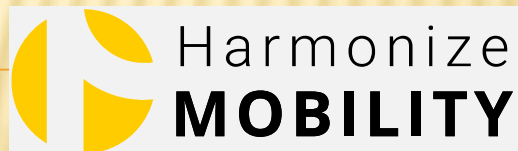


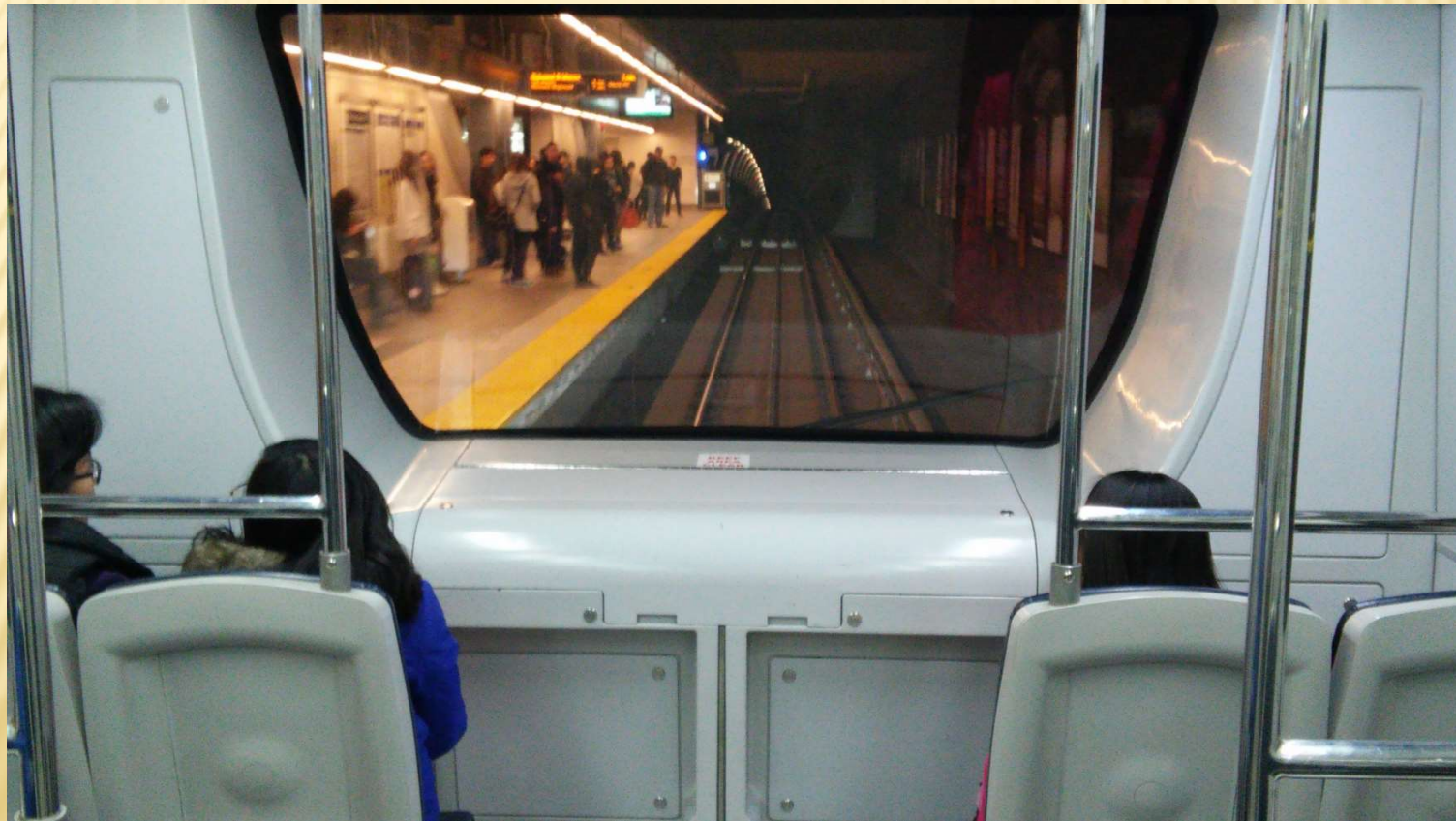
DRIVERLESS CARS: BARRIERS, ENABLERS, UNCERTAINTIES

John Niles
Harmonize Mobility, Inc.

