Planning for Autonomous and Connected Vehicles in Iowa

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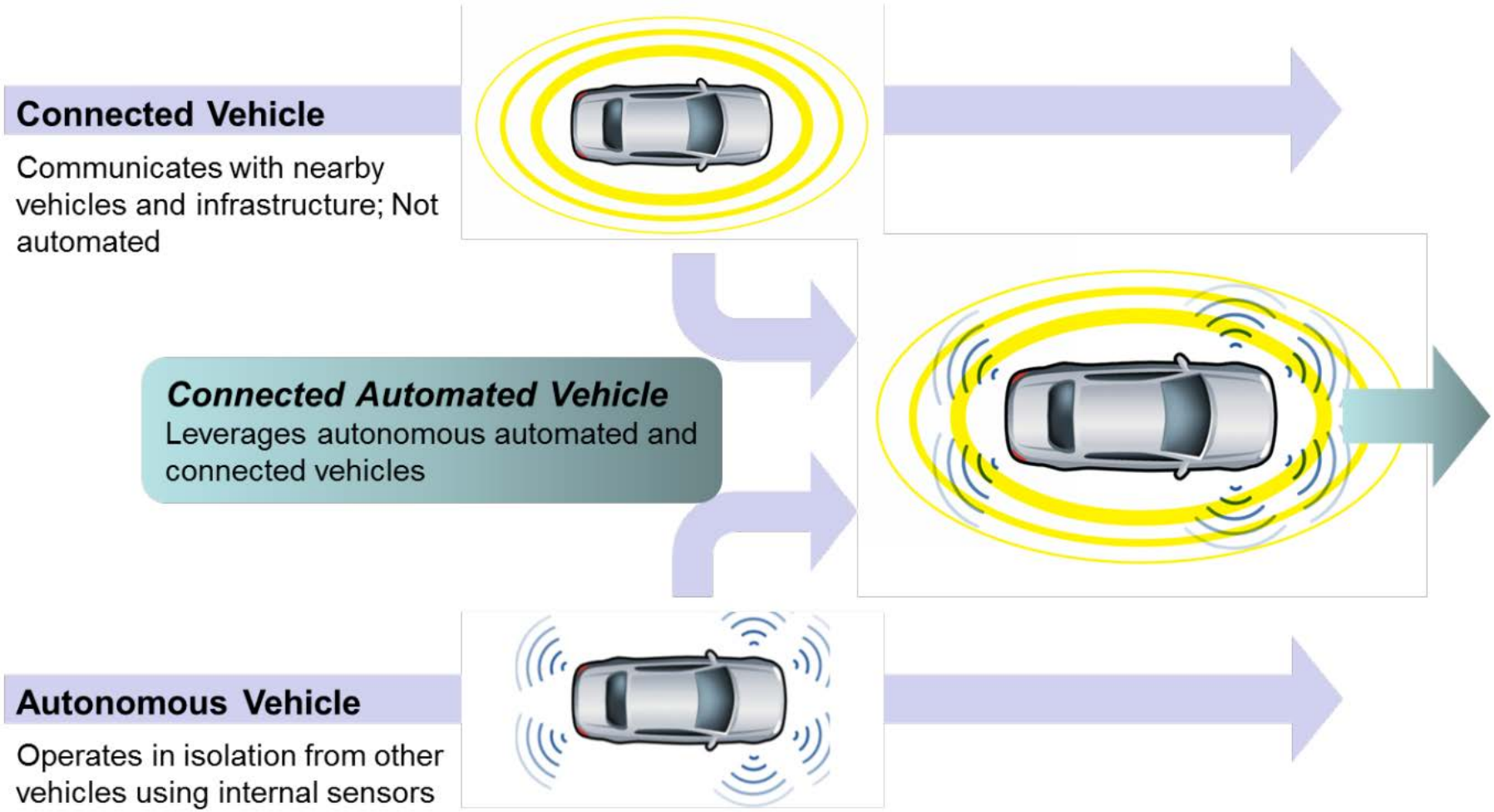
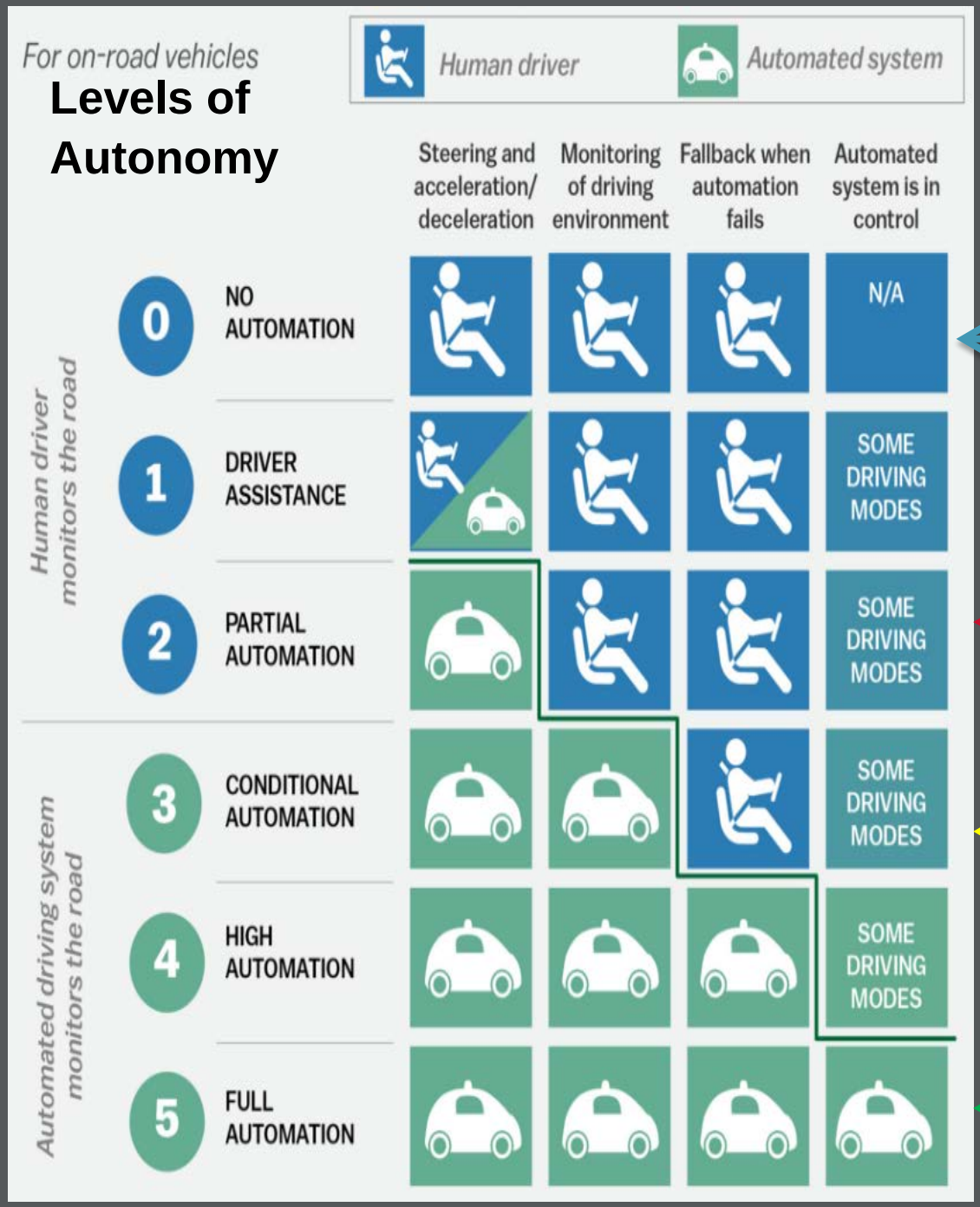
Omaha - Council Bluffs
Metropolitan Area
Planning Agency

