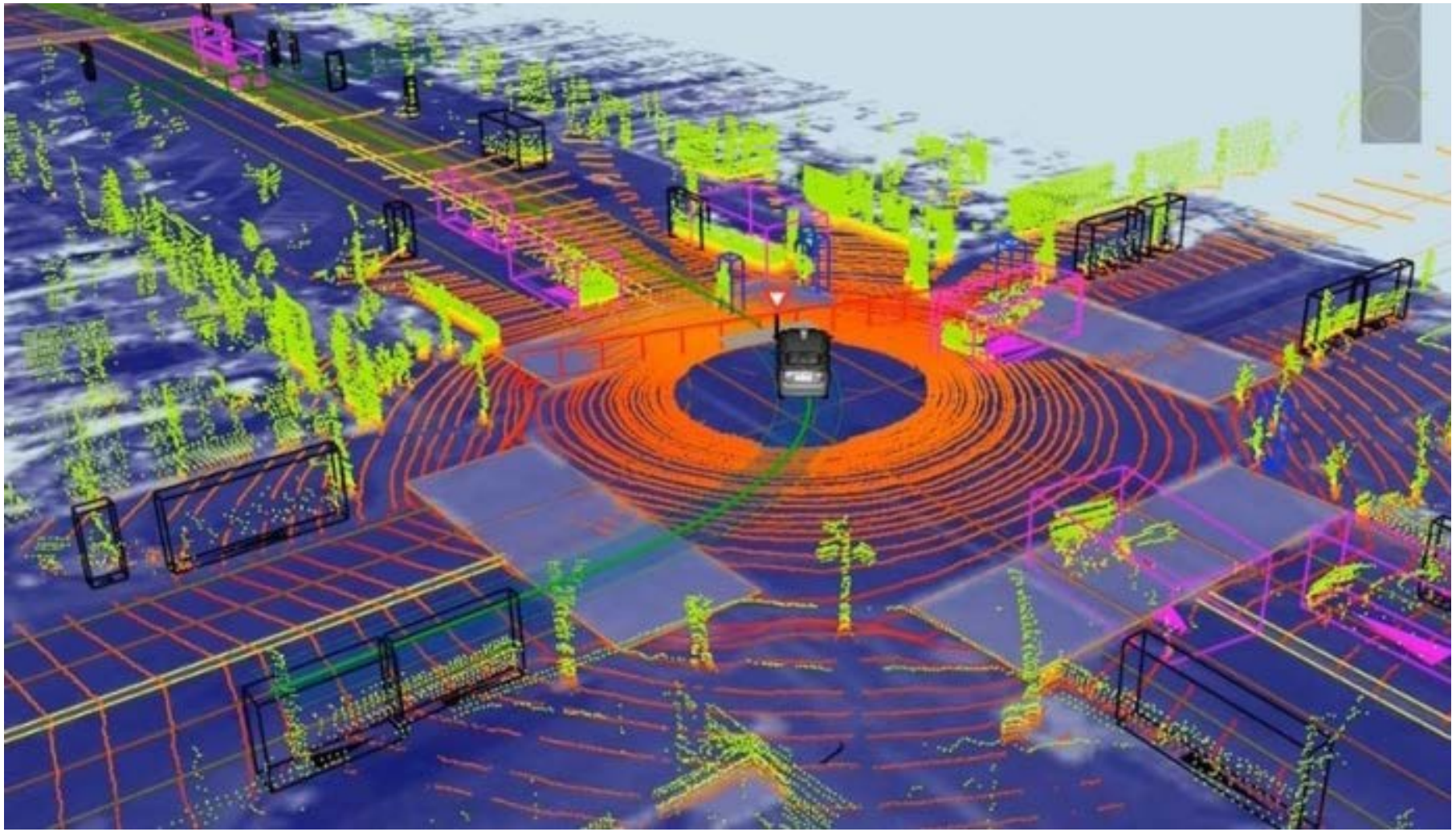
Agenda

- **Brief Primer on AVs**
- **Planning for AVs**
- **Work in Toronto**
- **Moving Forward**

NHTSA Levels of Automation



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

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Complexities of AVs

Data

Communications Systems

Technology

Infrastructure

Standards

Managing the Transition

Ethics

Planning

Liability

Consumer Preference

Impact to Jobs

Privacy

Enforcement

Security

Regulation

Human Factors

Safety

Business Models

Economics

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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

With “cost” of travel coming down, this will likely:

- increase trip-making
- increase the distance of trip-making
- increase PMT
- increase VMT

In addition, it:

- MAY decrease transit and AT trip-making
- COULD increase OR decrease congestion
- MAY undermine land use polices
- MAY impact locational choices of residents and employers
- MAY 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

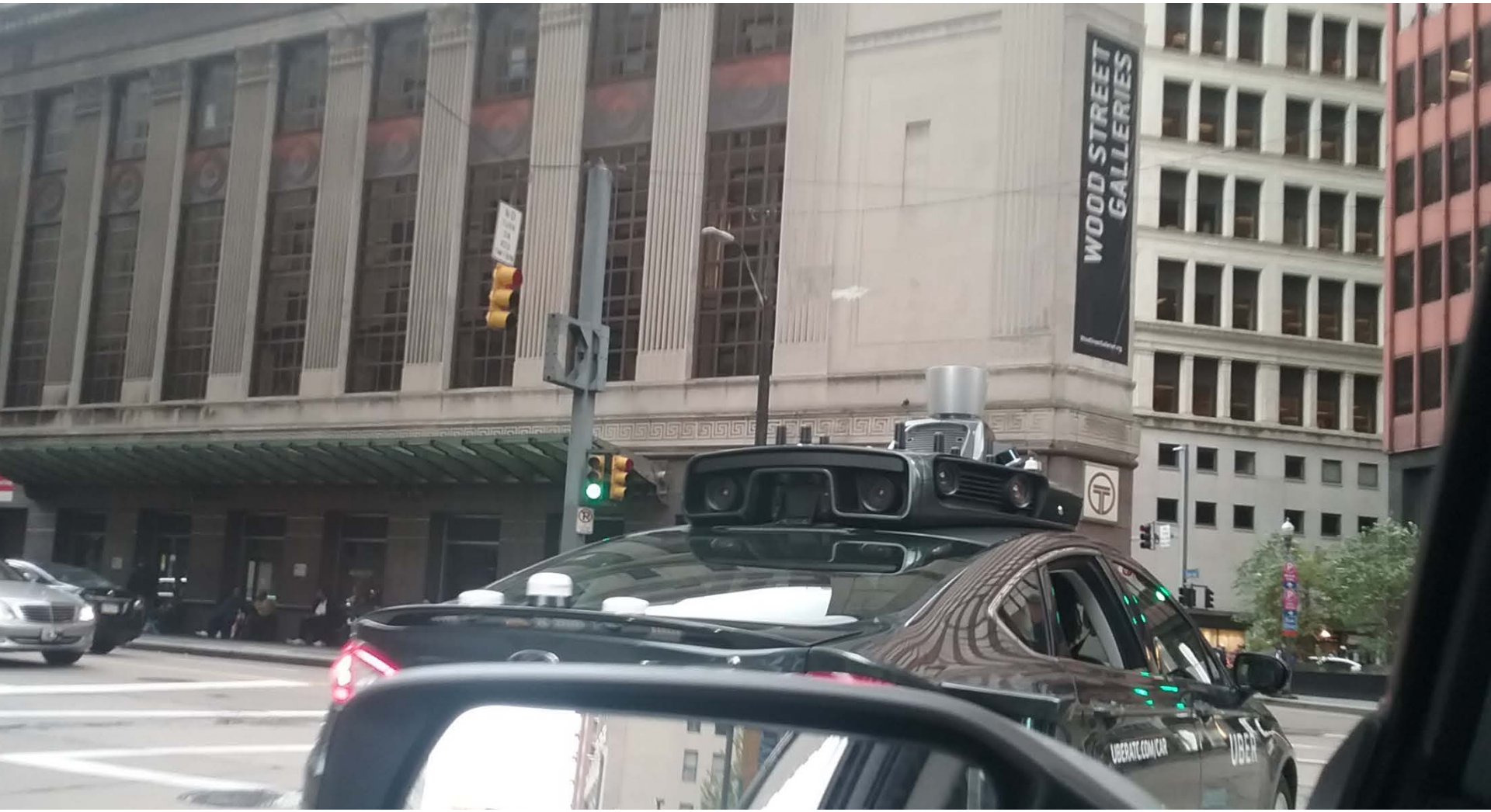
Google starts deploying its self-driving Chrysler Pacifica minivans: first prototypes spotted