May 27, 2019



DRIVERLESS MOBILITY IN VANCOUVER SINCE 1986



GM ELECTRIC BOLT ROBOCAB



DRIVERLESS CAR INTERIOR IMAGINED



Rinspeed

TWO KINDS OF AUTOMATED VEHICLES WILL HAPPEN

Market 1

**Personal
Automation**

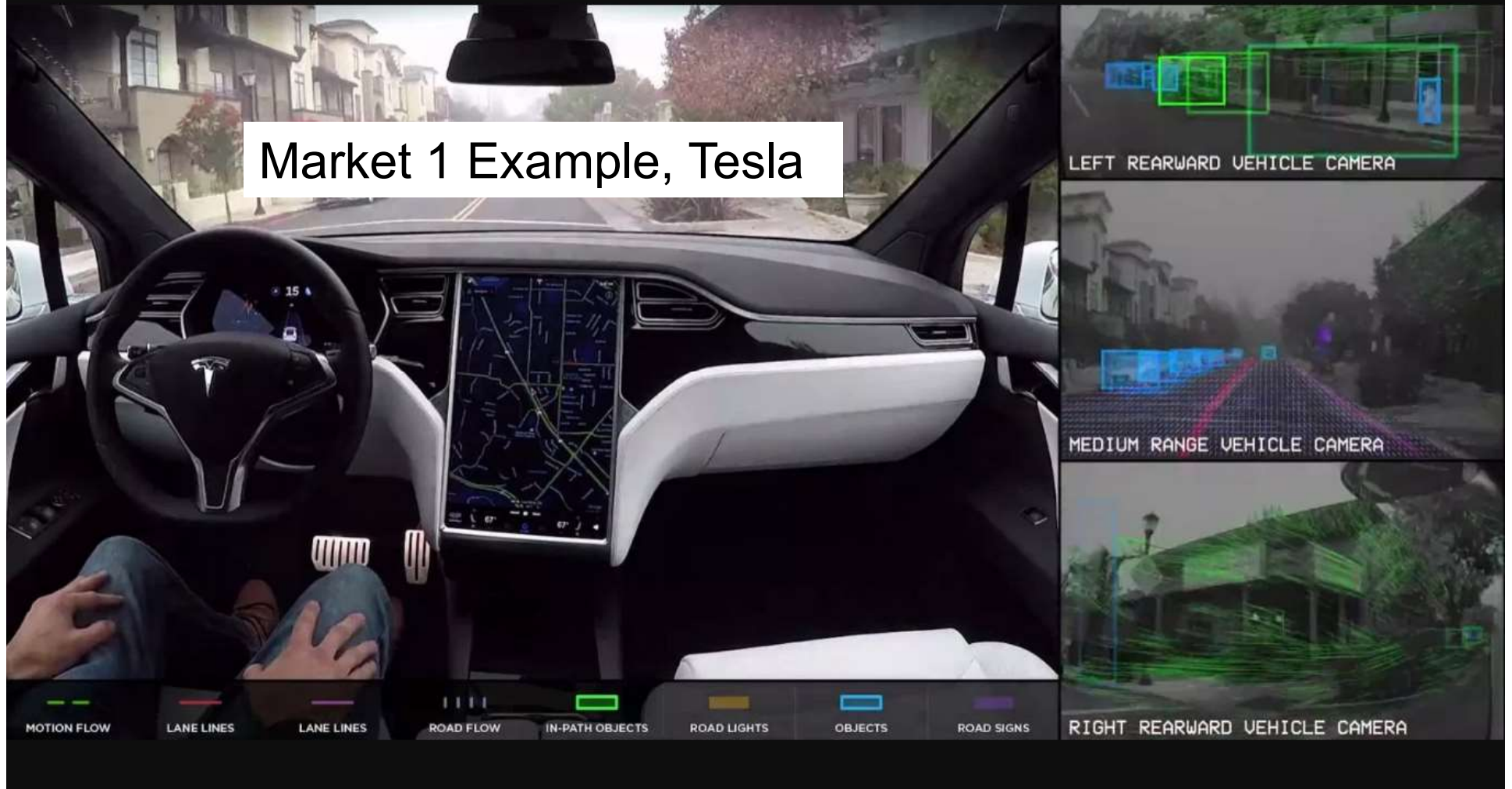
People buying CARS

Market 2

**Public
Automation**

People buying RIDES

Market 1 Example, Tesla



Audi Q2

Driver assistance systems - overview of sensors

06/16

Market 1 Example: Audi



Front camera:

- adaptive cruise control (ACC)
- Stop&Go incl. Traffic jam assist
- Audi active lane assist
- Camera-based traffic sign recognition
- High beam assist

Ultrasonic sensors at rear:

- Parking system rear
- Parking system plus
- Parking assist

Ultrasonic sensors at front:

- adaptive cruise control (ACC)
- Stop&Go incl. Traffic jam assist
- Parking system plus
- Park assist

Front radar sensors:

- adaptive cruise control (ACC)
- Stop&Go incl. Traffic jam assist
- Audi active lane assist
- Audi pre-sense front
- Distance display

Ultrasonic sensors at side:

- Parking assist

Rear radar sensors:

- adaptive cruise control (ACC)
- Audi active lane assist
- Audi side assist
- Rear cross traffic assist



Market 1 Example: Kia



Periodic Table of Automobile SAFETY FEATURES

<div>INTERSECTION COLLISION AVOIDANCE</div> <div>Collision Prevention & Mitigation 1</div>										<div>DROWSINESS ALERT</div> <div>Driver State Monitoring 1</div>	
<div>FORWARD COLLISION WARNING</div> <div>Collision Prevention & Mitigation 2</div>										<div>HEALTHY WORKLOAD MONITORING</div> <div>Driver State Monitoring 1</div>	
<div>INTELLIGENT SPEED ADAPTATION</div> <div>Speeding 1</div>										<div>ADAPTIVE ROUTE GUIDANCE</div> <div>Driver Communication 2</div>	
<div>AUTOMATIC EMERGENCY BRAKING</div> <div>Collision Prevention & Mitigation 1</div>										<div>LANE DEPARTURE WARNING</div> <div>Lane Assisting 2</div>	
<div>HIGH SPEED ALERT</div> <div>Speeding 2</div>										<div>BLIND SPOT MONITOR</div> <div>Side Assisting 2</div>	
<div>CRUISE CONTROL</div> <div>Cruise Control 2</div>										<div>ADAPTIVE COLLISION NOTIFICATION</div> <div>Driver Communication 1</div>	
<div>OBSTACLE DETECTION</div> <div>Collision Prevention & Mitigation 1</div>										<div>LANE KEEPING ASSIST</div> <div>Lane Assisting 1</div>	
<div>CURVE SPEED WARNING</div> <div>Speeding 2</div>										<div>SIDEVIEW CAMERA</div> <div>Side Assisting 2</div>	
<div>ADAPTIVE CRUISE CONTROL</div> <div>Cruise Control 1</div>										<div>PUSH BUTTON START</div> <div>Driver Communication 2</div>	
<div>PEDESTRIAN DETECTION</div> <div>Collision Prevention & Mitigation 1</div>										<div>ENGINE START STOP</div> <div>Driver Communication 2</div>	
<div>PARKING SENSORS</div> <div>Parking Assistance 2</div>										<div>ASSISTIVE SAFETY SYSTEMS</div>	
<div>REAR CROSS TRAFFIC ALERT</div> <div>Backing Assistance 2</div>										<div>SAFETY SYSTEM SAFETY SYMBOL</div> <div>1) CAN CONTROL SOME BRAKING OR STEERING 2) DOES NOT TAKE CONTROL</div>	
<div>ACTIVE STEERING</div> <div>Steering & Suspension 1</div>										<div>SAFETY FAMILY</div> <div>XXXX</div>	
<div>ANTI-LOCK BRAKING SYSTEM (ABS)</div> <div>Braking & Anti-Roll-over 1</div>										<div>TRACTIVE FORCE MONITORING SYSTEM</div> <div>Terrain & Wheel Information 2</div>	
<div>BRAKE ASSIST</div> <div>Braking & Anti-Roll-over 2</div>										<div>SAFETY SYSTEM SAFETY SYMBOL</div> <div>1) CAN CONTROL SOME BRAKING OR STEERING 2) DOES NOT TAKE CONTROL</div>	