What are Autonomous and Connected Vehicles (AV/CVs)?





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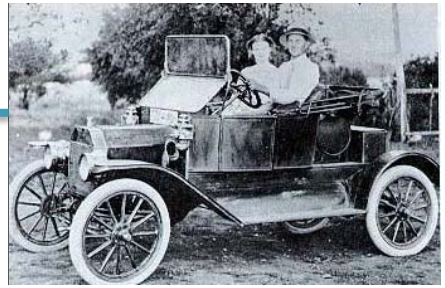


GM “Super Cruise”

2017 Cadillac CT6

Tesla Model S

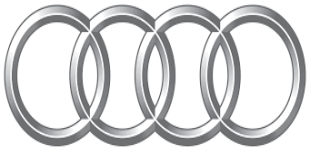
Waymo (Google)

AV/CV Adoption: Anecdotal

HDR AV/CV Expert perspective: Ben Pierce

- Technology progression following Moore's Law
- 10-year traditional vehicle development lifecycle
- Announcements suggest middle of lifecycle

2017



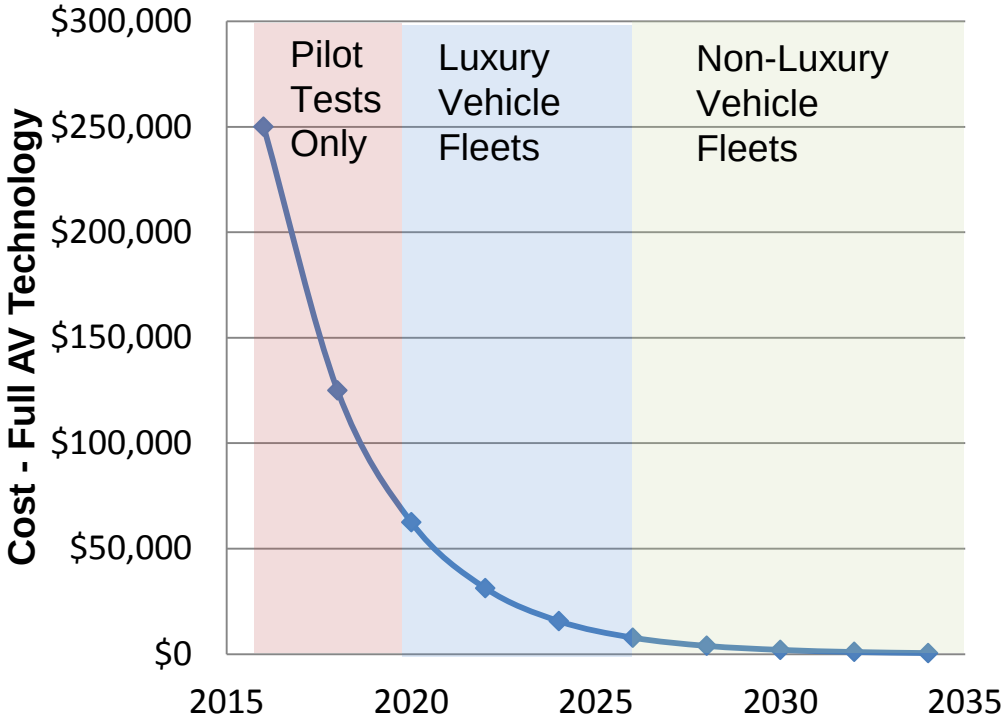
2020

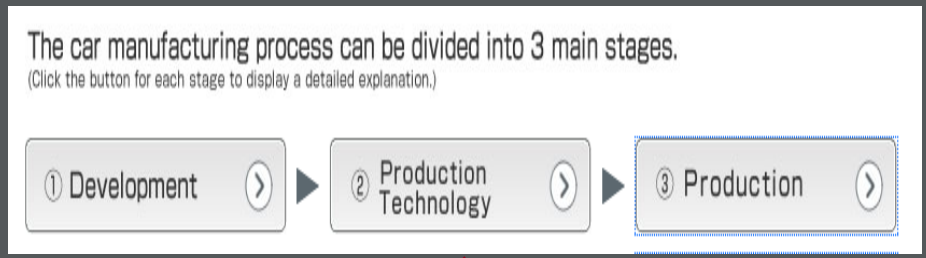
2021

2019

2020

2021





Each Major Stage is Typically 3 to 5 Year Timeline

Benefits

Safety

Reduced Driver Costs

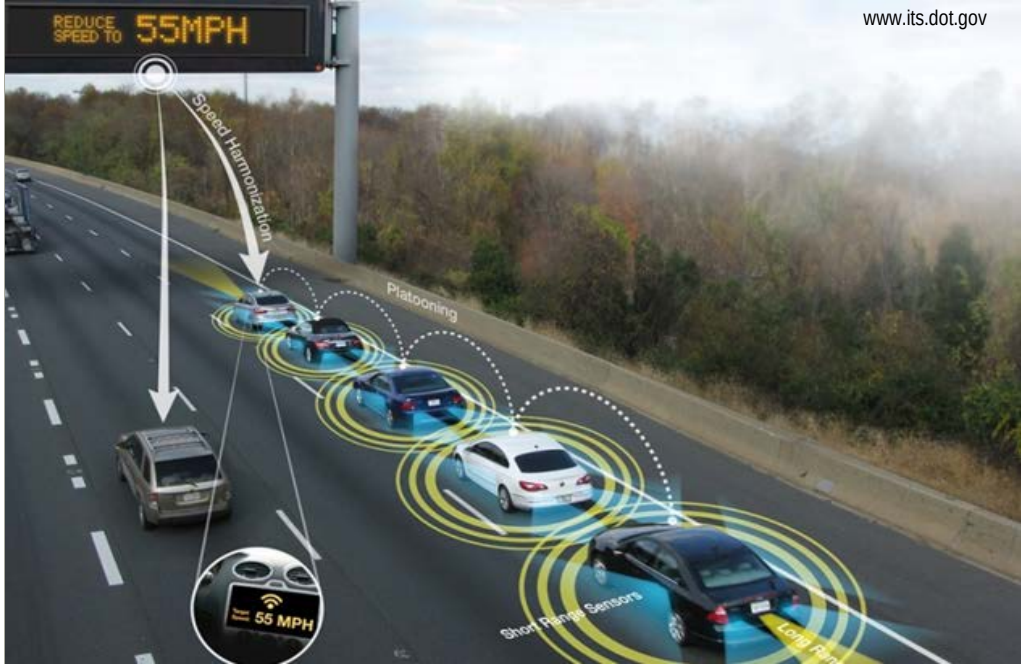