– *Electrek*, October 9, 2016

Speed of Technological Advancement

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							

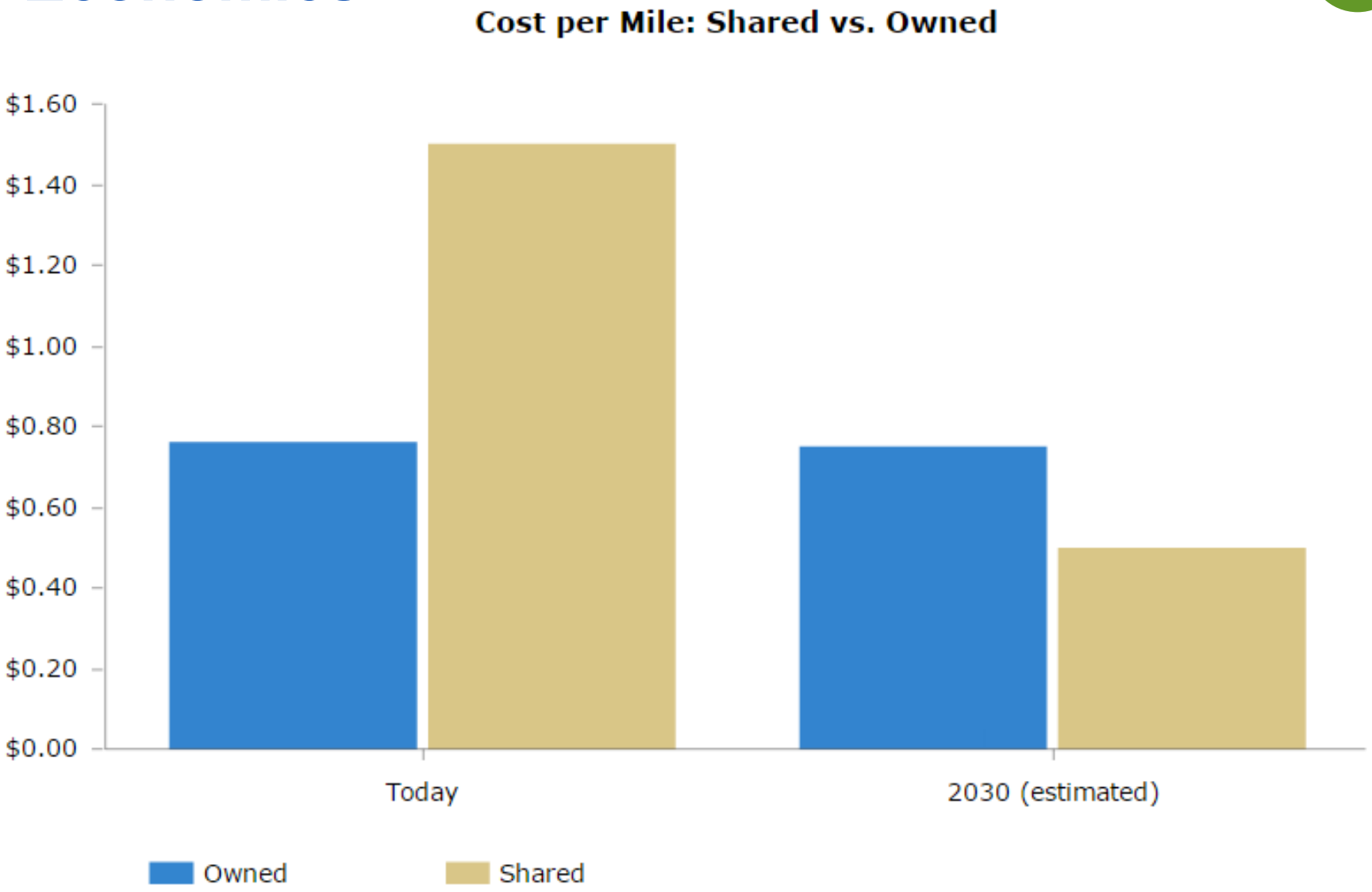
Source: Mashable


WOOD STREET GALLERIES
UBERATC.COM/CAR
UBER

Economics

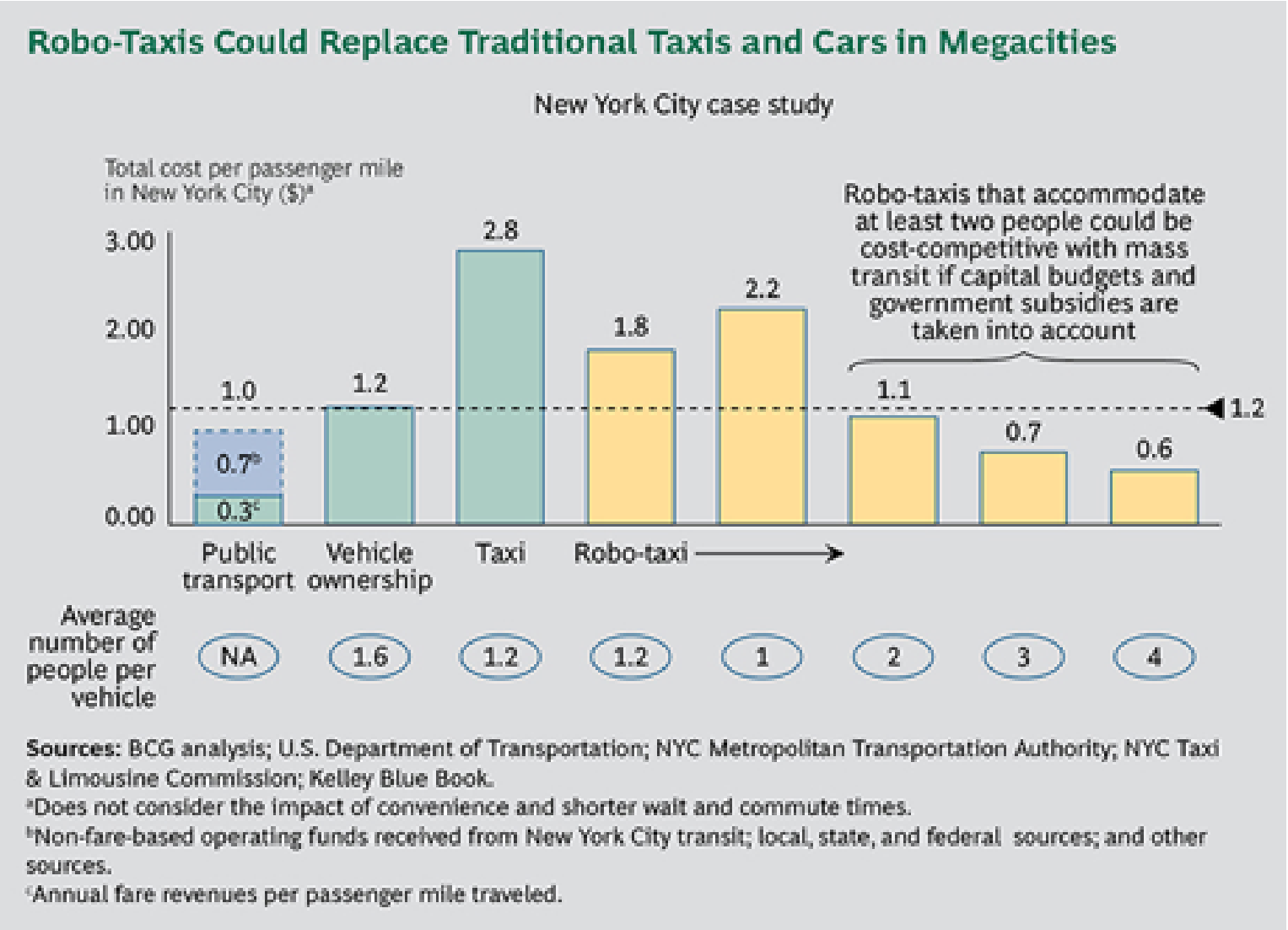
Source: ARK Investment Management

Economics



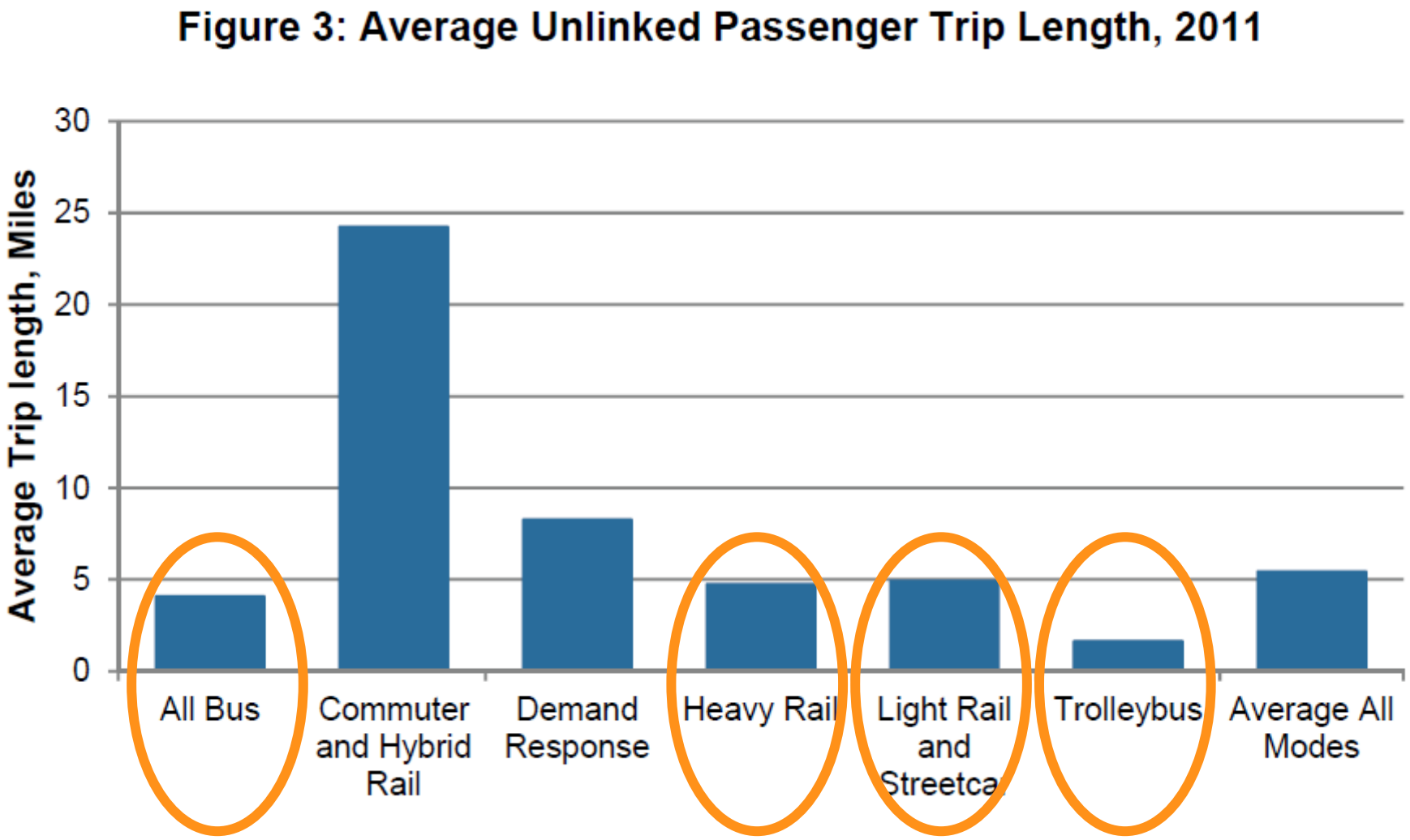
Source: Morgan Stanley (2016)

Economics



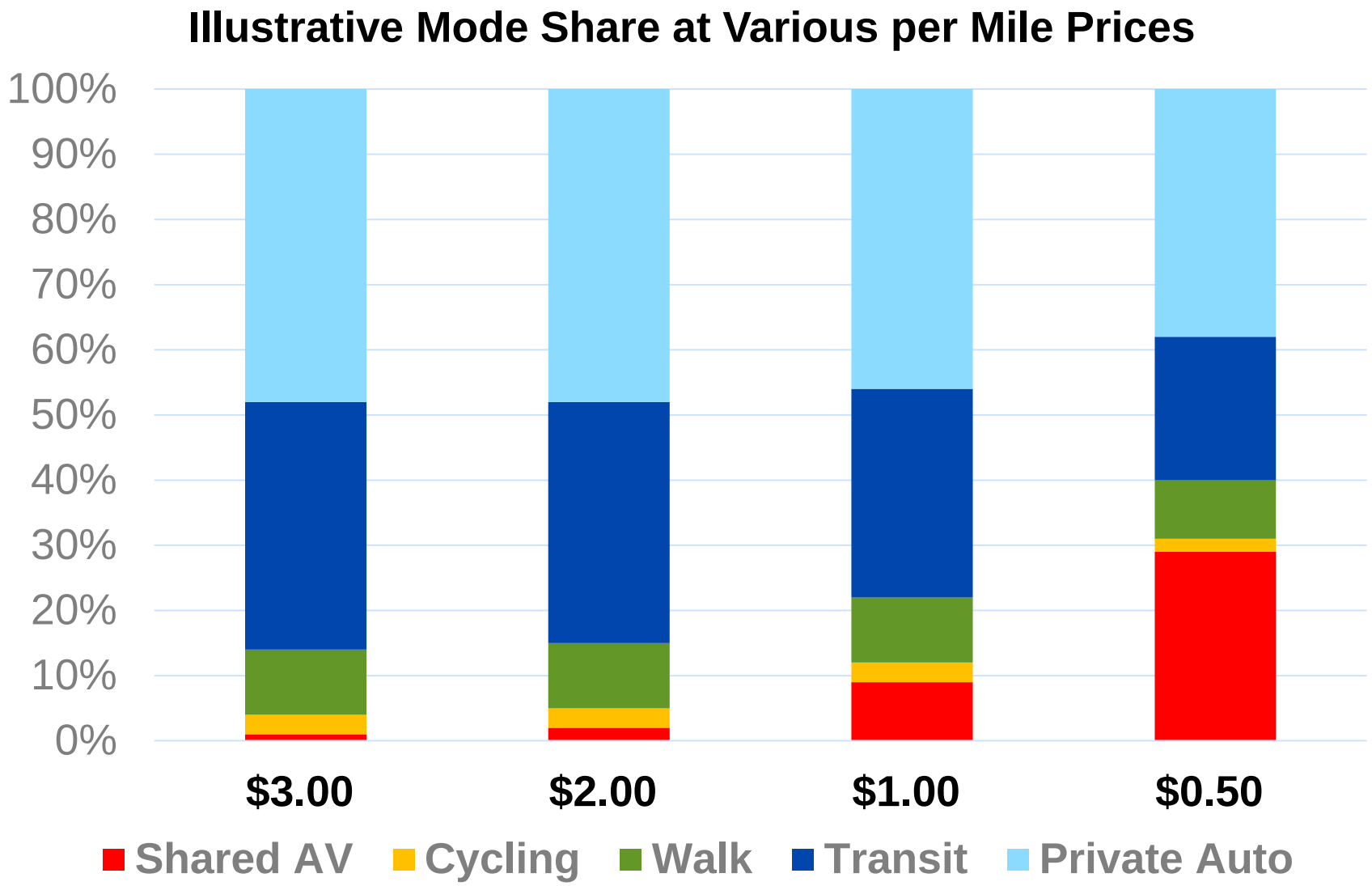
Source: Boston Consulting Group (2016)

Economics

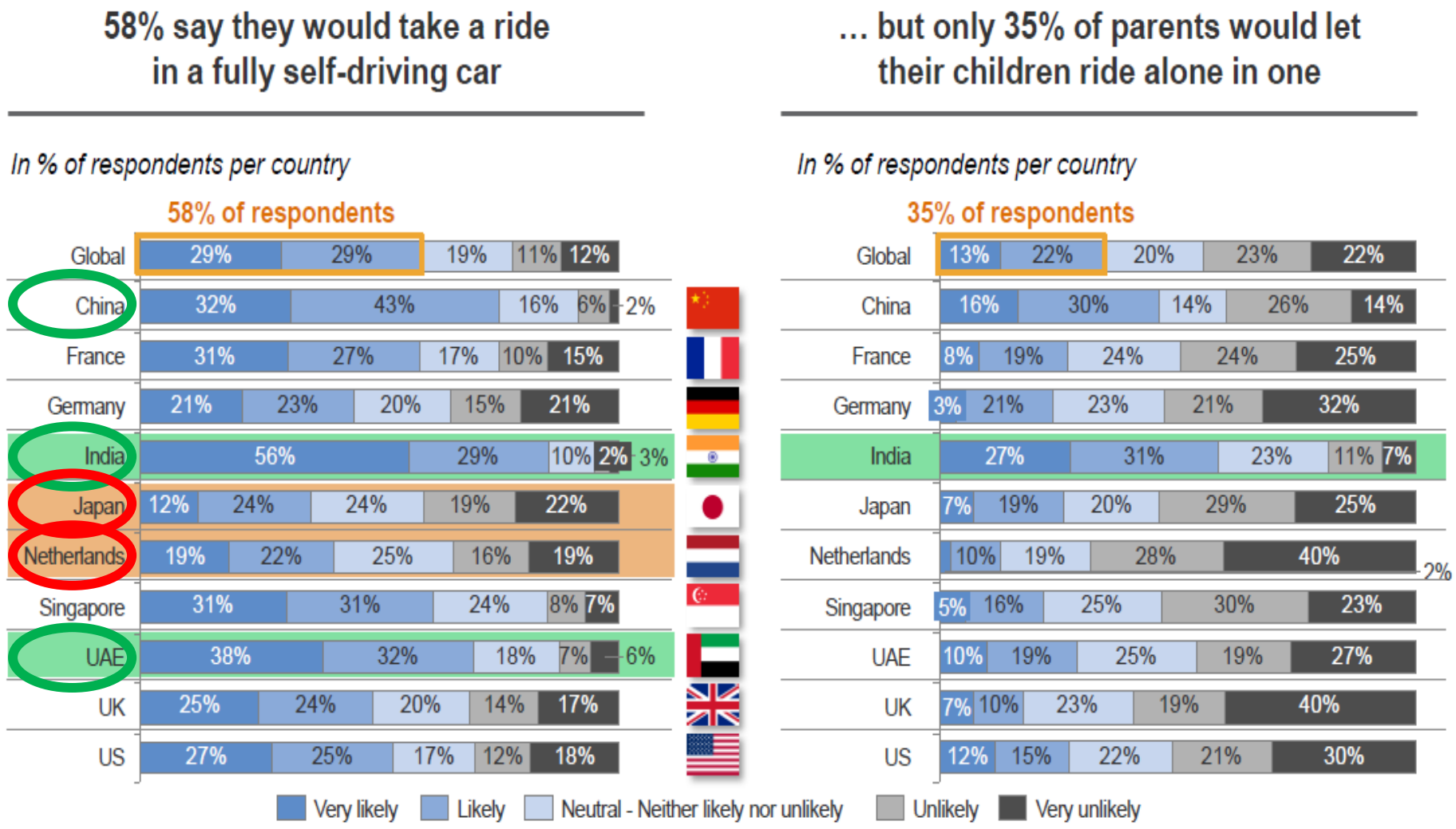


Source: APTA 2011 Fact Book

Economics


Illustrative Mode Share at Various per Mile Prices
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
$3.00
$2.00
$1.00
$0.50
Shared AV
Cycling
Walk
Transit
Private Auto