<div>UNKNOWN ELECTRONIC STABILITY CONTROL</div> <div>Braking & Anti-Roll-over 1</div>										<div>SAFETY SYSTEM SAFETY SYMBOL</div> <div>1) CAN CONTROL SOME BRAKING OR STEERING 2) DOES NOT TAKE CONTROL</div>	
<div>HILL START ASSIST</div> <div>Hill Assisting 1</div>										<div>SAFETY SYSTEM SAFETY SYMBOL</div> <div>1) CAN CONTROL SOME BRAKING OR STEERING 2) DOES NOT TAKE CONTROL</div>	
<div>TERRAIN MANAGEMENT</div> <div>Terrain & Wheel Information 1</div>										<div>SAFETY SYSTEM SAFETY SYMBOL</div> <div>1) CAN CONTROL SOME BRAKING OR STEERING 2) DOES NOT TAKE CONTROL</div>	
<div>LEFT TURN CRASH AVOIDANCE</div> <div>Collision Prevention & Mitigation 1</div>										<div>SAFETY SYSTEM SAFETY SYMBOL</div> <div>1) CAN CONTROL SOME BRAKING OR STEERING 2) DOES NOT TAKE CONTROL</div>	
<div>ADAPTIVE HEADLIGHTS</div> <div>Headlights & Vision 2</div>										<div>SAFETY SYSTEM SAFETY SYMBOL</div> <div>1) CAN CONTROL SOME BRAKING OR STEERING 2) DOES NOT TAKE CONTROL</div>	
<div>BICYCLE DETECTION</div> <div>Collision Prevention & Mitigation 2</div>										<div>SAFETY SYSTEM SAFETY SYMBOL</div> <div>1) CAN CONTROL SOME BRAKING OR STEERING 2) DOES NOT TAKE CONTROL</div>	
<div>AUTOMATIC PARALLEL PARKING</div> <div>Parking Assistance 1</div>										<div>SAFETY SYSTEM SAFETY SYMBOL</div> <div>1) CAN CONTROL SOME BRAKING OR STEERING 2) DOES NOT TAKE CONTROL</div>	
<div>BACK-UP CAMERA</div> <div>Backing Assistance 2</div>										<div>SAFETY SYSTEM SAFETY SYMBOL</div> <div>1) CAN CONTROL SOME BRAKING OR STEERING 2) DOES NOT TAKE CONTROL</div>	
<div>ADAPTIVE & ACTIVE SUSPENSION</div> <div>Steering & Suspension 2</div>										<div>SAFETY SYSTEM SAFETY SYMBOL</div> <div>1) CAN CONTROL SOME BRAKING OR STEERING 2) DOES NOT TAKE CONTROL</div>	
<div>CONTRASTING BRAKING CONTROL</div> <div>Braking & Anti-Roll-over 1</div>										<div>SAFETY SYSTEM SAFETY SYMBOL</div> <div>1) CAN CONTROL SOME BRAKING OR STEERING 2) DOES NOT TAKE CONTROL</div>	
<div>ELECTRONIC STABILITY CONTROL</div> <div>Braking & Anti-Roll-over 1</div>										<div>SAFETY SYSTEM SAFETY SYMBOL</div> <div>1) CAN CONTROL SOME BRAKING OR STEERING 2) DOES NOT TAKE CONTROL</div>	
<div>TRACTION CONTROL</div> <div>Braking & Anti-Roll-over 1</div>										<div>SAFETY SYSTEM SAFETY SYMBOL</div> <div>1) CAN CONTROL SOME BRAKING OR STEERING 2) DOES NOT TAKE CONTROL</div>	
<div>HILL DESCENT ASSIST</div> <div>Hill Assisting 1</div>										<div>SAFETY SYSTEM SAFETY SYMBOL</div> <div>1) CAN CONTROL SOME BRAKING OR STEERING 2) DOES NOT TAKE CONTROL</div>	
<div>TEMPERATURE WARNING</div> <div>Terrain & Wheel Information 2</div>										<div>SAFETY SYSTEM SAFETY SYMBOL</div> <div>1) CAN CONTROL SOME BRAKING OR STEERING 2) DOES NOT TAKE CONTROL</div>	
<div>NIGHT VISION</div> <div>Headlights & Vision 2</div>										<div>SAFETY SYSTEM SAFETY SYMBOL</div> <div>1) CAN CONTROL SOME BRAKING OR STEERING 2) DOES NOT TAKE CONTROL</div>	
<div>REVERSE AUTOMATIC BRAKING</div> <div>Backing Assistance 1</div>										<div>SAFETY SYSTEM SAFETY SYMBOL</div> <div>1) CAN CONTROL SOME BRAKING OR STEERING 2) DOES NOT TAKE CONTROL</div>	
<div>BACK-UP WARNING</div> <div>Backing Assistance 2</div>										<div>SAFETY SYSTEM SAFETY SYMBOL</div> <div>1) CAN CONTROL SOME BRAKING OR STEERING 2) DOES NOT TAKE CONTROL</div>	