Productive Commutes

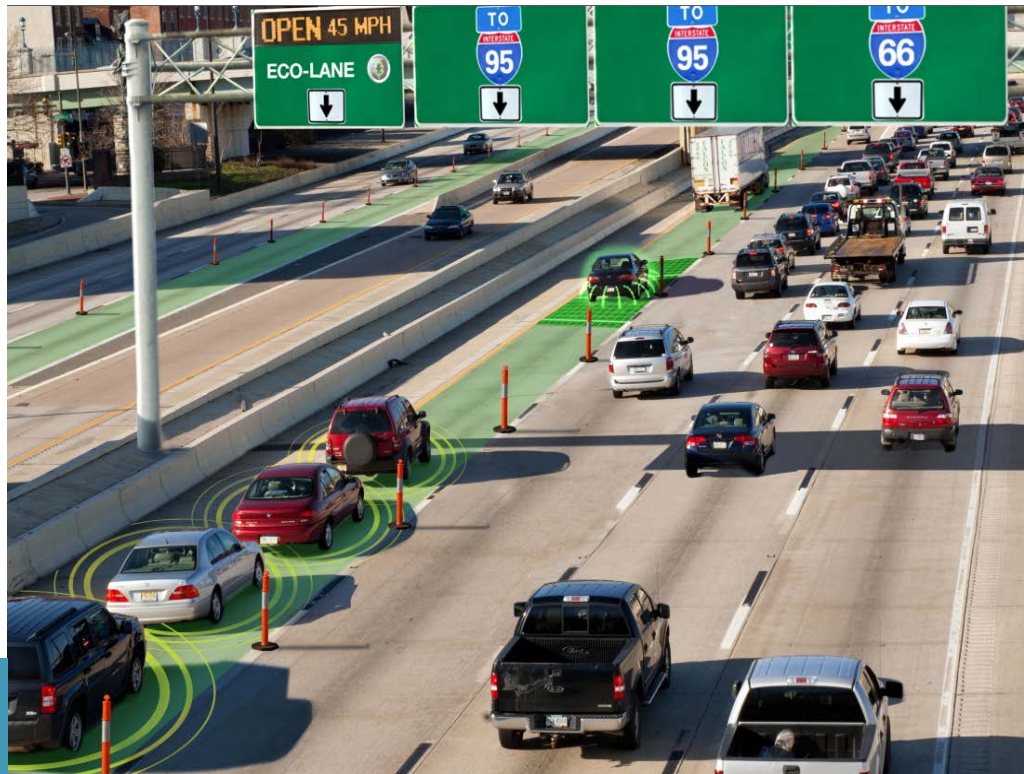
Wider-Reaching Mobility

Efficient Infrastructure

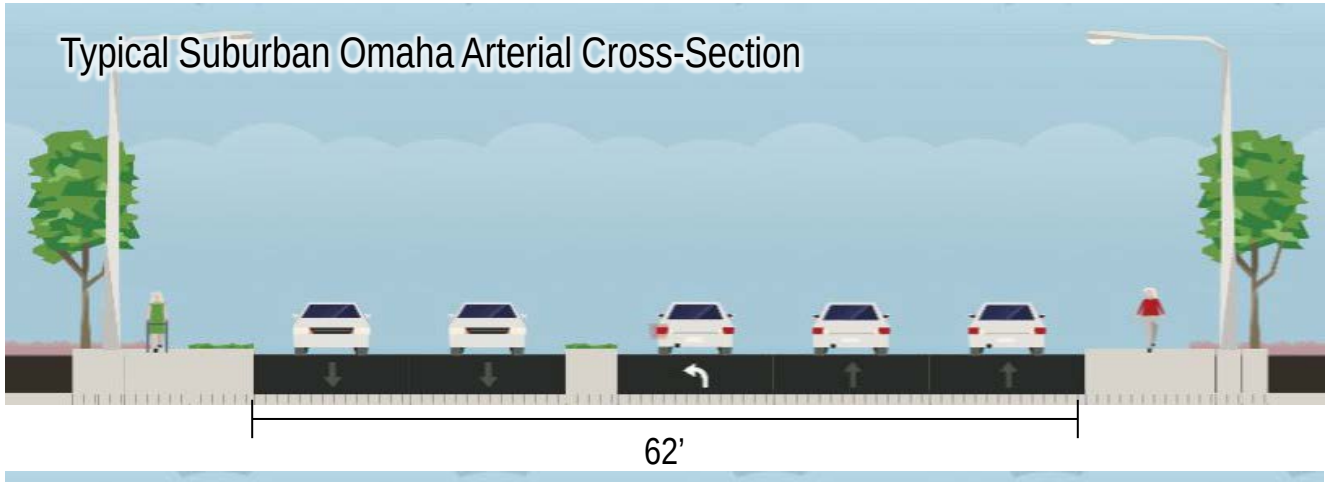
More Efficient Roadway Use

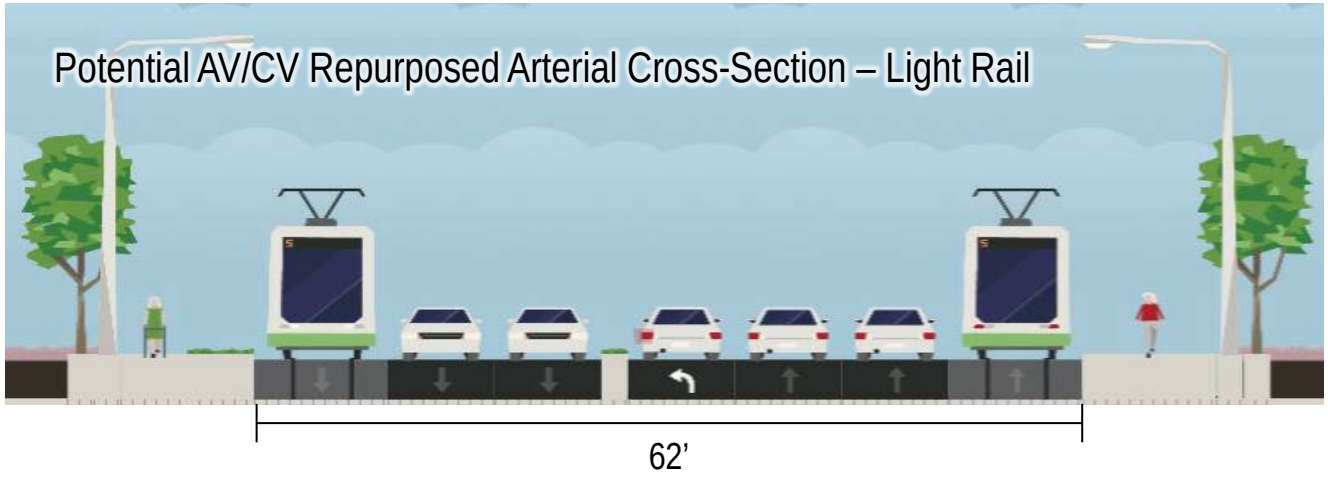
- Reduced Vehicle Headways
- Reduced Lane Widths





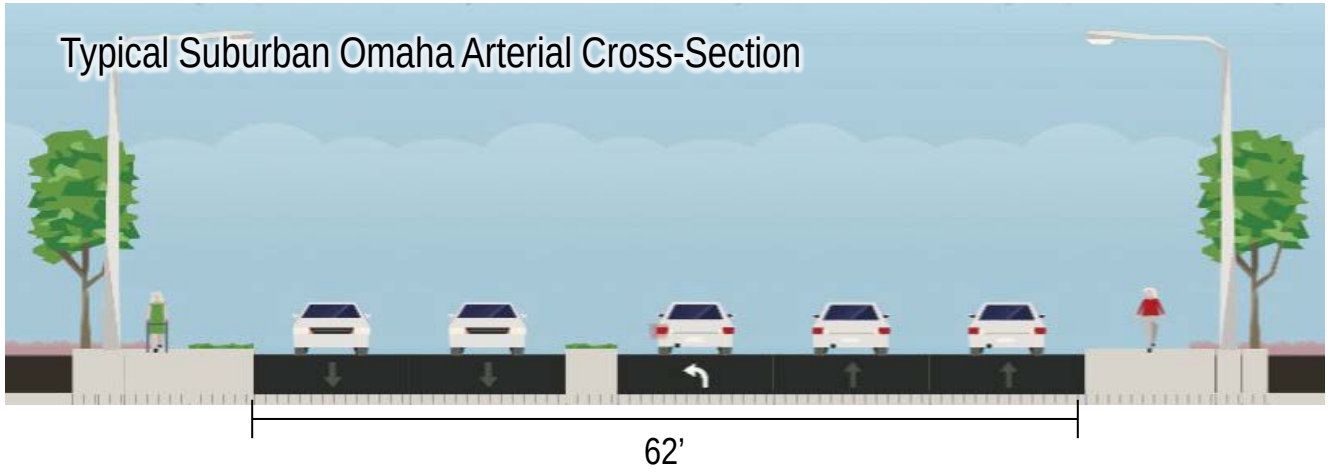
Repurposing Arterial Cross-Section – Illustration 1