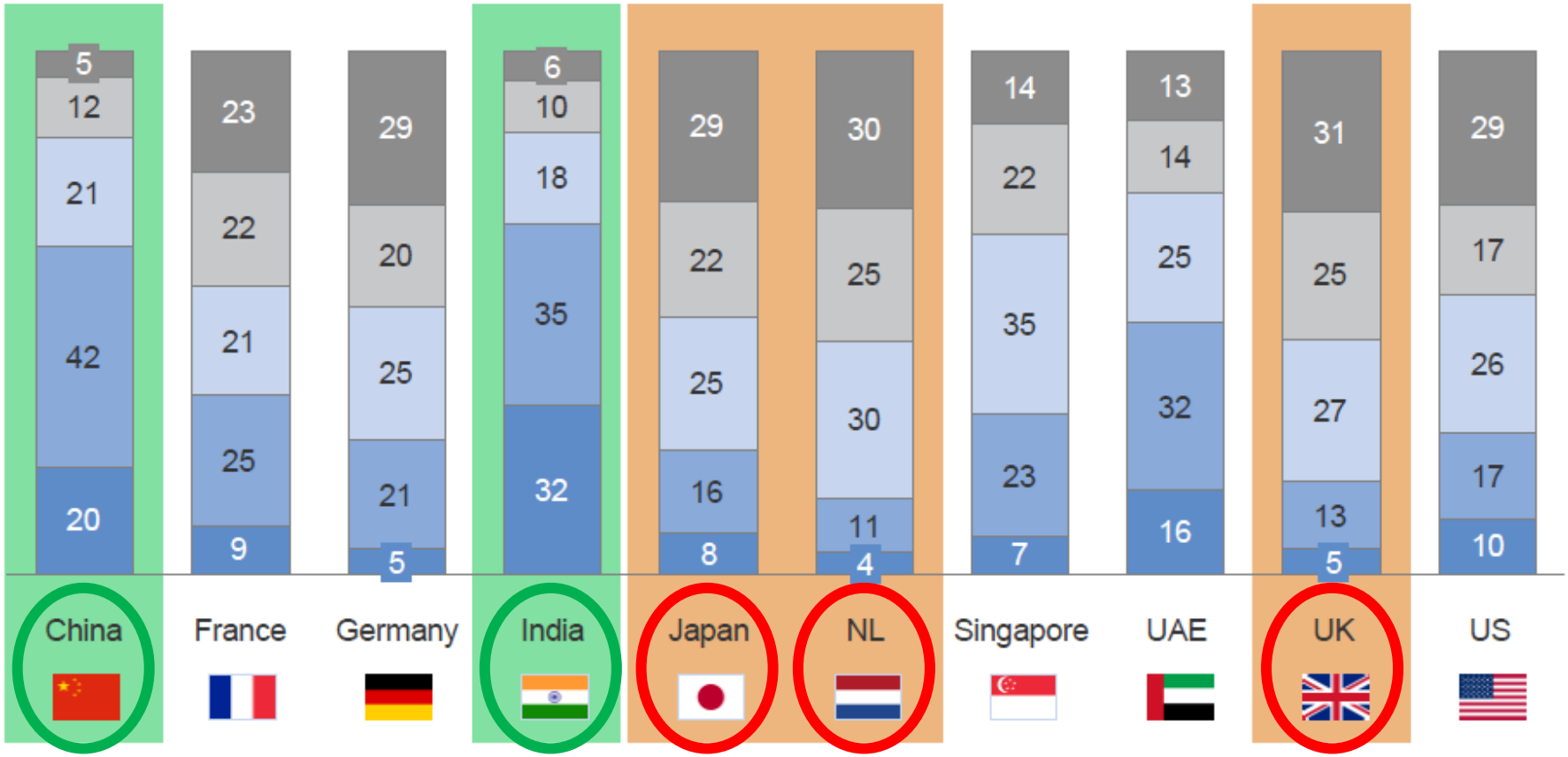
Public Acceptance – Trust of AVs



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

Public Acceptance – Shared Use

In % of respondents per country



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

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*

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

– December 21, 2016 Techcrunch.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

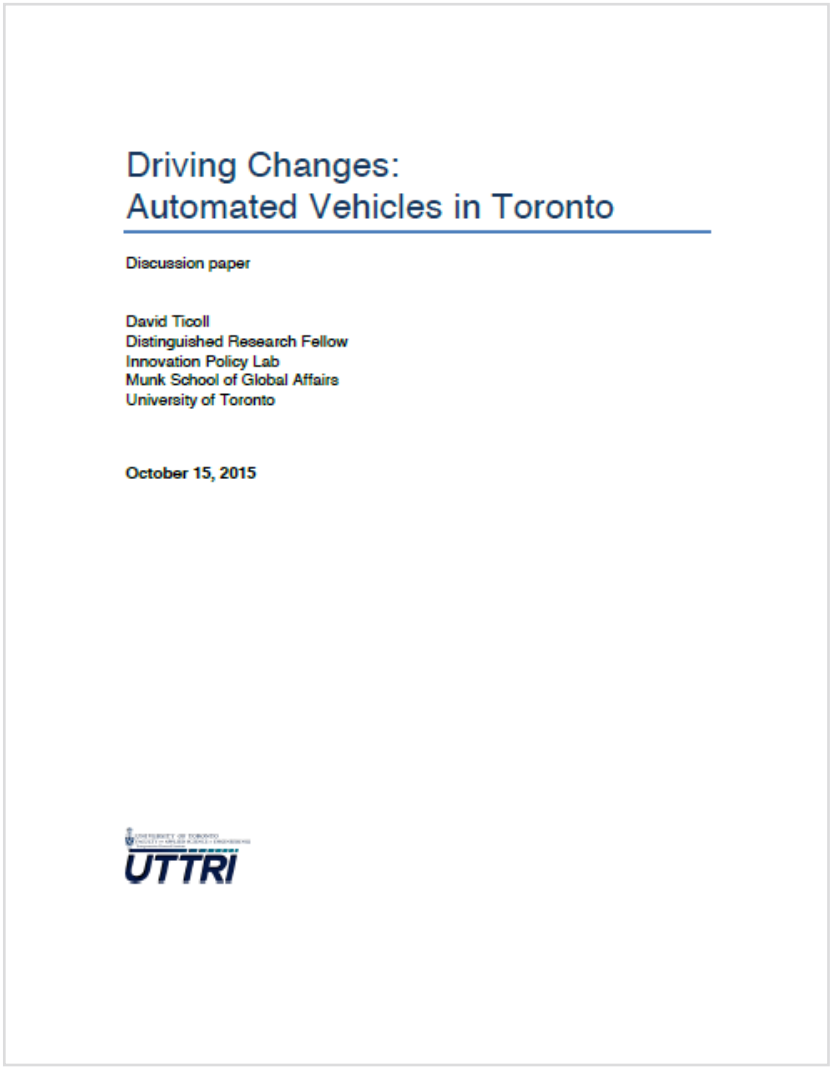
Market for a Shared Model

Key Unknowns

Without a clear understanding of the future,

how do we plan?

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

Driving Changes: Automated Vehicles in Toronto

– David Ticoll, University of Toronto

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	?	↓	↓

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.

Toronto Transportation Services Work Plan

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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.			

TRANSFORM

Are GTHA Residents Ready for Autonomous Vehicles?

Survey Overview

November 24, 2016

Sweet, Matthias; Laidlaw, Kailey; Olsen, Tyler

TRANSFORM 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

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

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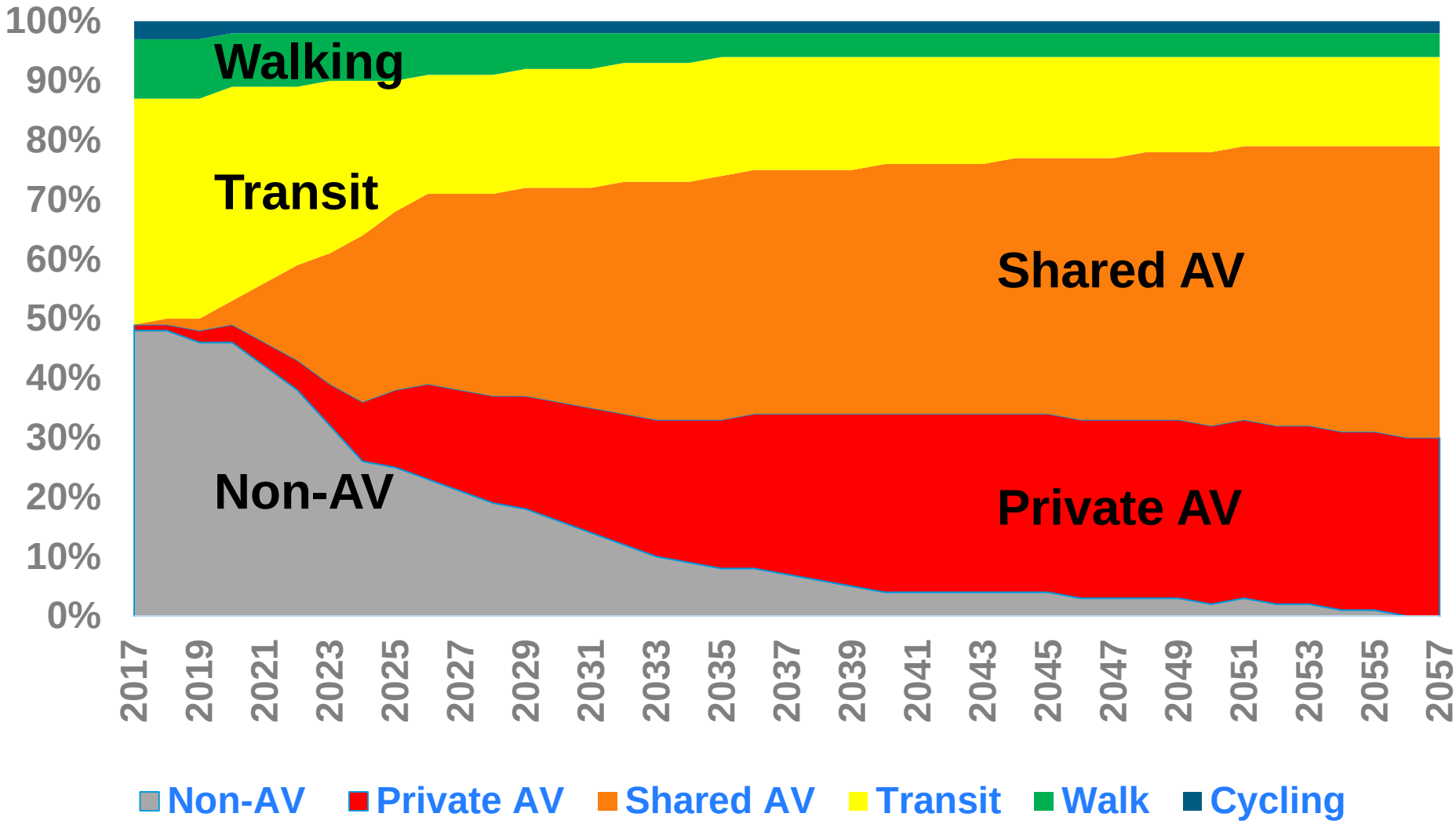
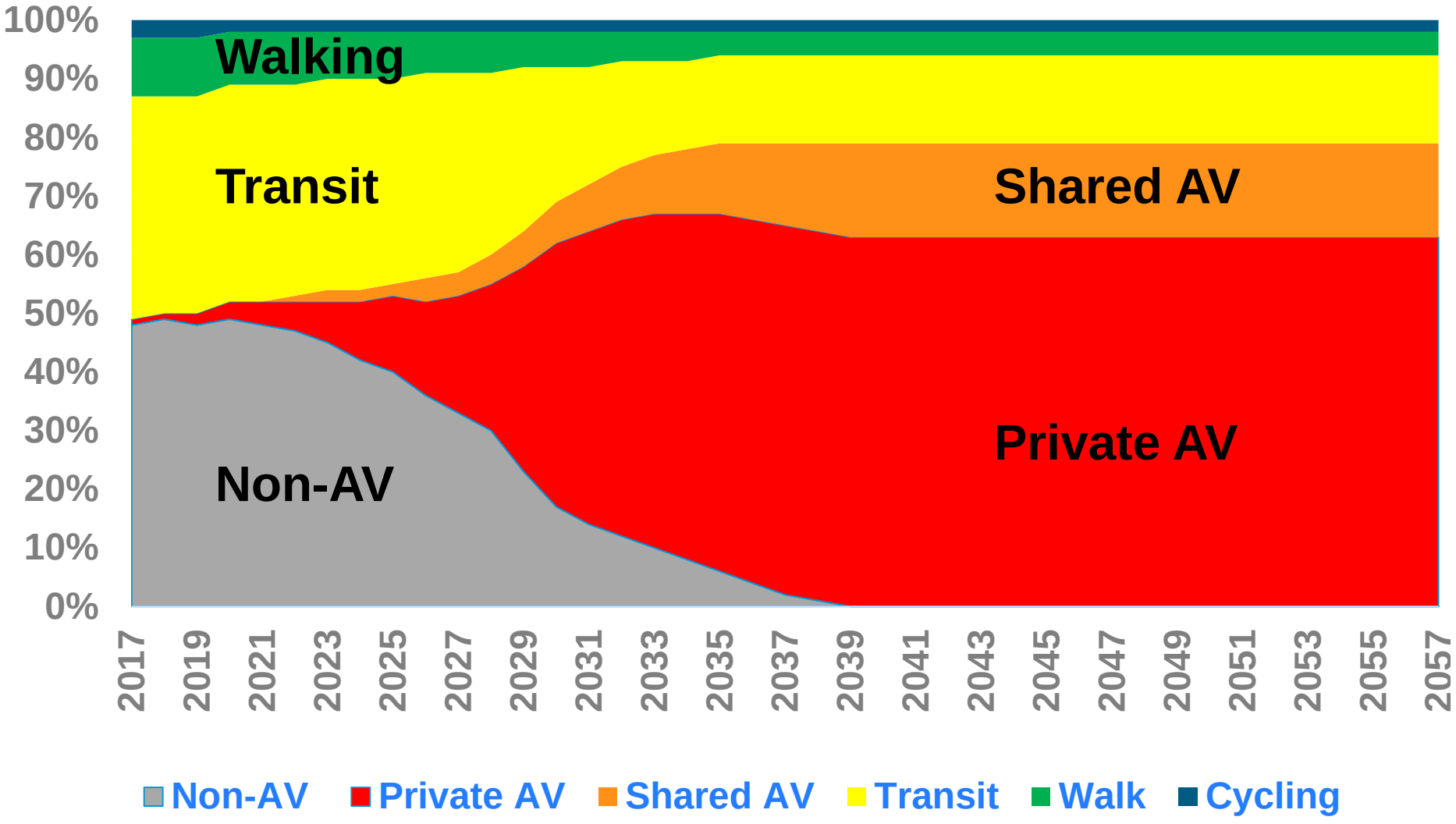
Market for a Shared Model