FORWARD COLLISION PREVENTION

PARKING AND BACKING ASSISTING

BRAKING, TIRE PRESSURE & ANTI-ROLLOVER

LANE & SIDE ASSISTING

DRIVER STATE MONITORING & COMMUNICATION

You are
your car's best
safety feature.

MyCar
DoesWhat.org
Know More. Drive Safer.



Copyright ©2017 National Safety Council

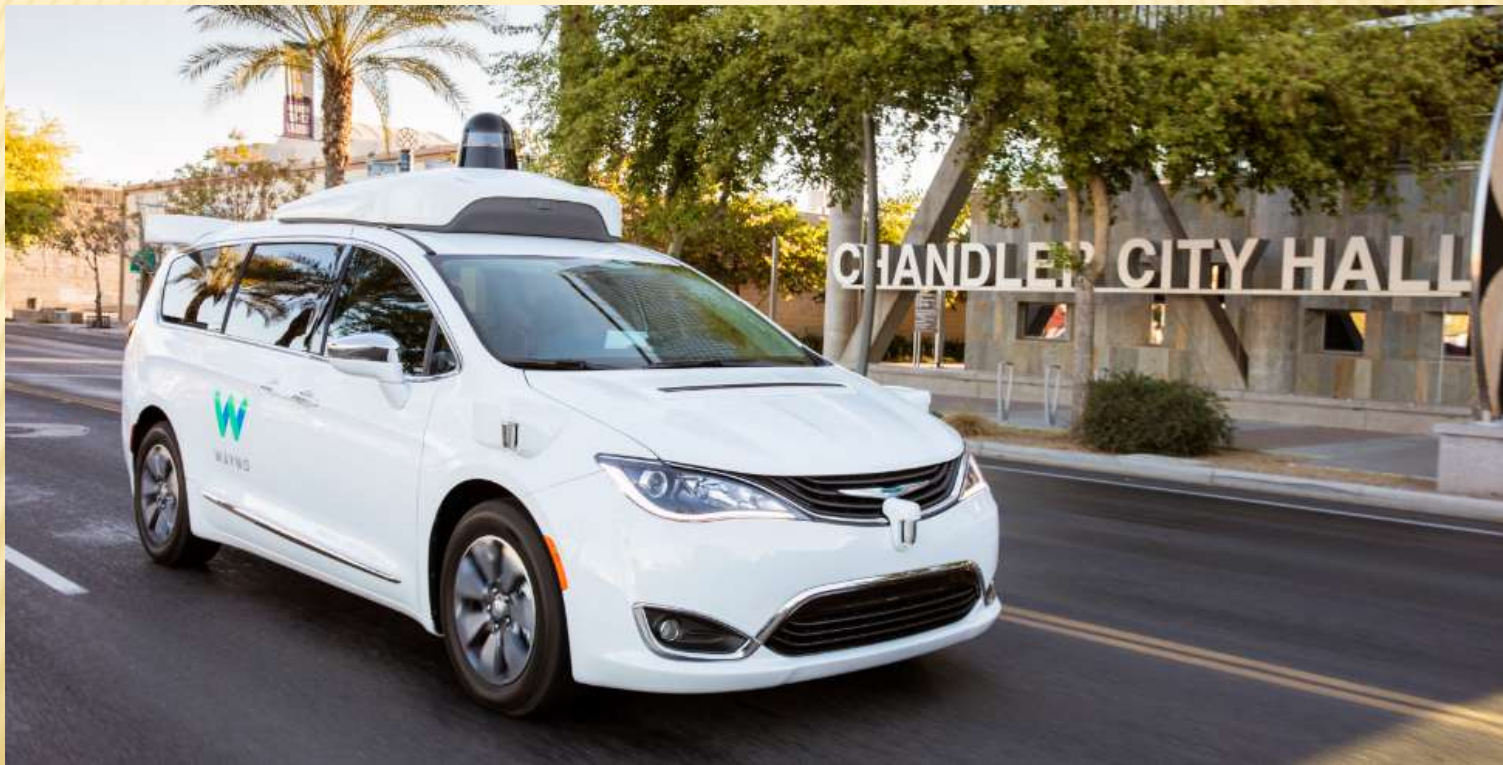
MARKET 2 – RIDE BUYING



MARKET 2 – RIDE BUYING



MARKET 2 – RIDE BUYING





Market 2 – Ride Buying

GM WANTS TO SELL BOTH AV CARS AND AV RIDES

WE ARE REDEFINING THE FUTURE OF PERSONAL MOBILITY



OWN THE CUSTOMER RELATIONSHIP BEYOND THE CAR

CORE BUSINESS

FUTURE OF PERSONAL MOBILITY

Winning
Portfolio
Strong Brands

Adjacent Business
Growth

Electric Vehicles
Connected Car/OnStar

Autonomous
Vehicles

Shared
Mobility

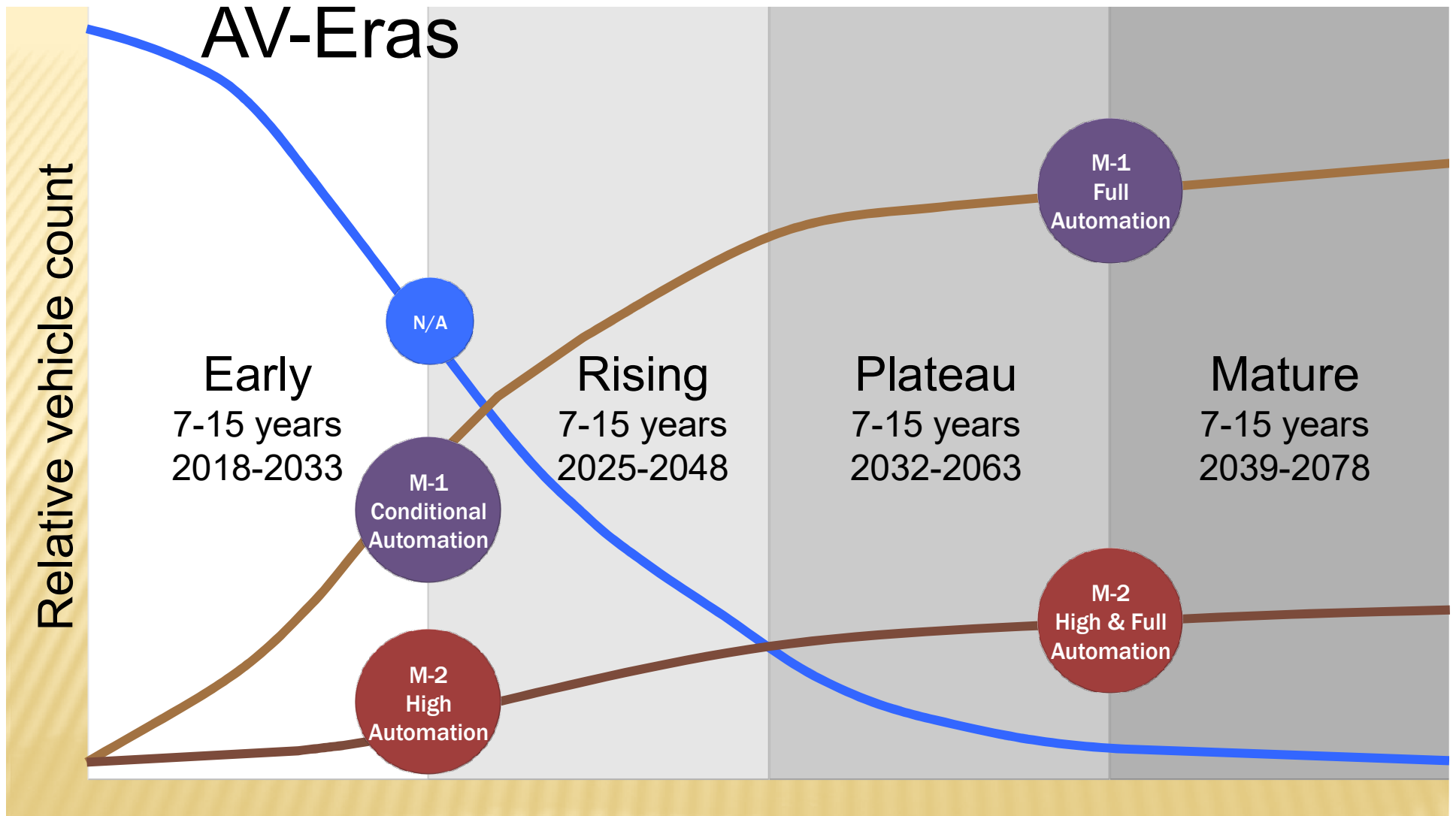