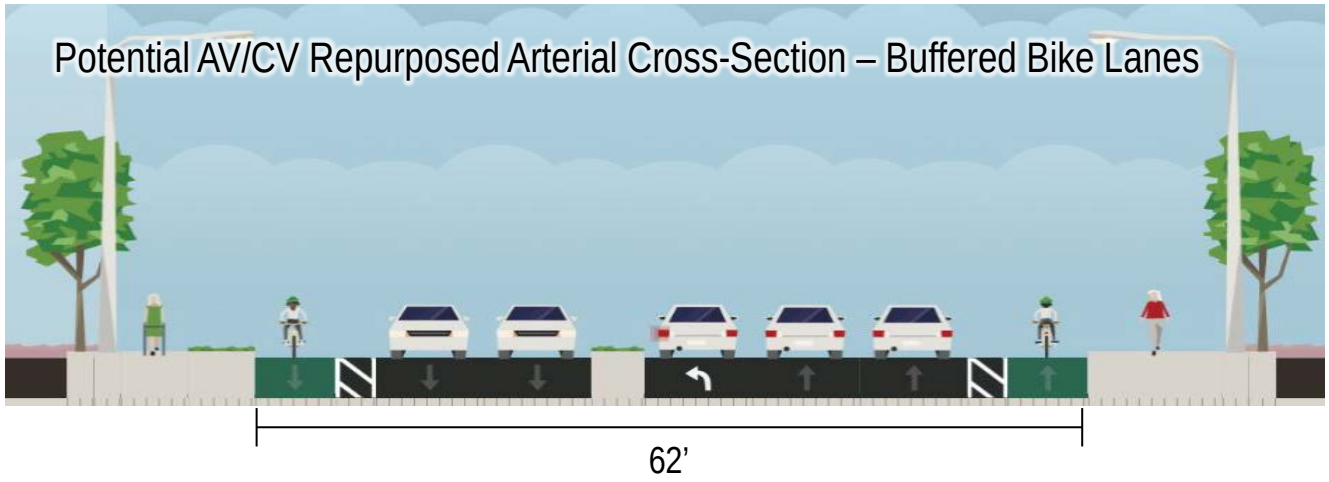




Graphics via Streetmix.org

Repurposing Arterial Cross-Section – Illustration 2





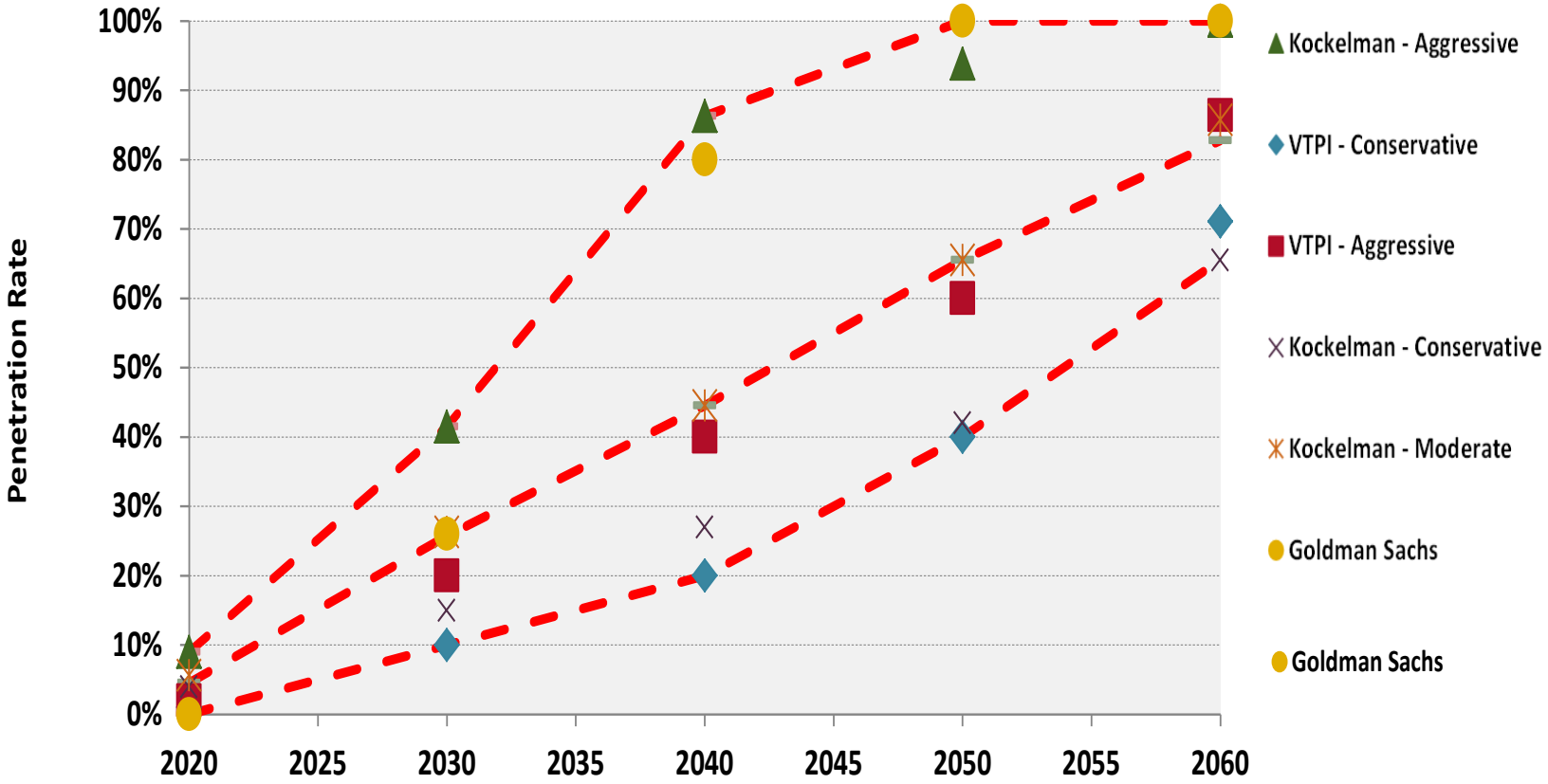
Graphics via Streetmix.org

How Does This Affect the Future of Our Transportation System?

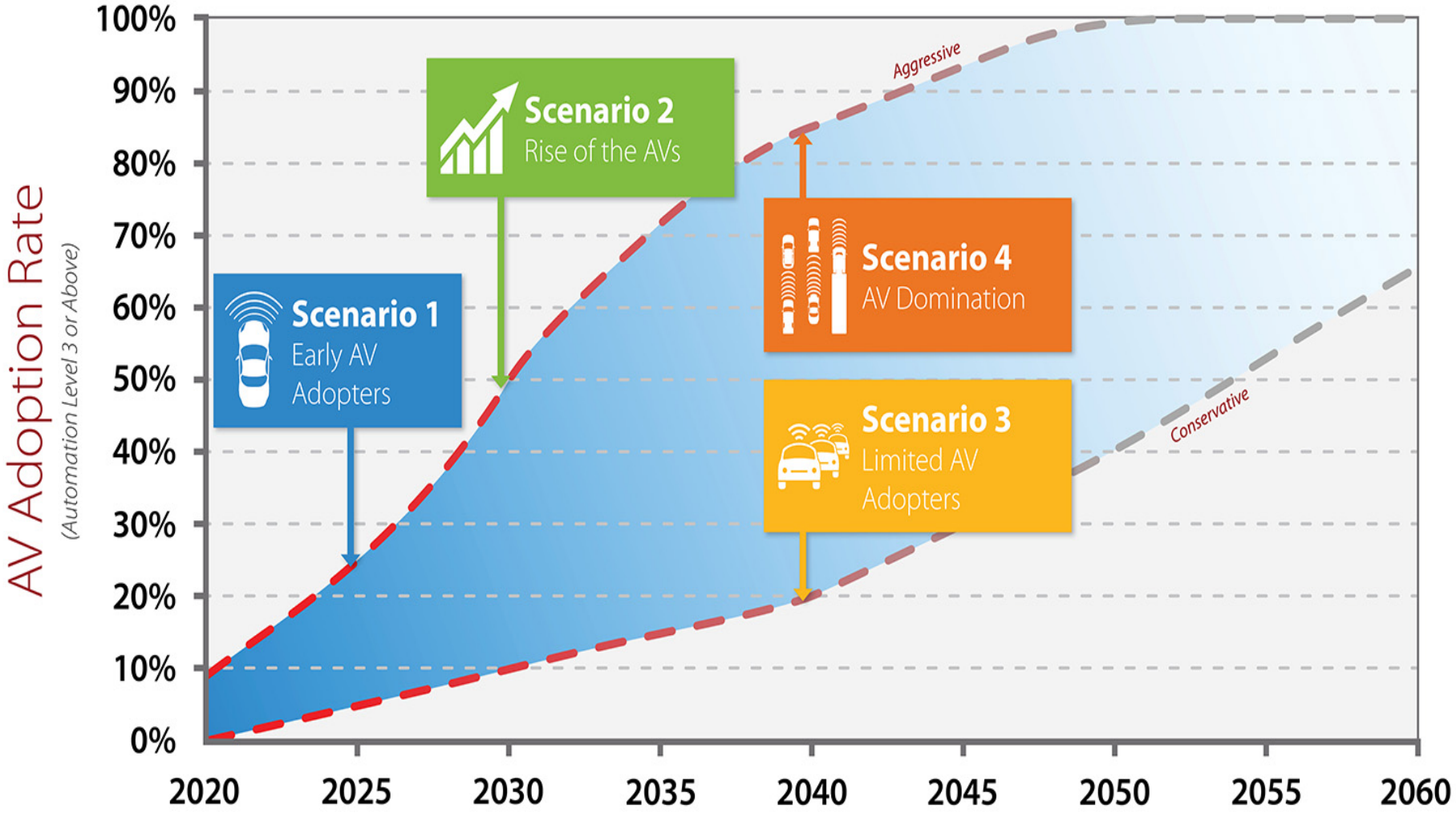
- What We Know: Things are Changing
- What We Don't Know: How They Will Change?

AV/CV Adoption Rates: Passenger Vehicles

Summary of Literature



Automated Vehicle (AV) Market Adoption



The I-80 Planning Study and market adoption rates and impacts of vehicle automation are informed by industry leading research by University of Texas, University of California at Berkeley, Victoria Transportation Policy Institute and Goldman Sachs. The scenarios ranged from conservative to aggressive in market adoption.