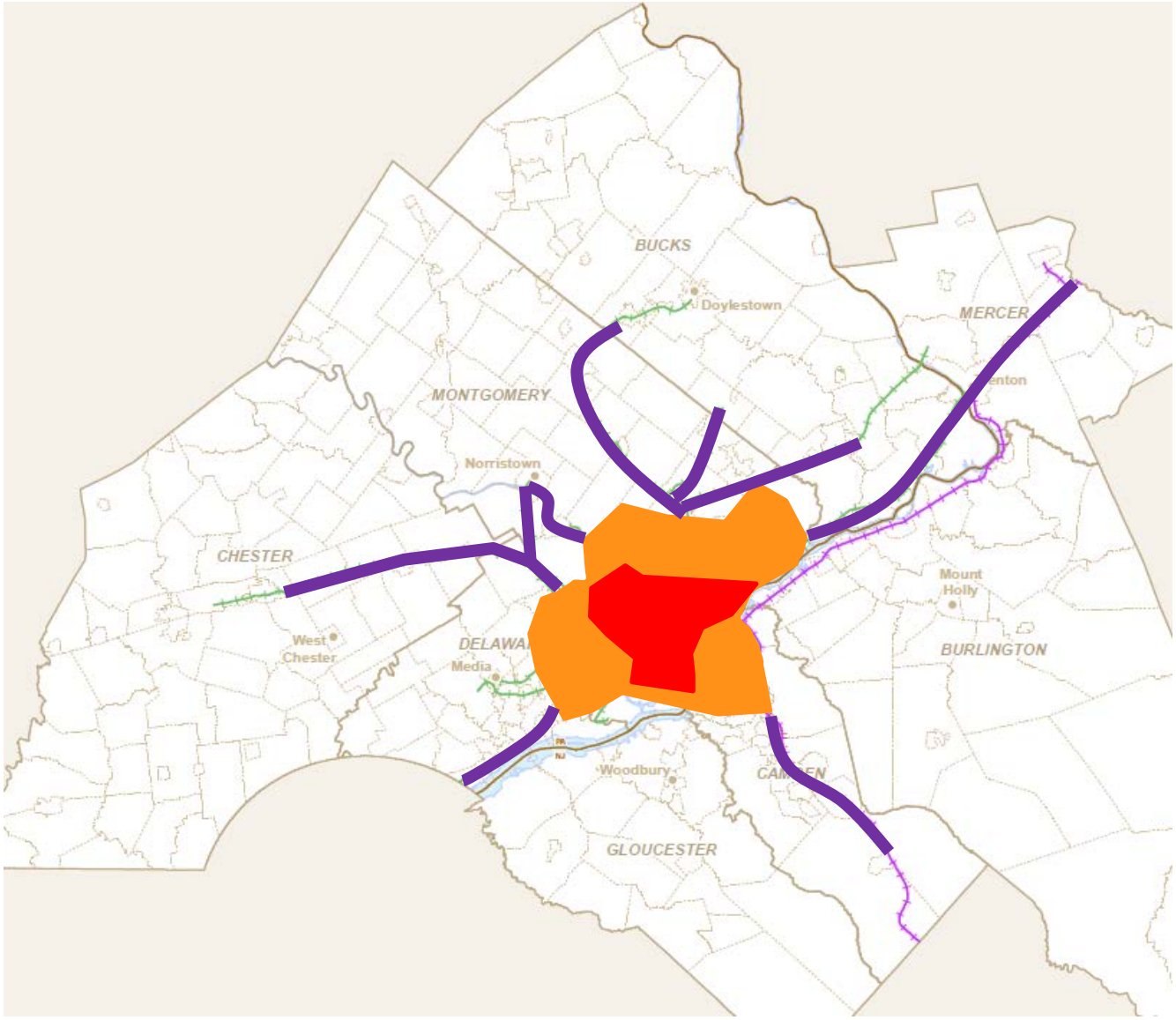
Scenarios – Shared Leads



Scenarios – Private Leads



Potential MaaS Markets



Highly Viable MaaS Service

Viable MaaS Service

Transit-Supportive MaaS Service

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Wildcards

Catastrophic Event

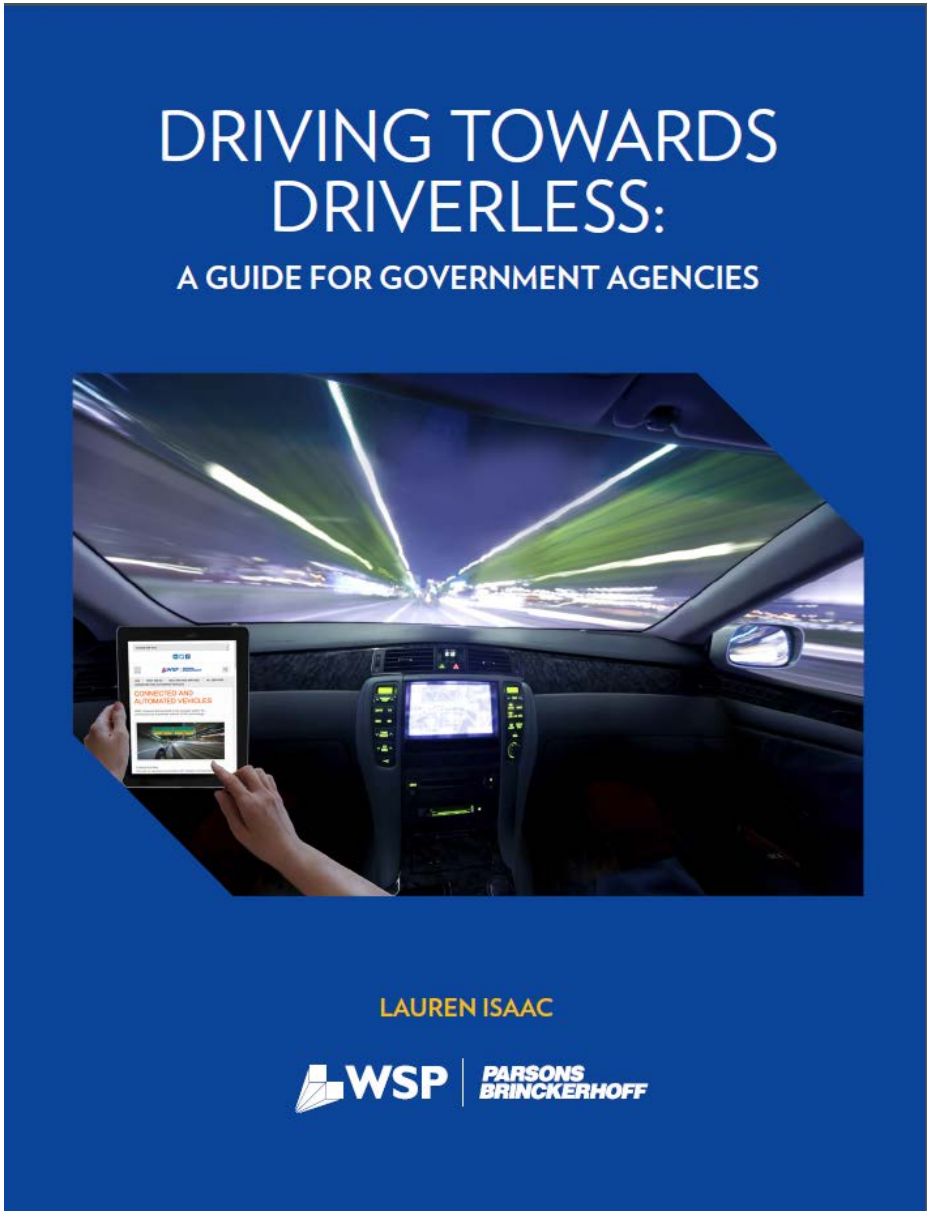
Public Backlash Regarding Data and Privacy

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
WSP
PARSONS BRINCKERHOFF

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

Resources

CAVCOE

AV Update

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

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Richard Voith

The Future of Transportation

ECONSULT SOLUTIONS
economics | policy | strategy

February 8, 2017

Transportation in the Digital Age: A Changing Landscape

- Digital reframing in personal and public transportation
- Ride sharing
- Autonomous vehicles

Transportation in the Digital Age: A Changing Landscape

Data Driven Transportation

- Optimization
- Customer Expectations and Communities

Ridesharing Disruption

- Ridesharing & Transit as Substitutes
- Ridesharing & Transit as Complements

Automation Disruption

- Automation substituting for labor
- Changing spatial needs

Transportation in the Digital Age: The Big Picture

Landscape

A.V.'s

Electric Cars

Ridesharing

Connectivity

Customer Expectations

Mobile Apps

Convenience

Real Time Information

Turmoil for Agencies

Transportation in the Digital Age: 3 Main Players

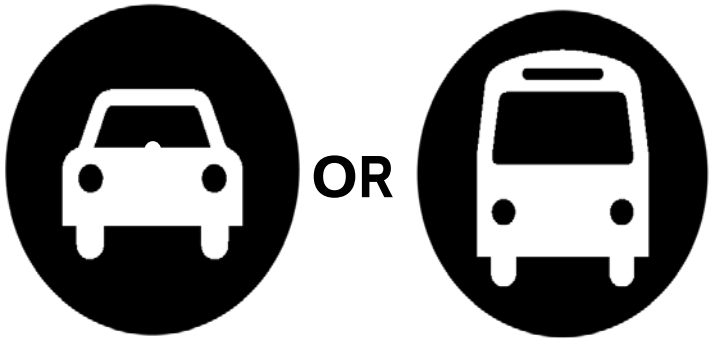
1 Increased Options

2 Mobiles

3 Cashless Transactions

Transportation in the Digital Age: Increased Options for Consumers

From Binary transportation modes (car or transit)



Private Car

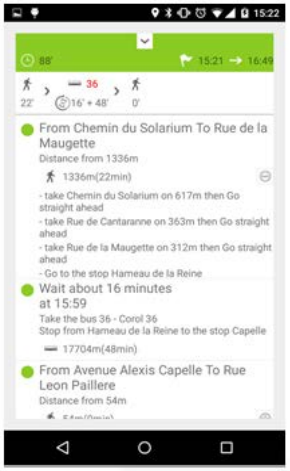
Public Transit

To Multi-modal (transit and rideshare and bike and car share and…)