Driver/Miles
Driven Data

FOUNDATION

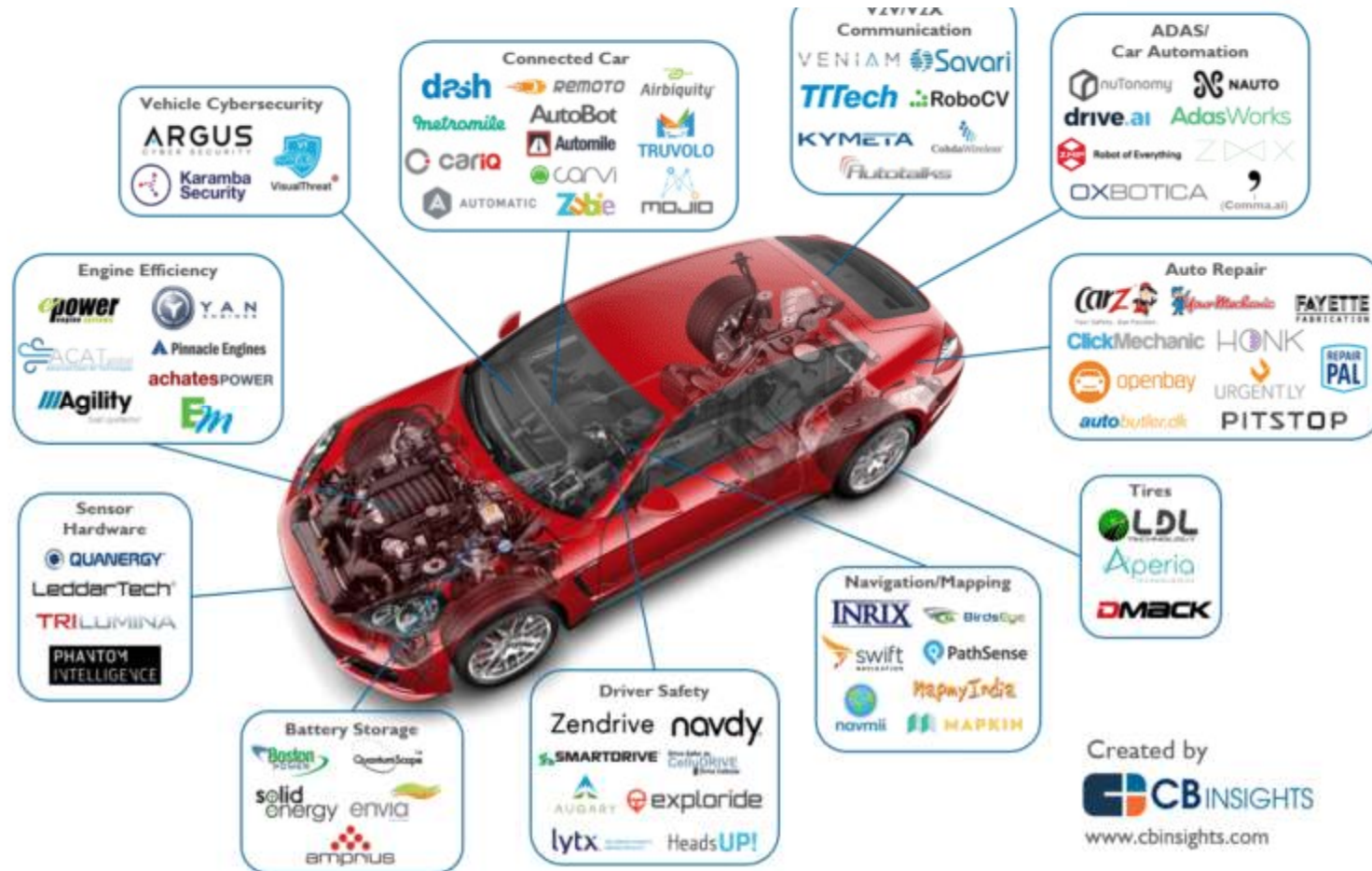
People

Values/Behavior

Culture



Vehicle Technology is Challenging

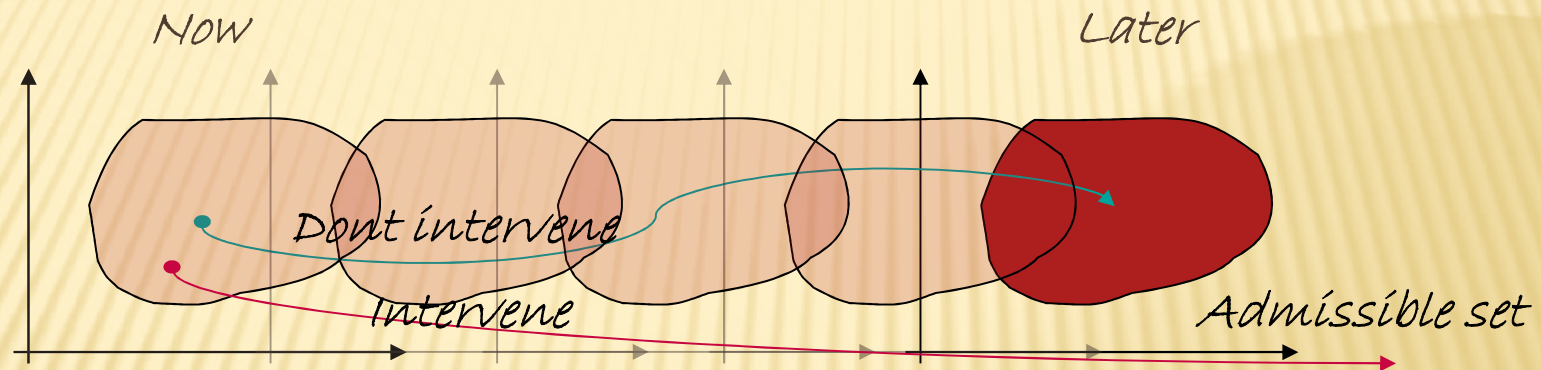


BASIC TECHNOLOGY CHALLENGE

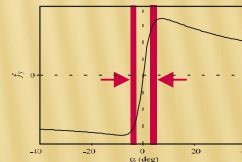
Sensors & computers must work constantly and quickly to determine:

- × Where is this vehicle?
- × What's around it that doesn't move?
- × What is around this vehicle that's moving or might move?
- × What will happen next with what's moving or might?
- × What should the vehicle do now?

EXAMPLE: THREAT ASSESSMENT PROBLEM



Given estimates of vehicle state and surrounding environment, can we find an admissible sequence of control signals so that the vehicle state evolves within the prescribed constraints?



TECHNO-CONTROVERSY – LIDAR OR CAMERAS?