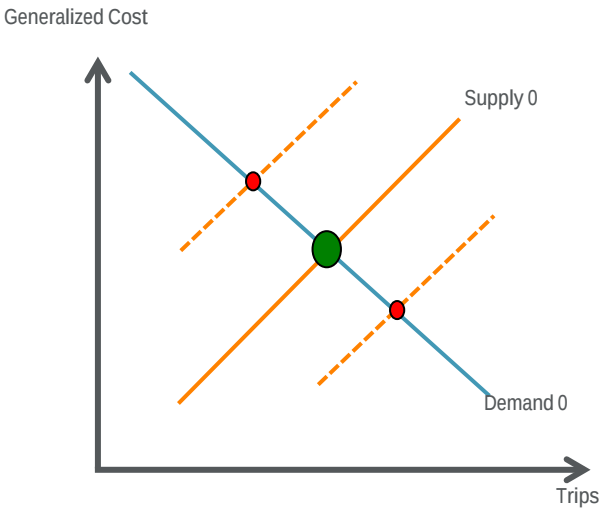
Potential Factors

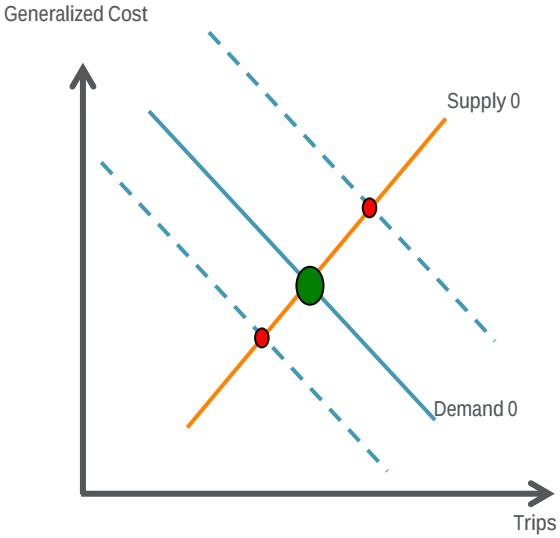
Impacting Supply

- Automated Passenger Vehicles
- Automated Commercial Vehicles
- Ride Hailing Service
- Car Sharing

Impacting Demand

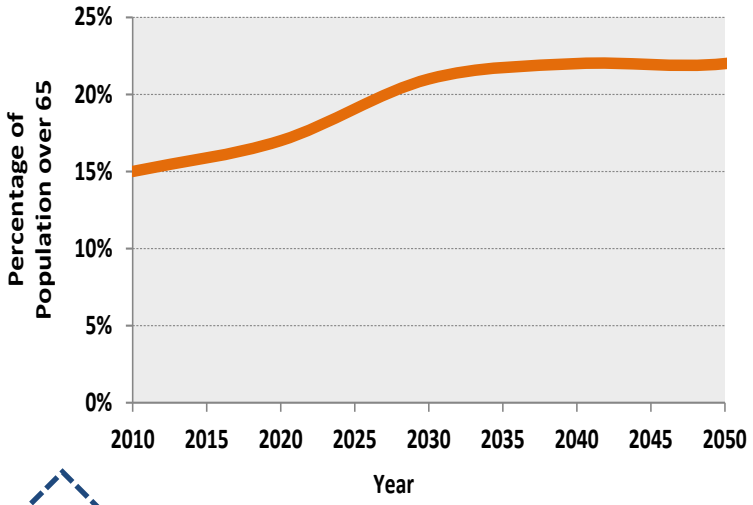
- Aging Population
- Millennial Travel Behavior
- Telecommuting



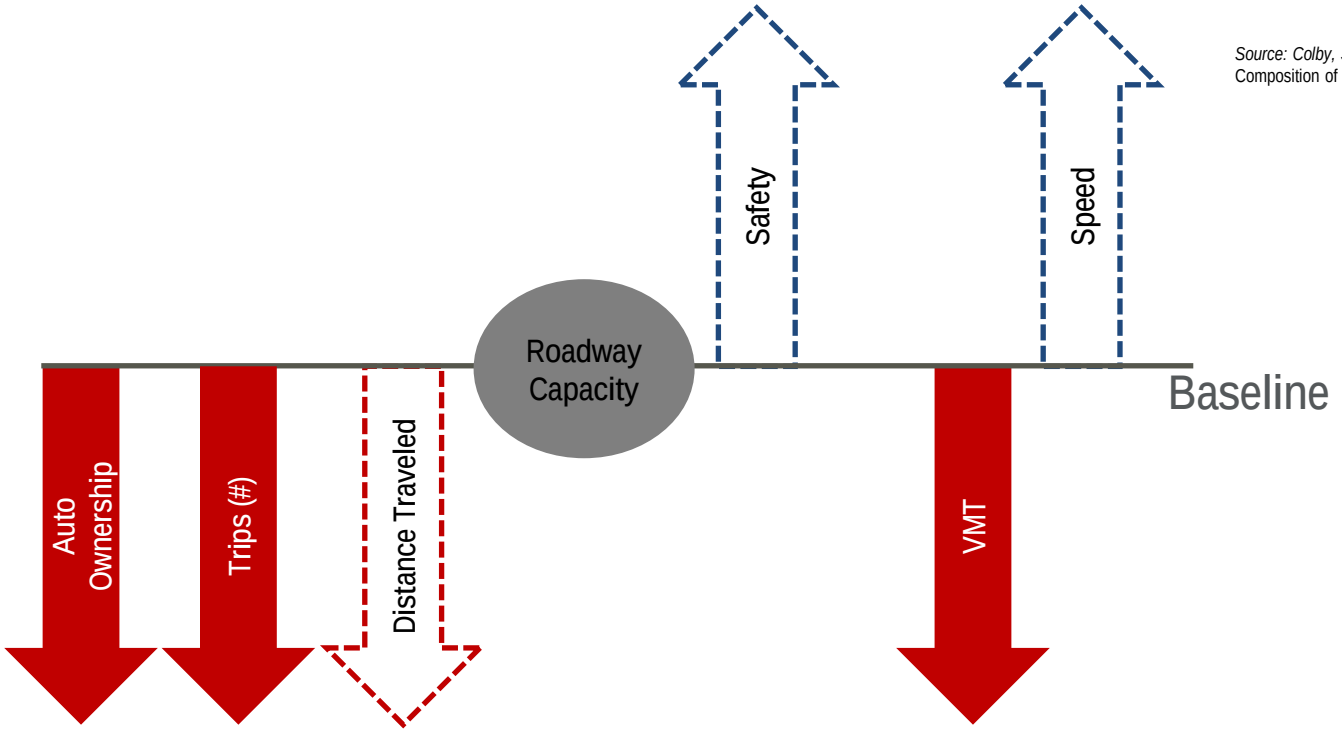


Example: Aging Population

- Population 65 plus to increase as Baby Boomer age
- Travel demand peaks at middle age and declines thereafter
- Effect may be greater in rural areas, but fewer travel alternatives