Transportation in the Digital Age: Mobiles & Cashless Transactions

Trip options

Result on map



Different steps with details

Transportation in the Digital Age: Cashless Transactions

2013

- Overall pass usage: 25% decrease
- Pay per use: 20% increase

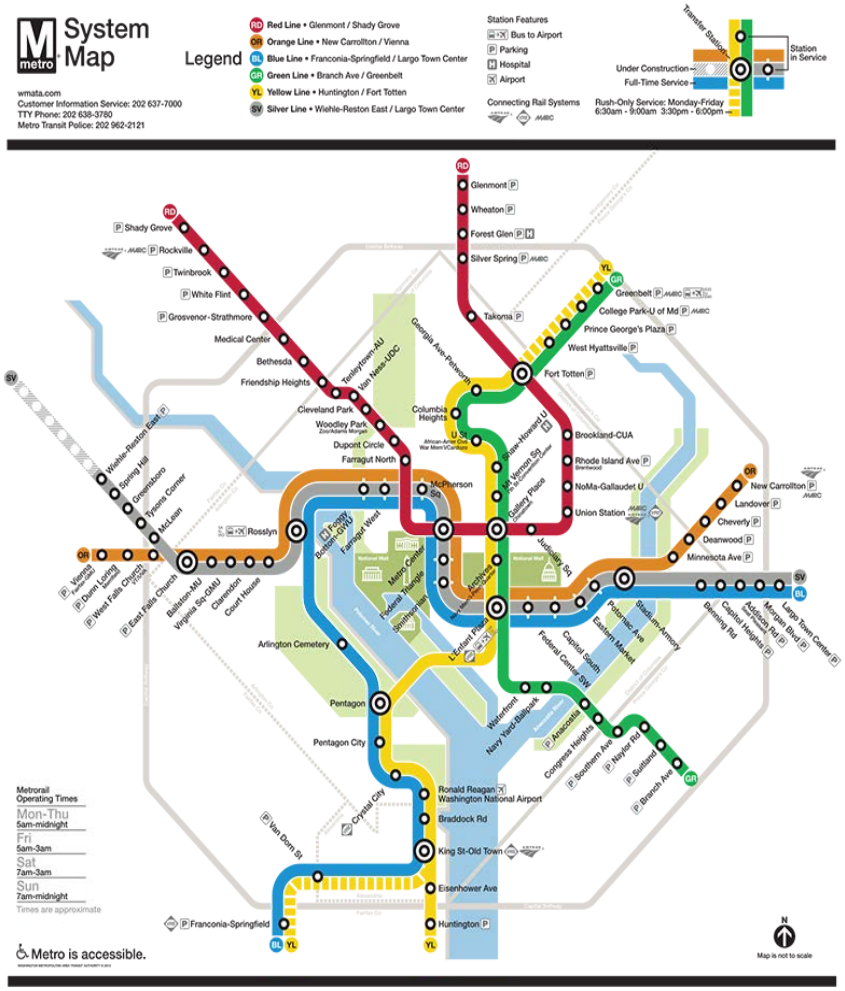
2014

- Bus users: 30% decrease
- Pay per use: 24% increase

2015

- First 9 months: $55 M

Transportation in the Digital Age: Turmoil for Agencies

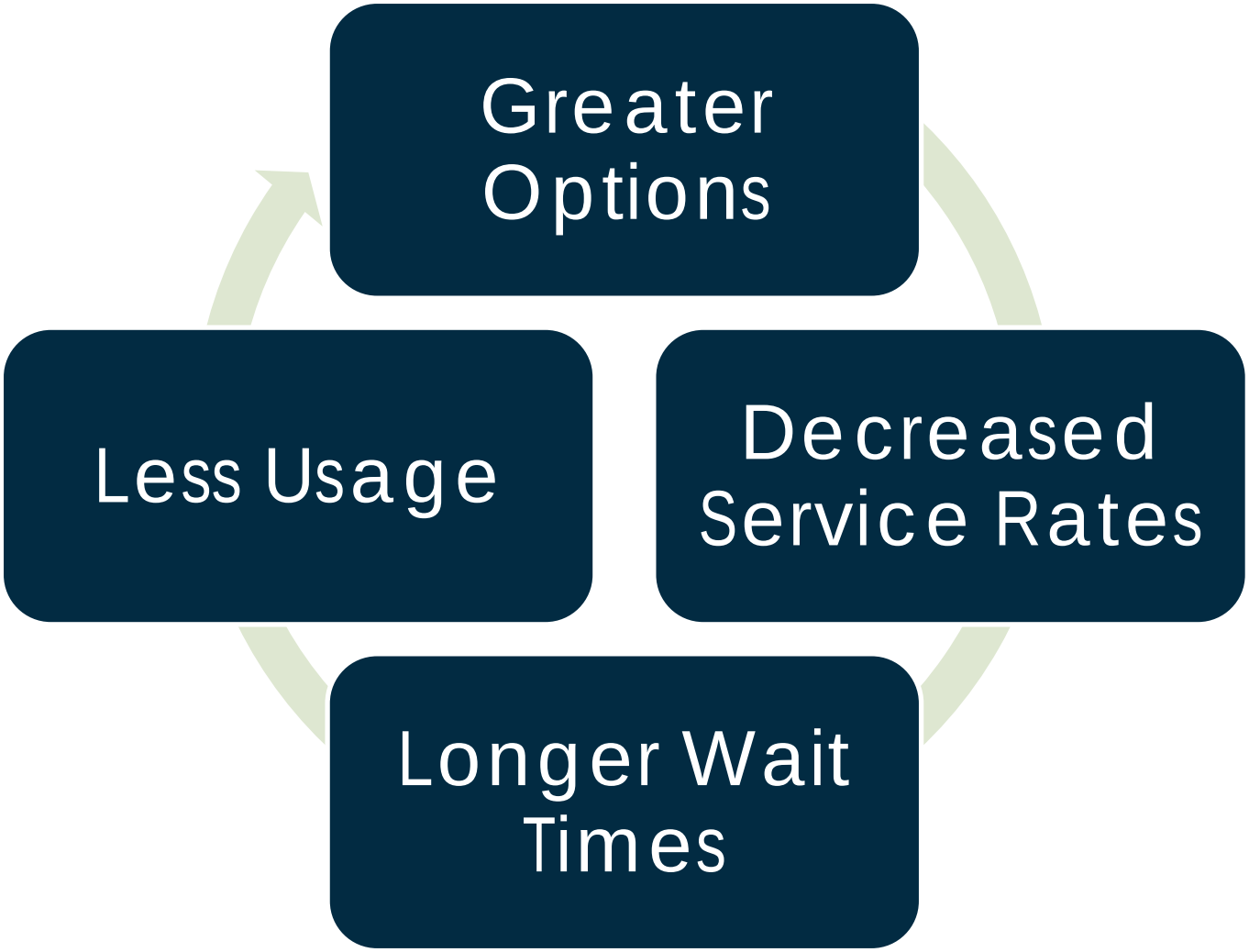


Overdue / Poor-Quality Repairs

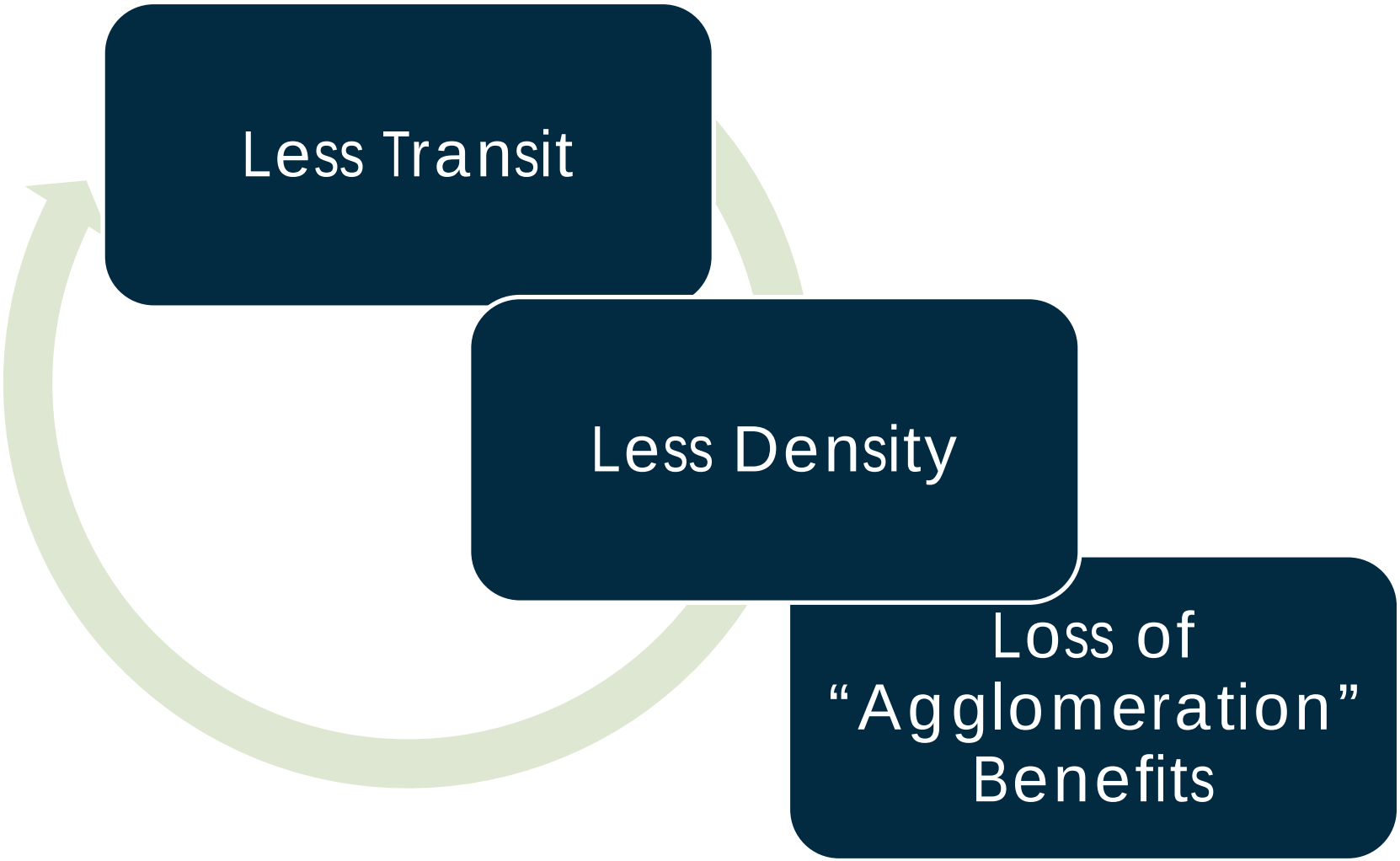
Reduced Service Hours

Decreasing Consumer Confidence

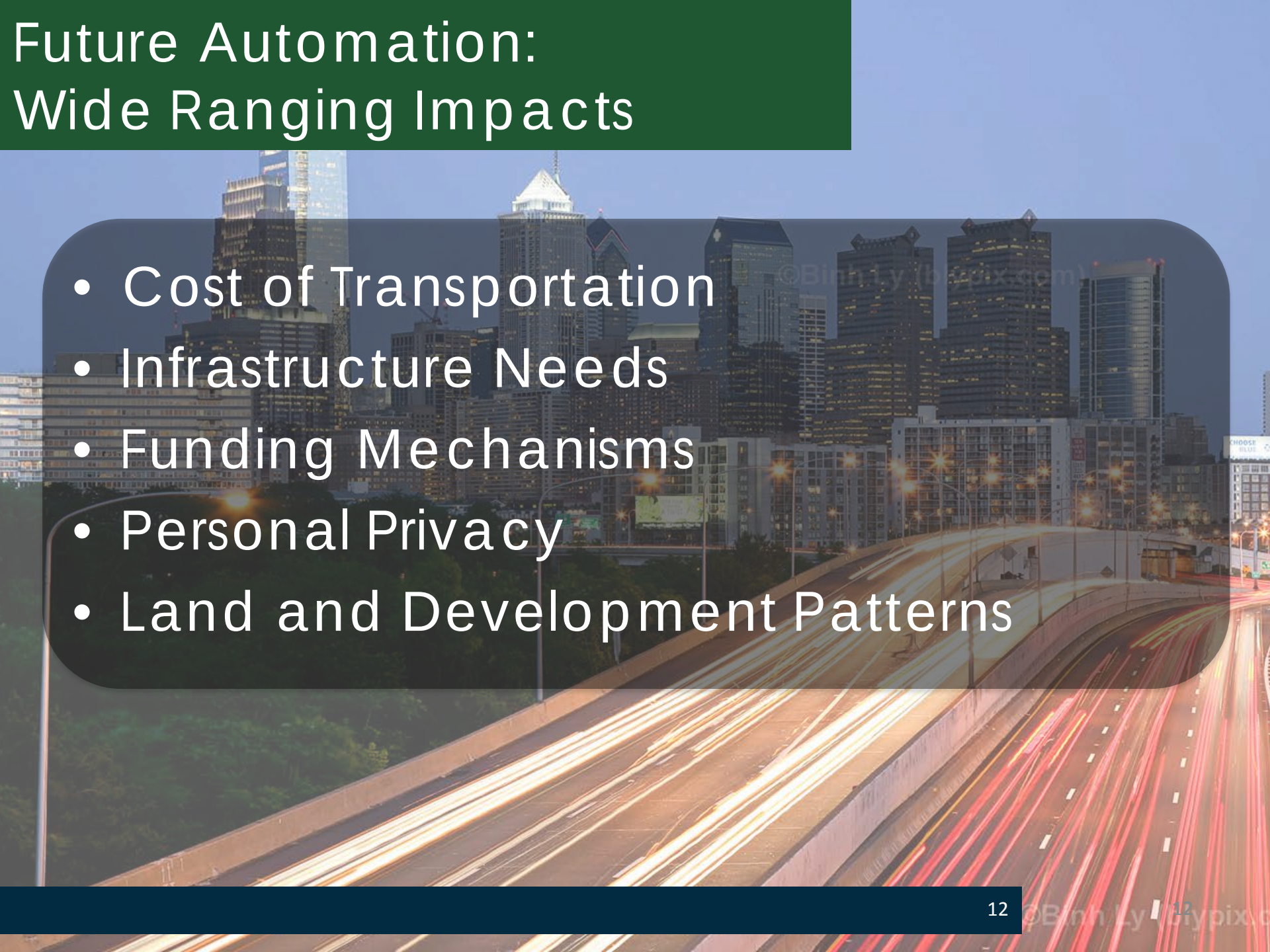
Transportation in the Digital Age: Loss of Public Benefits