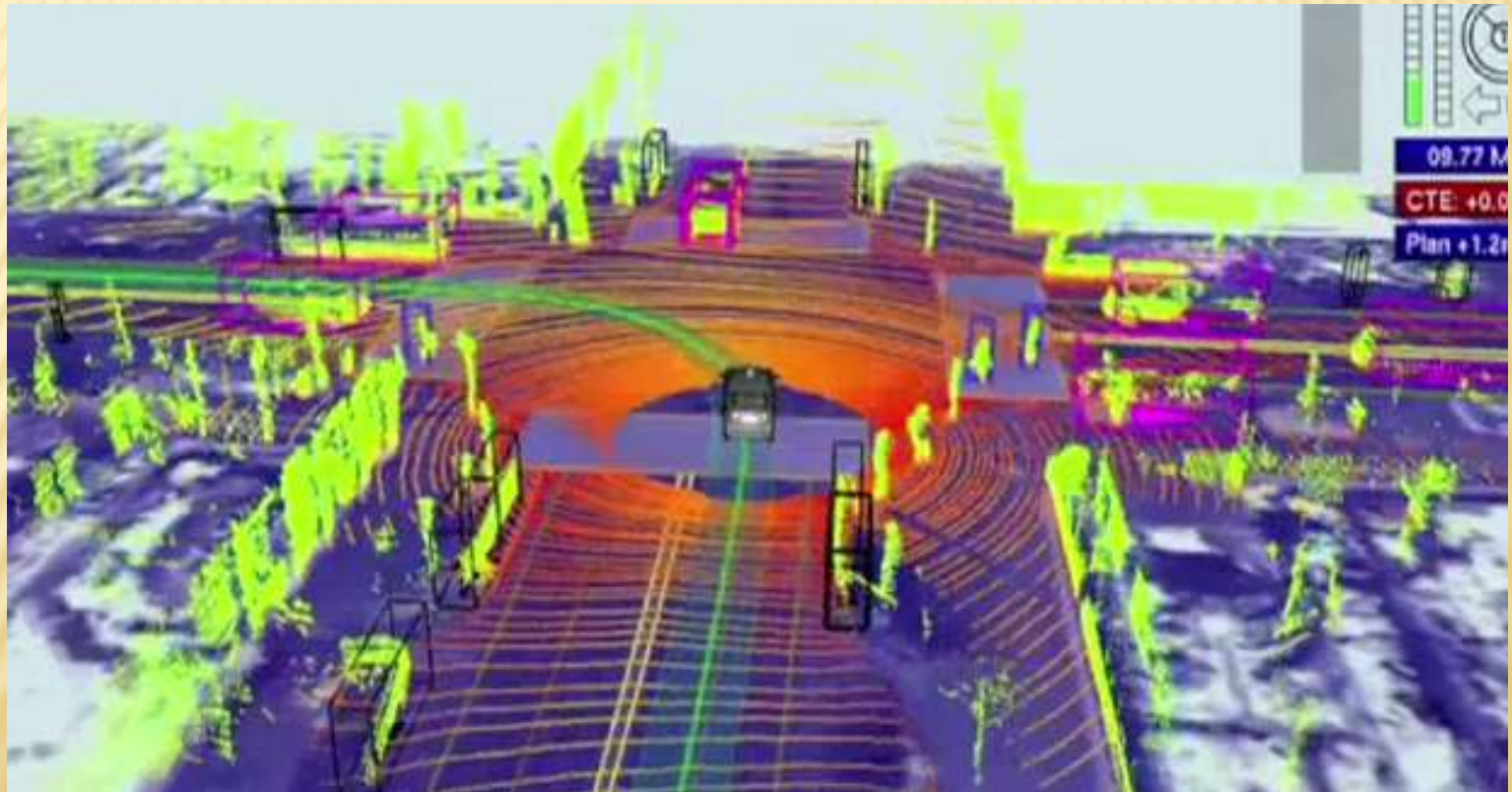


Image: Sebastian Thrun & Chris Urmson/Google



Connected Transportation

Contact info@venturescanner.com to see all 702 companies



Venture Scanner

Future of vehicle automation depends on what it means...

- Fewer vehicles
- Fewer drivers
- Easier travel
- Less congestion
- Fewer accidents
- Less parking needed
- Less car ownership
- Fewer roads
- More ride sharing



- More vehicles
- More drivers
- More travel
- More congestion
- New accident types
- More parking needed
- More sprawl
- More roads
- Less ride sharing

Public Policy Planning vs. Consumer Behavior

WILL AVS REDUCE CONGESTION?

YES SIDE...

- × Driver assistance automation & collision avoidance → **reduce accidents.**
- × Automated speed control & braking → **smoother flows.**
- × Precision guidance → **fit more cars** into existing road space.
- × Automated parking → cars quickly **out of the way.**
- × More use of shared-ride services → **fewer private cars** on the street

NO SIDE...

- × Automated features → **more/longer trips.**
- × Travel time **more productive** → **more trips.**
- × Older, younger, unlicensed and disabled drivers → **more trips.**
- × Volume of cars and driving → may **exceed efficiency gains.**
- × **Infrastructure** investment → may be insufficient.
- × Easier, safer driving → **more driving** will be the result

PUBLIC PERCEPTION OF AV BENEFITS?

OUR NEXT FEATURE. SPARE TIME.

FINALLY, DISTRACTED DRIVING BECOMES SAFE!



TEMPE POLICE DEPT.

As long as everything
works as it is supposed to!



FOX 10

8:05 84°

DEADLY UBER SELF-DRIVING CAR CRASH

TEMPE POLICE RELEASE BODY CAM, PICTURES & REPORT

GOVERNMENT ALREADY HAS ROLES TO PLAY

FEDERAL AREAS OF RESPONSIBILITY⁵

- *Setting and enforcing compliance with vehicle safety standards

PROVINCIAL/ TERRITORIAL AREAS OF RESPONSIBILITY

- *Driver Licensing
- *Vehicle Registration
- *Enacting traffic laws
- *Adapting infrastructure to support AVs

MUNICIPAL AREAS OF RESPONSIBILITY⁶

- *Enforcing traffic laws
- *Managing public transit & taxi cabs
- *Parking
- *Traffic control

SOCIAL IMPACT OF MARKET 2 – TRANSIT

What happens if
robotaxi fares cost
the same as the bus?



What happens if
robotaxi fares cost
less than the bus?



FUTURE OF MOTORIZED AUTOMOBILITY



“...a war brewing ...between the automotive sector and the transit sector” re who will deliver shared-mobility, autonomous, electrified services.”

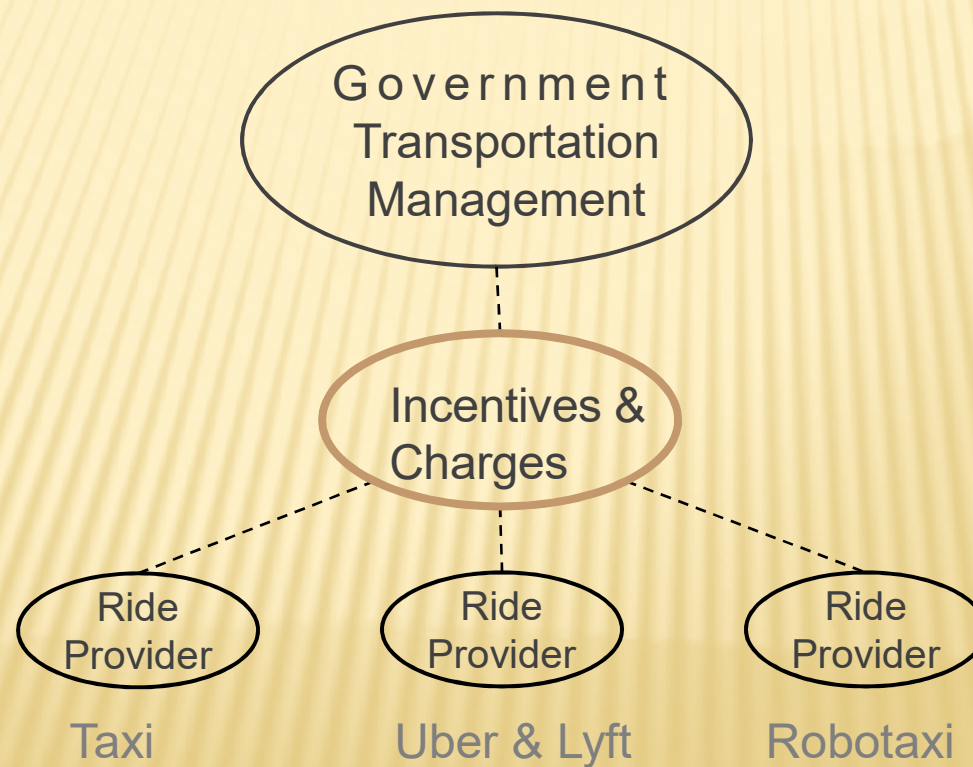
Josipa Petronic, Canadian Urban Transit Research and Innovation Consortium (CUTRIC)

Public transit agencies beginning to influence Market 2 supply and demand case by case

- ✓ First-last mile to transit
- ✓ Transit deserts
- ✓ Parking shortages
- ✓ Seniors
- ✓ Disabled
- ✓ Employment areas
- ✓ Guaranteed ride home
- ✓ Late night
- ✓ No bus available



Harmonization Management Services Could Deliver Incentives and Fees Covering All Ride Services



MAP TRA

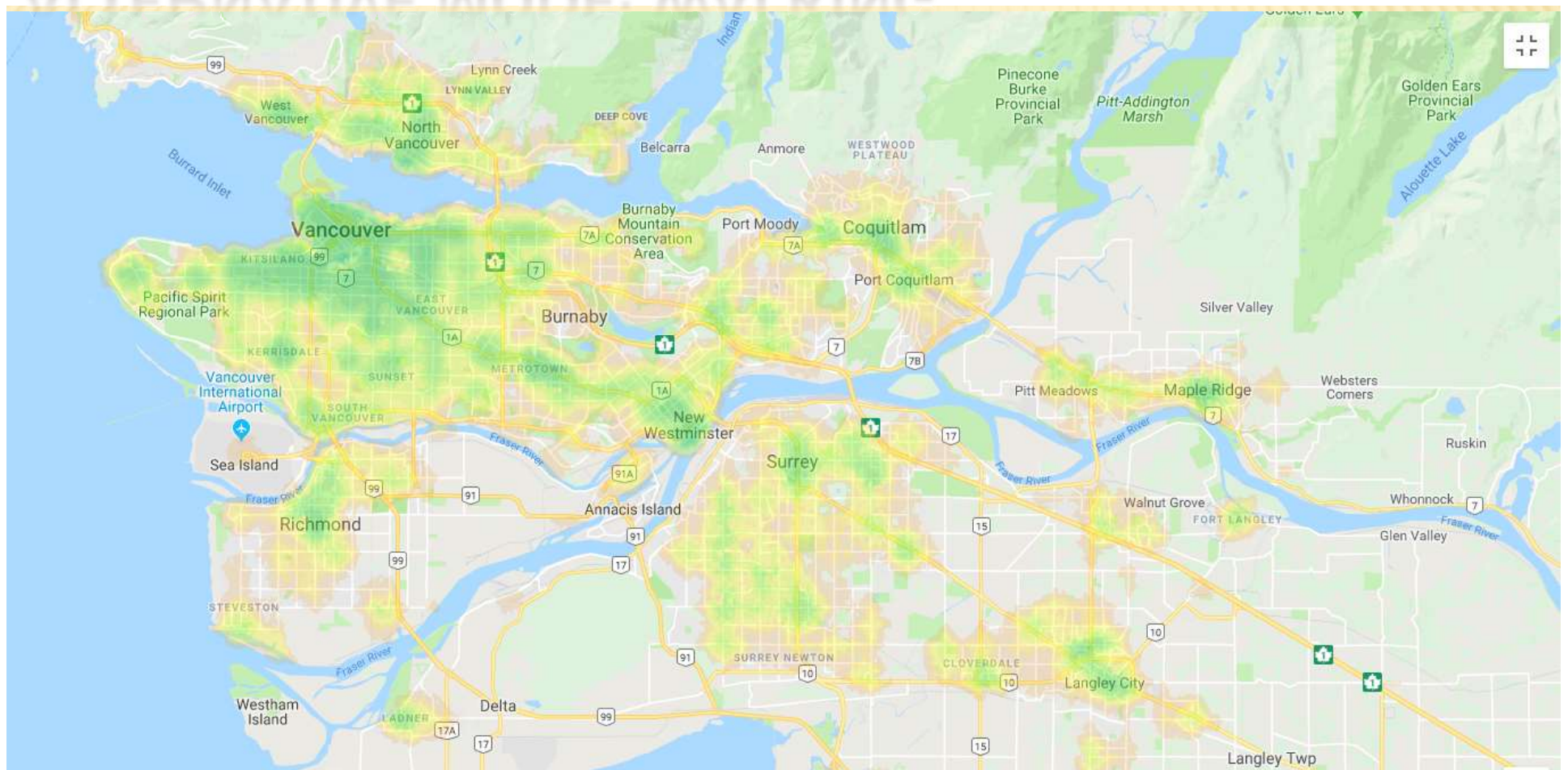


FORECASTING AV PROGRESS IS A CHALLENGE

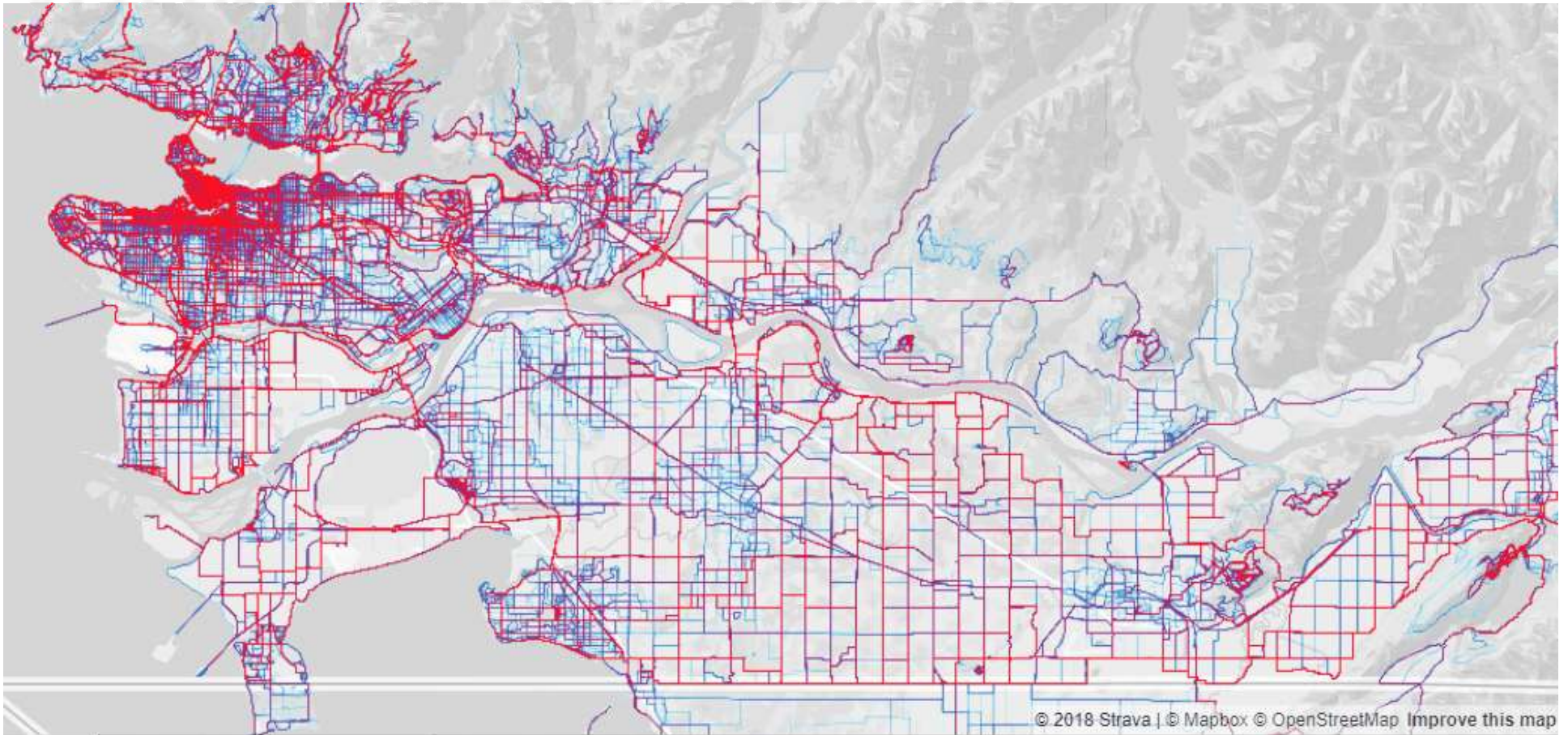
- ✗ Technology improvement not smooth
- ✗ Adoption lags tech
- ✗ Regulation lags innovation
- ✗ Bad luck events happen
- ✗ Congestion & sprawl fears
- ✗ Automation anxiety
 - ❑ Safety Anxiety
 - ❑ Privacy Anxiety
 - ❑ Control Anxiety
 - ❑ Access Anxiety



ALTERNATIVE MODE: WALKING



ALTERNATIVE MODE: CYCLING



ALTERNATIVE MODE: URBAN VTOL AVIATION

NON-EXHAUSTIVE					