Transportation in the Digital Age: Loss of Public Benefits



Future Automation: Wide Ranging Impacts



- Cost of Transportation
- Infrastructure Needs
- Funding Mechanisms
- Personal Privacy
- Land and Development Patterns

12

Automation: Costs of Passenger Transport (Autos)

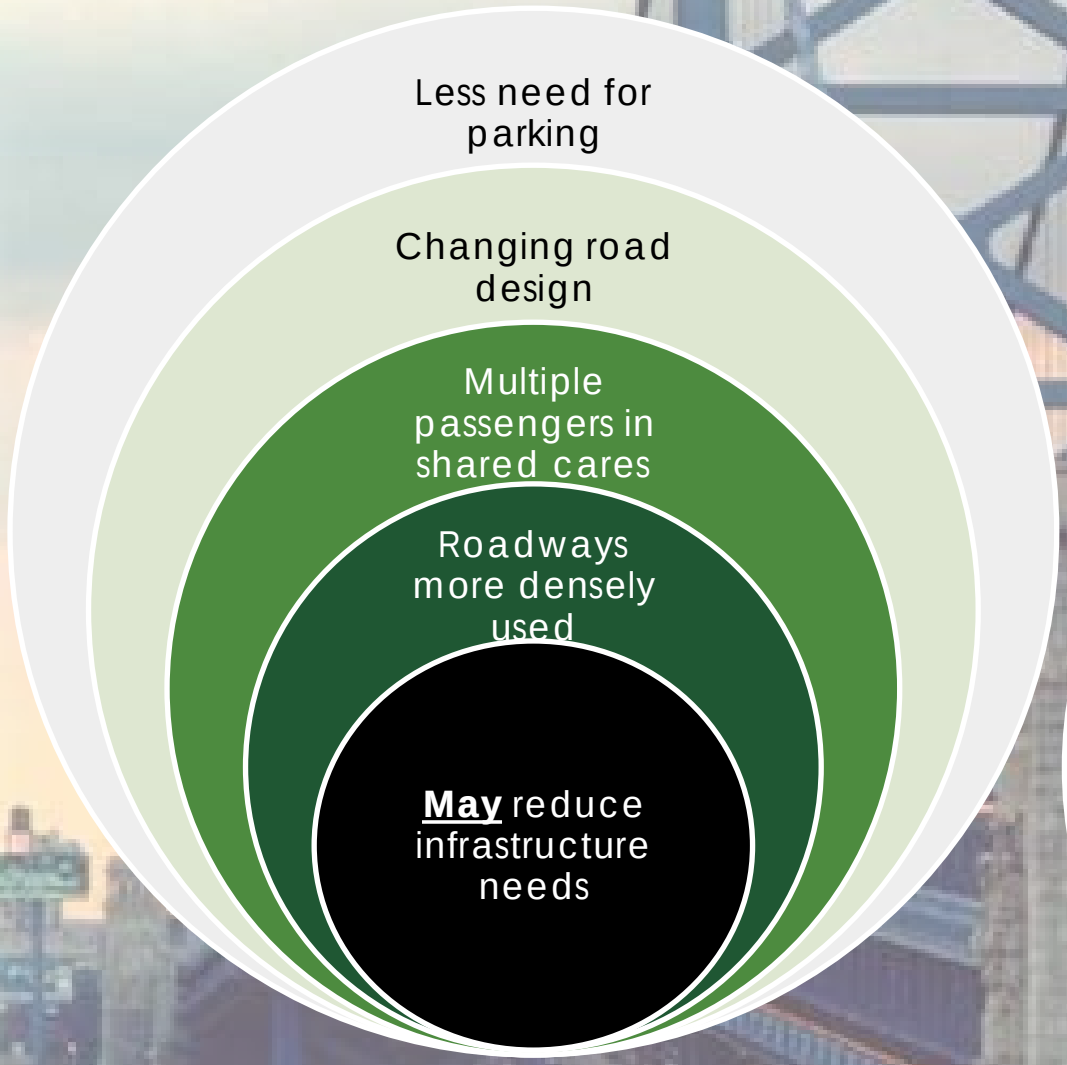
- Autos more expensive, but shared so costs fall
- Travel time can be redirected toward productivity or leisure
- Parking costs can be lower
- Safety risks reduced

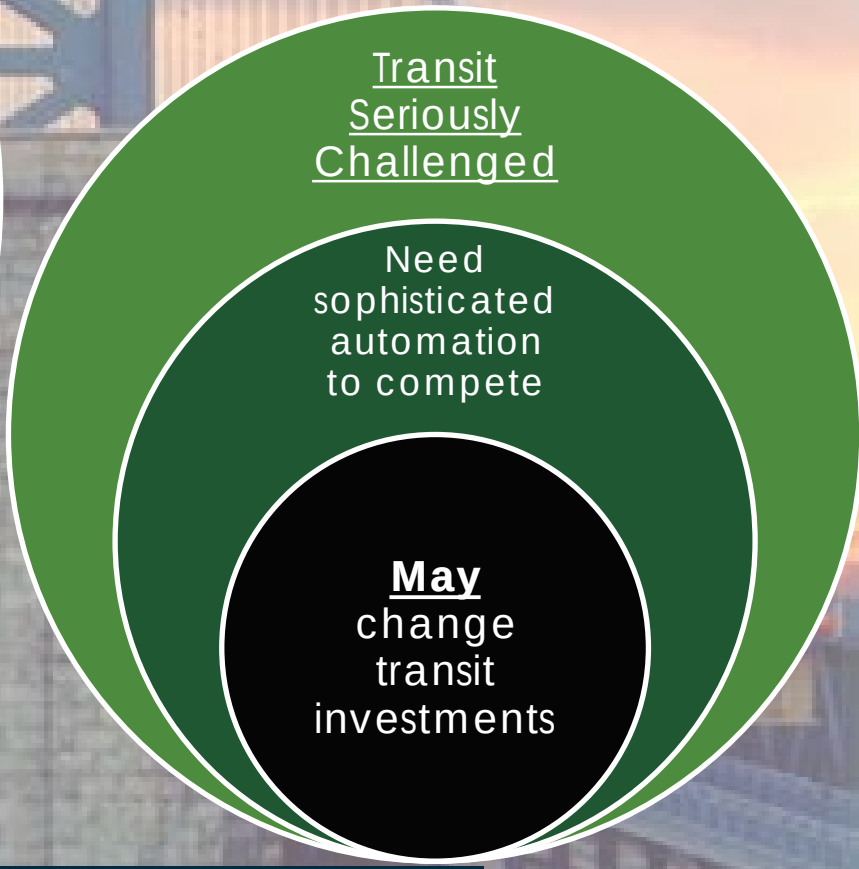
Automation: Costs of Passenger Transport (Transit)

- Last mile transit could fall
- Reduced service levels could raise time costs
- Less dense development could exacerbate transit problems

Infrastructure

Infrastructure: Automation





Infrastructure: Automation

- Infrastructure Savings Depends in Part on
  - Future Land Use Patterns
  - Status of Transit
    - Congestion increase if transit uncompetitive-> more infrastructure

Infrastructure Needs: Freight and Logistics

- Reduced need for cars to carry packages
  - Need for shared delivery locations
  - Changing nature of retail
- Need public and private infrastructure to support new delivery logistics

Funding Mechanisms

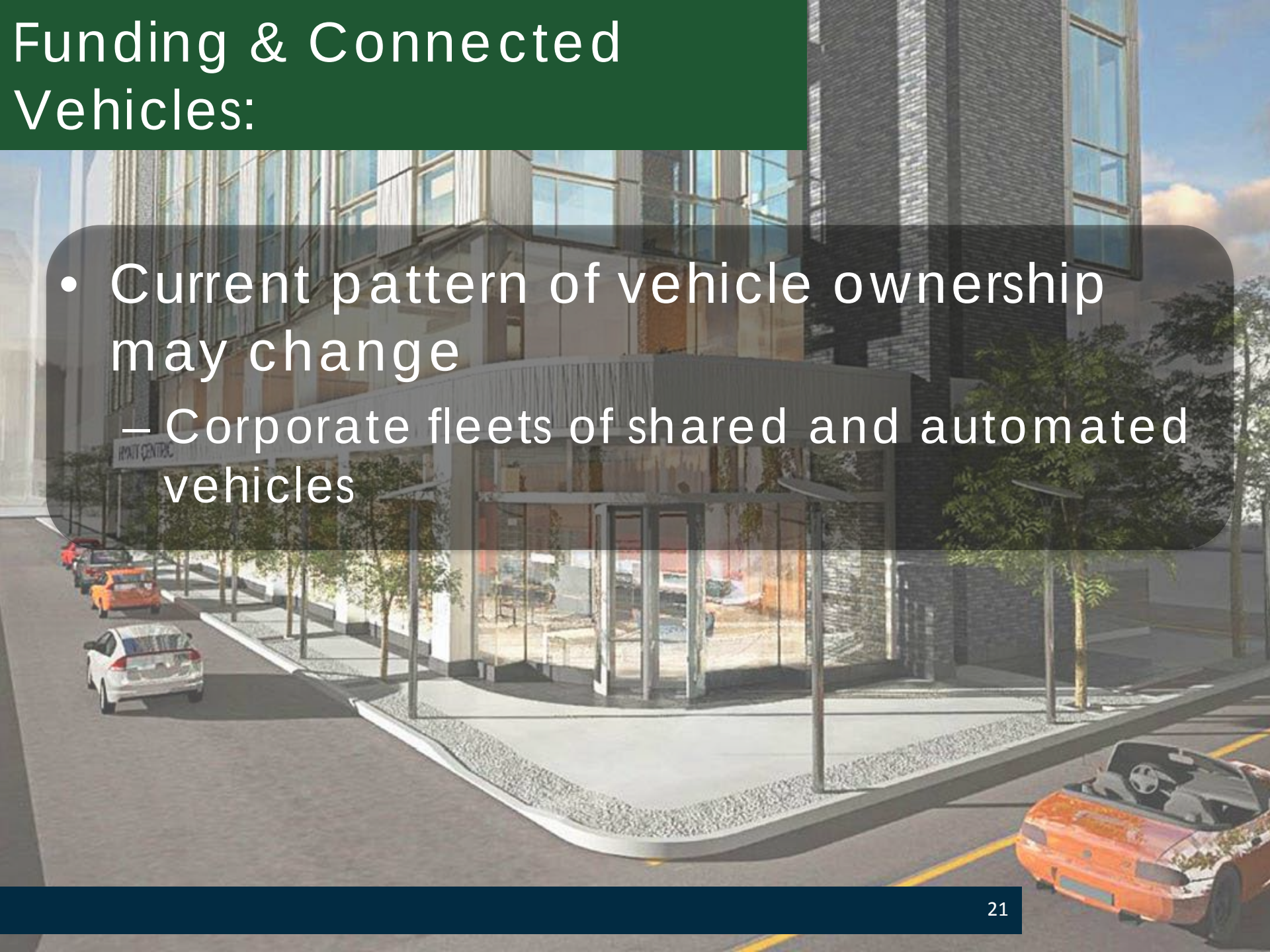
Transportation Funding in PA and NJ

- Gas Tax based funding of infrastructure should work well into the near future

BUT:

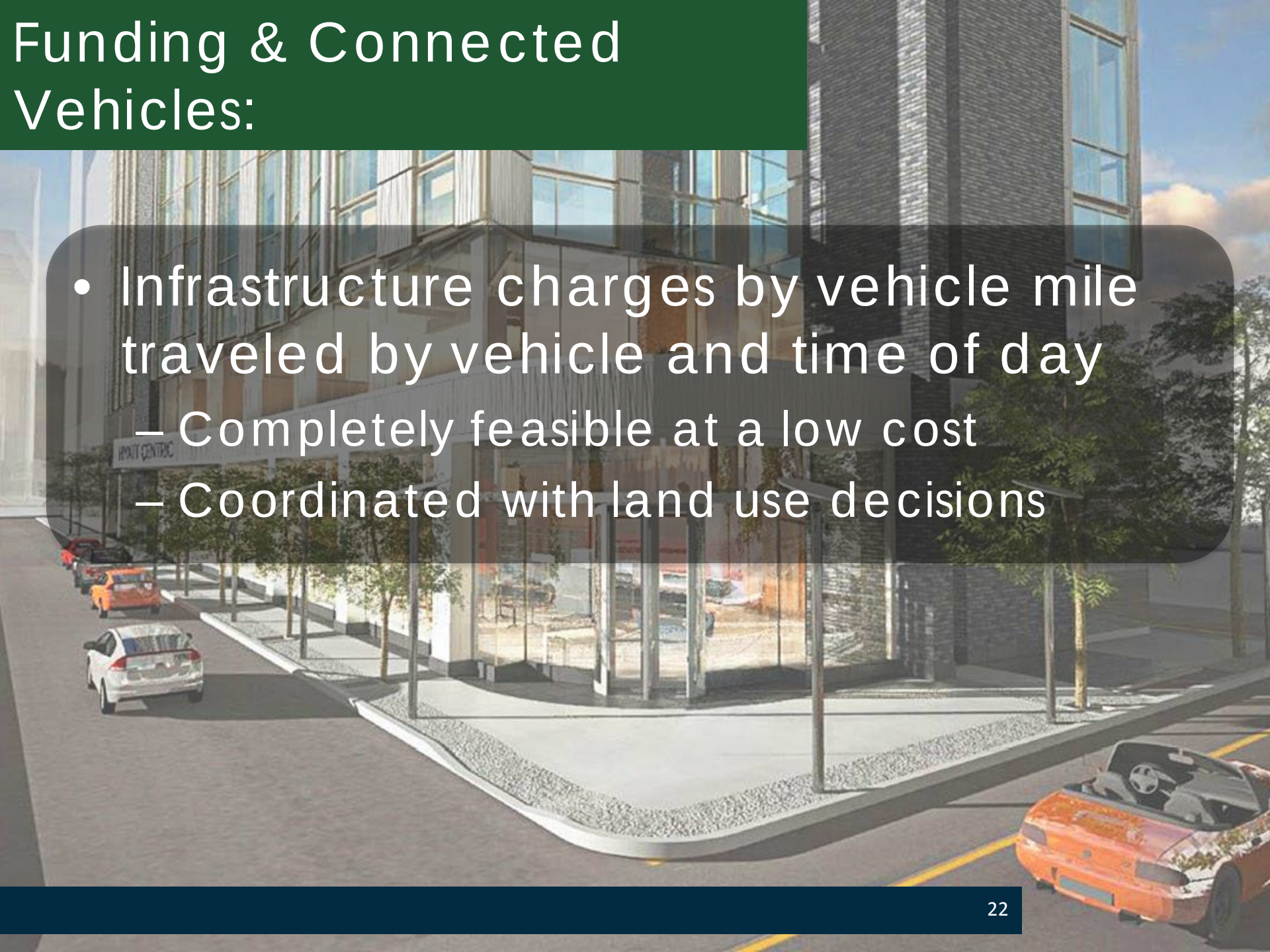
- The world and transportation landscape is changing

Funding & Connected Vehicles:



- Current pattern of vehicle ownership may change
  - Corporate fleets of shared and automated vehicles

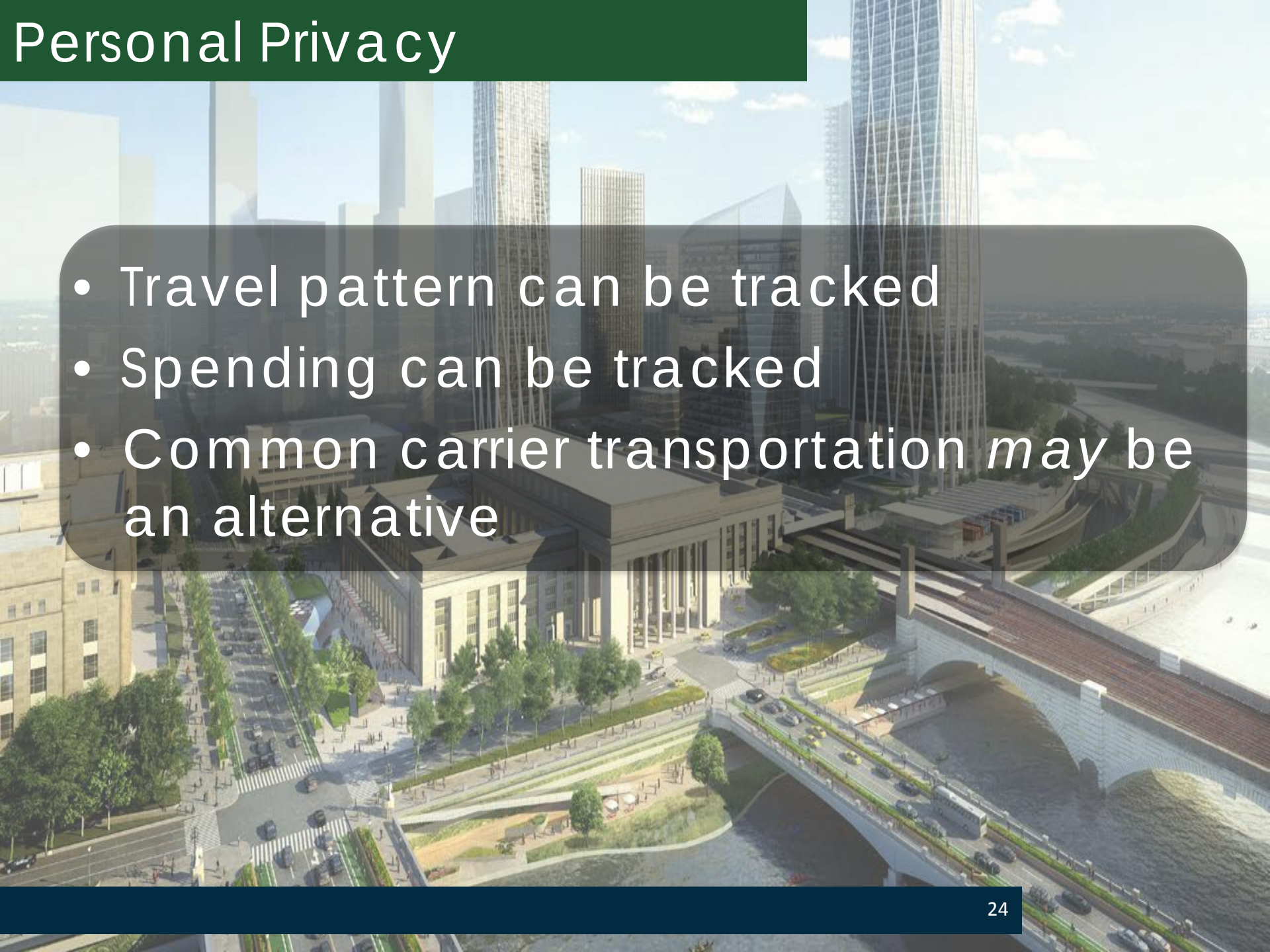
Funding & Connected Vehicles:



- Infrastructure charges by vehicle mile traveled by vehicle and time of day
  - Completely feasible at a low cost
  - Coordinated with land use decisions

Personal Privacy:

Personal Privacy



- Travel pattern can be tracked
- Spending can be tracked
- Common carrier transportation *may* be an alternative

Personal Privacy

Land Use & Development Patterns:

Automation: Land Use & Development

- Remote parking
- Denser centers (maybe)
- Lower travel costs -> More travel, greater decentralization

Automation: Land Use & Development

- Potential agglomeration loss
- Access for lower income citizens could be adversely impacted

Thank You

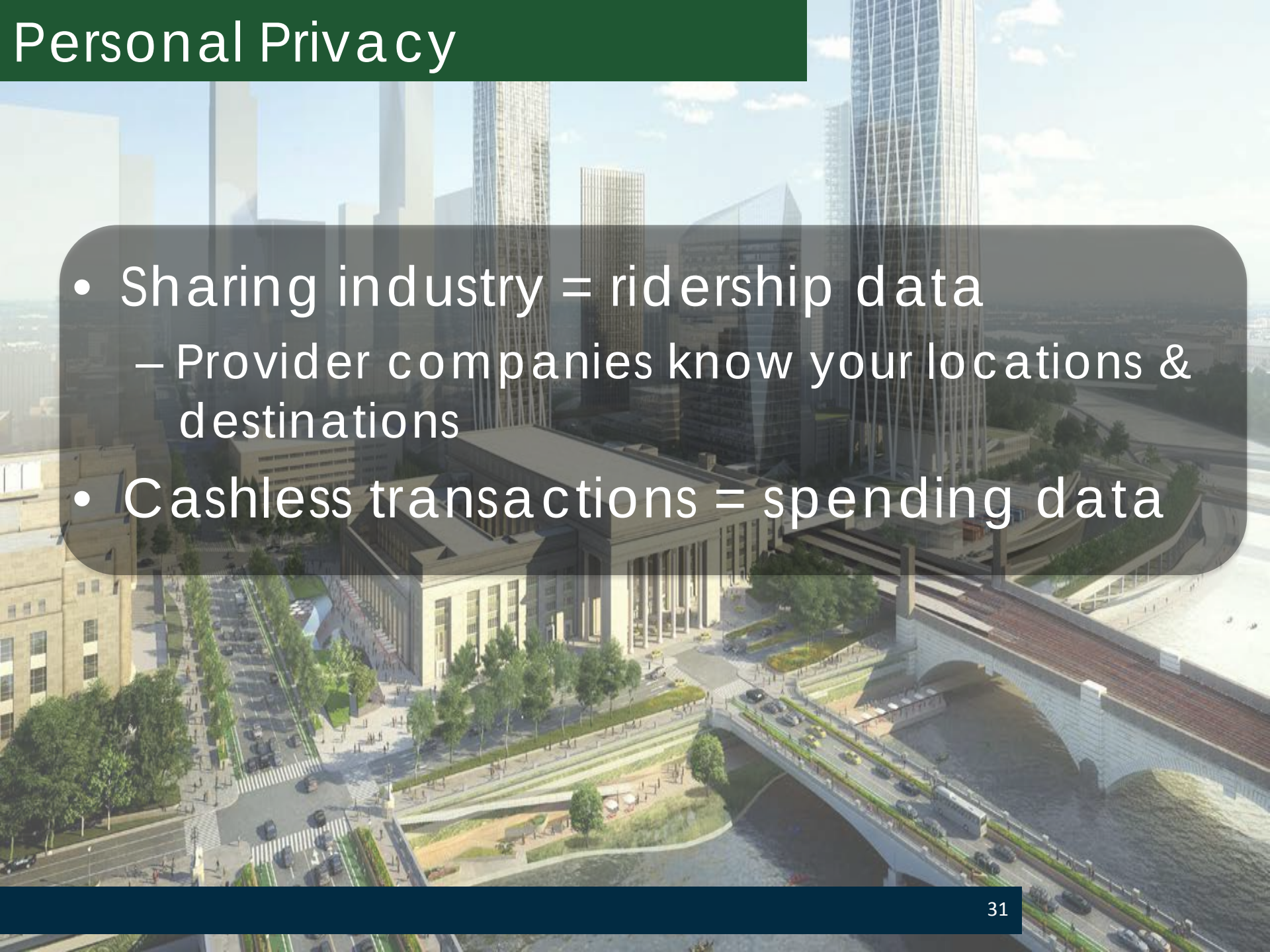
Questions?

Econsult Solutions
1435 Walnut Street, 4th floor
Philadelphia, PA 19147
215-717-2777

Infrastructure: Automation

- **May** reduce infrastructure needs
  - Roadways more densely used
    - Multiple passengers in shared cars
    - Closer spacing with connected vehicles
    - Changing road design
  - Less need for parking

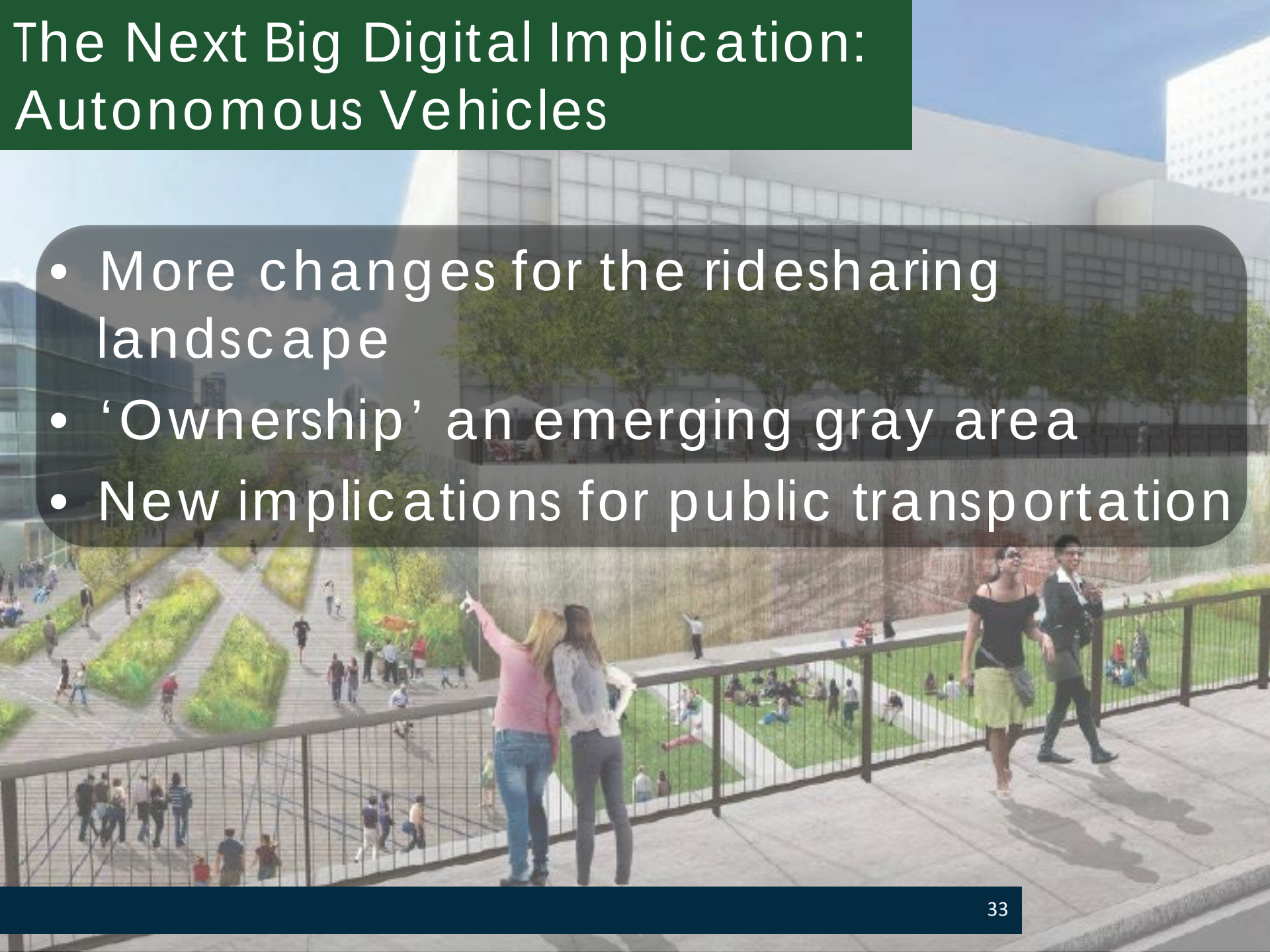
Personal Privacy



- Sharing industry = ridership data
  - Provider companies know your locations & destinations
- Cashless transactions = spending data