<i>SureFly</i>	<i>Napoleon Aero VTOL</i>	<i>Unmanned AAV</i>	<i>Lightning Strike</i>	<i>Lilium Jet</i>	<i>Personal Air Taxi</i>
					
<i>Passenger Drone</i>	<i>TriFan 600</i>	<i>Hop Flyt</i>	<i>Scorpion</i>	<i>NeoXCraft</i>	<i>Hornisse Type 2B</i>
					
<i>Ehang 184</i>	<i>Flying Car</i>	<i>S2 EVOTL</i>	<i>XO1</i>	<i>Flyer</i>	<i>Skypod</i>
					
<i>Electric VTOL Multicopter</i>	<i>AO</i>	<i>Bell Air Taxi</i>	<i>Skydrive</i>	<i>MOBi</i>	<i>Vahana</i>
					

WILL RIDE-BUYING DOMINATE?

**Person Kilometers
Traveled (PKT)
in Personal
Vehicles**

M-1 PKT

M-1 PKT

M-1 PKT

**Person
Kilometers
Traveled (PKT)
using Ride
Services**

M-2 PKT

M-2 PKT

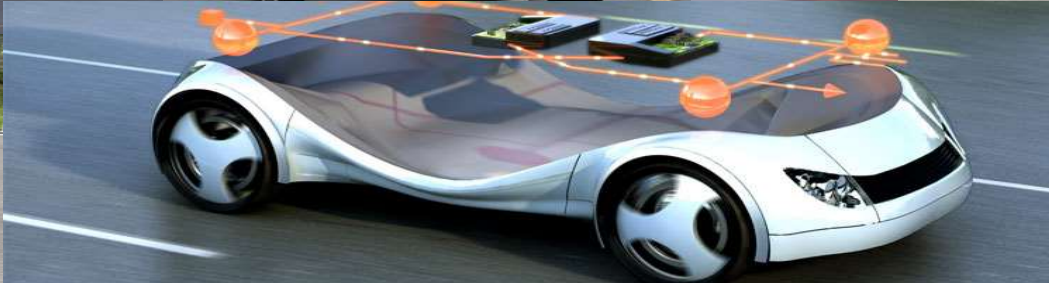
M-2 PKT

now

early automation
early 2020s

possible future
2030s-2040
*(no evidence for
this...)*

2040: UNCERTAIN MIX OF VEHICLE SIZES IN TWO MARKETS

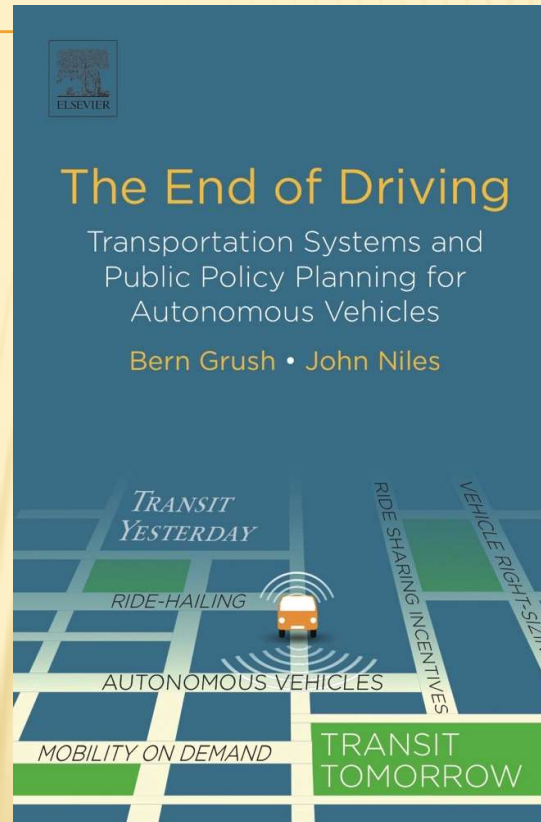


THANK YOU

John Niles

john@harmonizemobility.com

1-206-781-4475



Free chapter
summaries at
EndOfDriving.org