Development Patterns:

The Next Big Digital Implication: Autonomous Vehicles



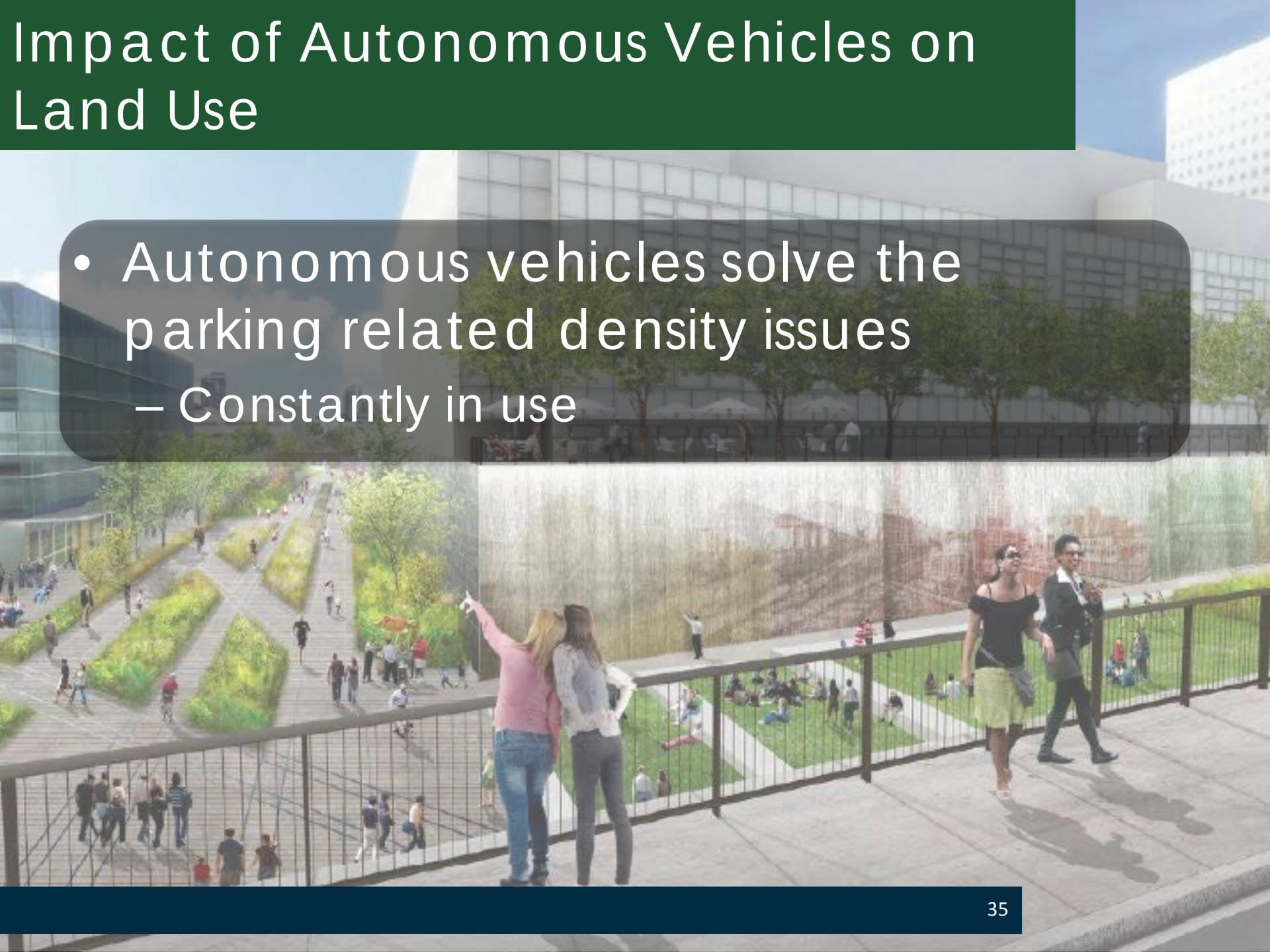
- More changes for the ridesharing landscape
- ‘Ownership’ an emerging gray area
- New implications for public transportation

The Next Big Digital Implication: Autonomous Vehicles

- Cannot satisfy demand for larger scale transportation

Impact of Autonomous Vehicles on Land Use

- Autonomous vehicles solve the parking related density issues
  - Constantly in use



Transportation in the Digital Age: A Changing Landscape

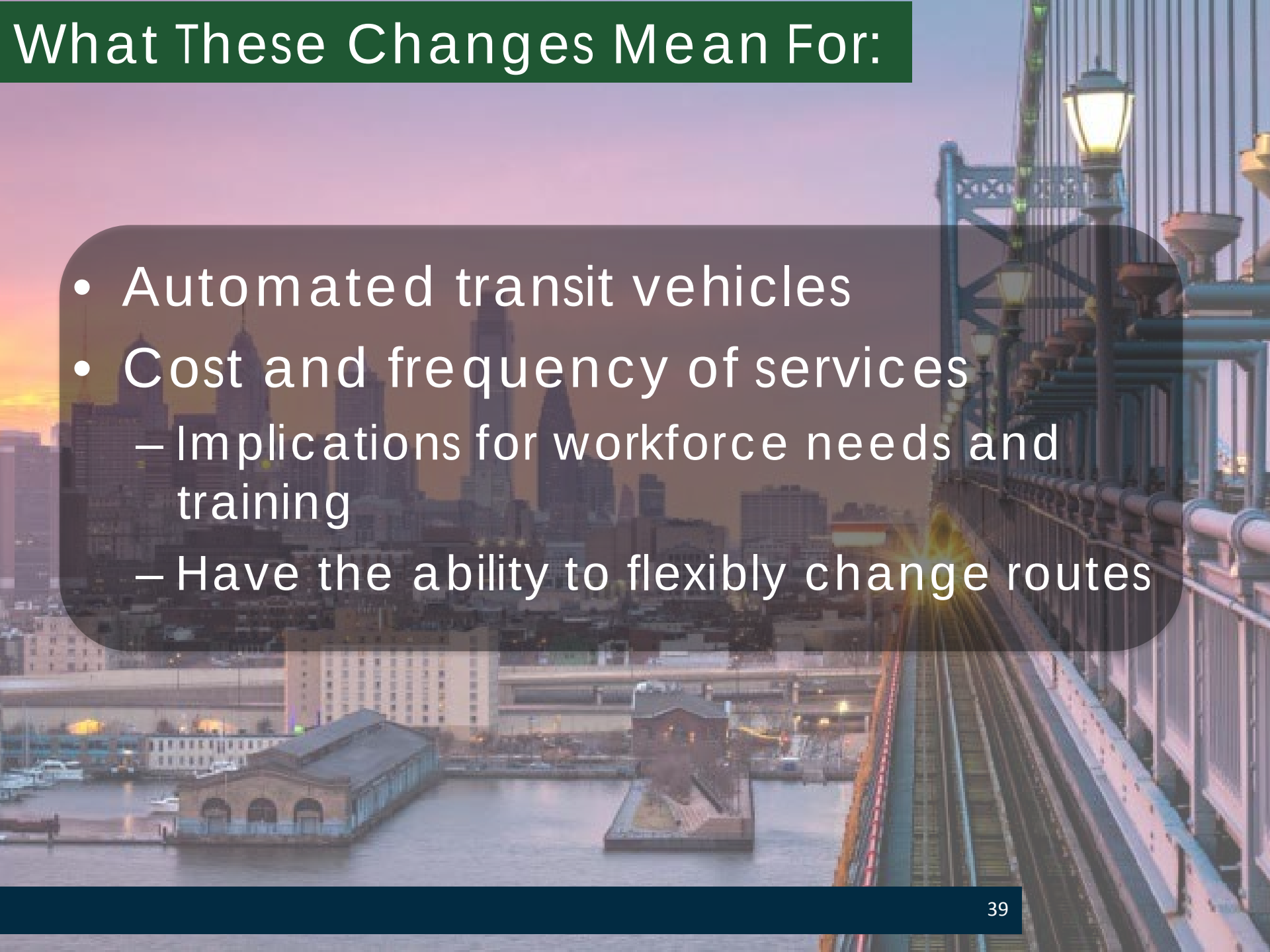
- Data-driven Transportation Services
  - Optimization
  - Customer Expectations and Communication
- Ridesharing Disruption
  - Ridesharing & Transit as substitutes
  - Ridesharing & Transit as complements
- Automation Disruption
  - Automation substituting for labor
  - Changing spatial needs

Infrastructure Needs: Urban

- Cities have less of a need for parking in central areas
- More efficient use of roads will lead to greater density
  - Lower cost transit
  - Less need for cars
  - Increased sharing, less need for urban personal ownership

- Time costs may be lowered if not shared
- Lower cost implies more travel
  - More travel = decentralization
  - Time costs don't fall = decentralization of lower income people

What These Changes Mean For:



- Automated transit vehicles
- Cost and frequency of services
  - Implications for workforce needs and training
  - Have the ability to flexibly change routes

Infrastructure: Automation

- **May** change transit investments
  - Need sophisticated automation to compete
  - Implications depend on land use

Pennsylvania Autonomous Vehicle Testing Policy Task Force

Highly Automated Vehicles

The Coming Revolution

Background: *Innovation Unleashed*

- PA leadership
  - Academic: Carnegie Mellon; UPenn; Penn State
  - AAMVA, AASHTO, TRB
- City of Pittsburgh
  - CMU Autonomous Vehicle
  - GM
  - Uber
- 2016 USDOT Smart Cities Finalist
  - Awarded $10.9 million by USDOT to implement a component of their original smart city application

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PennDOT HAV Goals

1. Promote and encourage HAV R&D, innovation and testing in Pennsylvania
2. Ensure public safety on Pennsylvania roadways

Safety is PennDOT's paramount mission

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Our Approach

- Current law: legal, but limited

- Proposed legislation (SB 1412; HB 2203)
  - Advance AV testing on public roads
  - Testing to be overseen by PennDOT; PA Turnpike

- Regulations versus Policy
  - Flexibility to keep pace with innovation
  - Readiness to address safety issues promptly

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Stakeholder Collaboration: Participating Members

Federal Government

U.S. Department of Transportation
Federal Highway Administration

State Government

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PENNA TURN PIKE

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STATE POLICE

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INSURANCE DEPARTMENT

General Assembly of Pennsylvania

PA pennsylvania
DEPARTMENT OF COMMUNITY & ECONOMIC DEVELOPMENT

Local Government

CITY OF PITTSBURGH

Private Sector Organizations

SAE INTERNATIONAL

AAA

ATA AMERICAN TRUCKING ASSOCIATIONS

PENNSYLVANIA ASSOCIATION FOR JUSTICE

PMTA Pennsylvania Motor Truck Association

Academia

Carnegie Mellon University

Penn
University of Pennsylvania

Private Sector Business

GM

UBER

AV Task Force Mission

- Develop testing policy recommendations in anticipation of legislation
- Consensus seeking effort
- Alternate views and opinions recorded

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Task Force – Policy Framework

1. Establishing the minimum levels that HAVs must achieve to begin testing
2. Identifying “The ‘Where, When, and How’ of Testing”
3. Defining “Who is the Driver?”
4. Considering “Vehicle Characteristics, Capabilities, and Security”
5. Determining what data do we want/need to collect, and what do we do with it?
6. Examining how we approve and govern testing now and in the future

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Task Force Report Accepted – Nov. 2016

Resources

- PennDOT AV webpage: http://www.penndot.gov/ProjectAndPrograms/ResearchandTesting/Pages/Autonomous-Vehicle-Testing.aspx
- Task Force report: http://www.penndot.gov/ProjectAndPrograms/ResearchandTesting/Documents/AV%20Testing%20Policy%20DRAFT%20FINAL%20REPORT.pdf
- Town Hall webinar: http://www.pacast.com/players/cmsplayer_ios.asp?video_filename=14404_penndot_auto_feed.m4v
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Next Steps

- Enact legislation
- Expand Task Force representation and mission
- Foster and promote citizen engagement
- Identify and address critical issues
  - Trial and error
  - Human/automated driver transition
  - Workforce/business impacts
  - Cyber security, data privacy, and ownership

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