Source: Colby, S, Ortman,, J, "Projections of the Size and Composition of the U.S. Population:: 2014 to 2060, March 2015.

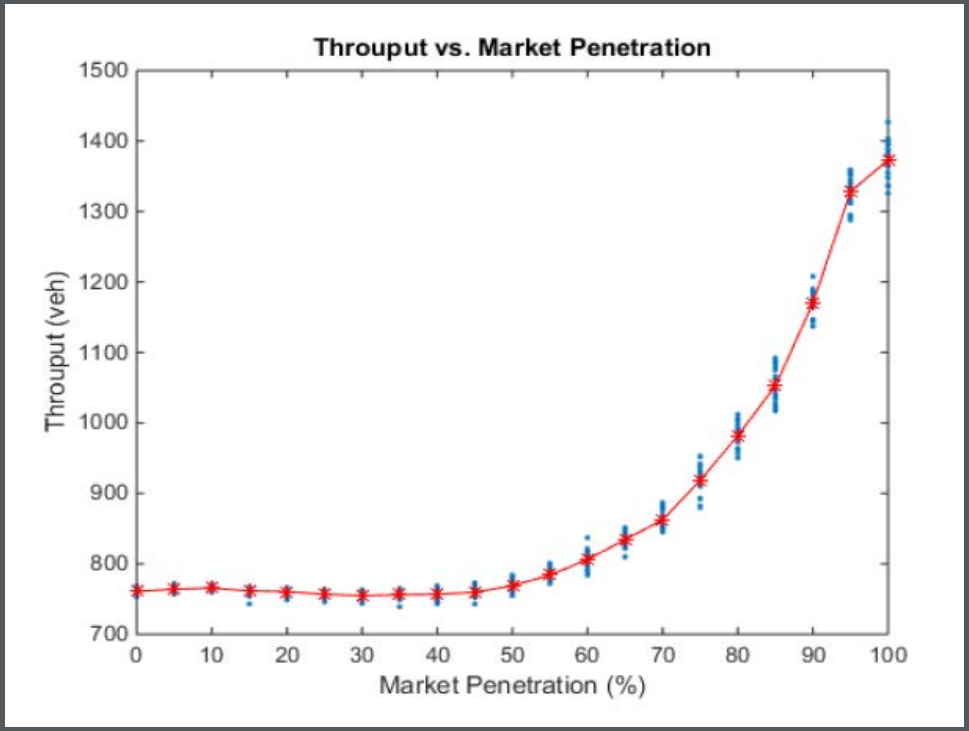


Summary of Potential Impacts

Factors	Auto Ownership	Trips (#)	Distance Travelled	Roadway Capacity	Safety	VMT	Speed
Automated Vehicle—Passenger	↓	↑	↑	↑	↑	↑	↑
Automated Vehicle—Commercial	—	↑	↑	↑	↑	↑	↑
Aging Population	↓	↓	↓	—	↑	↓	↑
Millennial Travel Behavior	↓?	↓?	↓?	—	↑?	↓?	↑?
Telecommuting	↓	↓	↕	—	↑	↓	↑
Car Sharing	↓	↕	↕	—	↑	↕	↑
Ride Hailing Service	↓	↕	↕	—	↑	↕	↑

Capacity Benefits

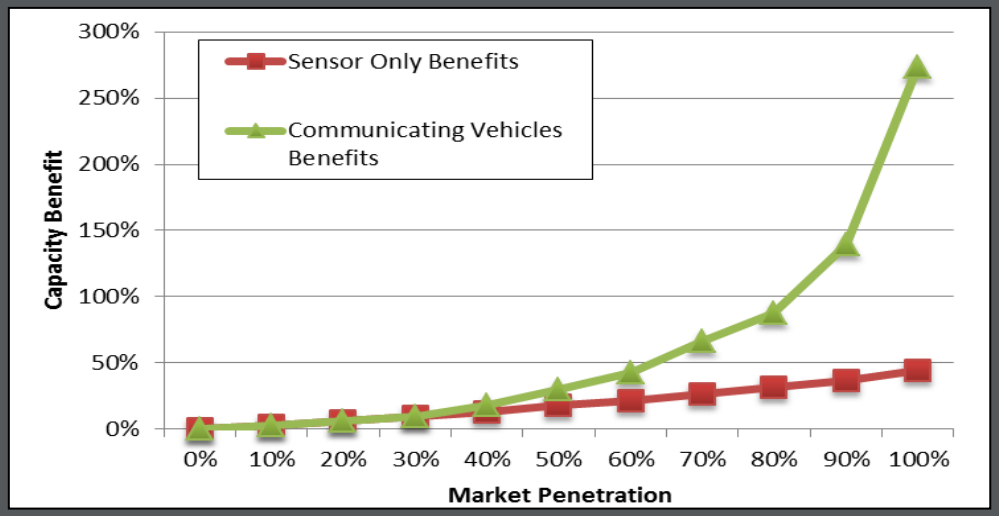
- Travel Impacts of Automation



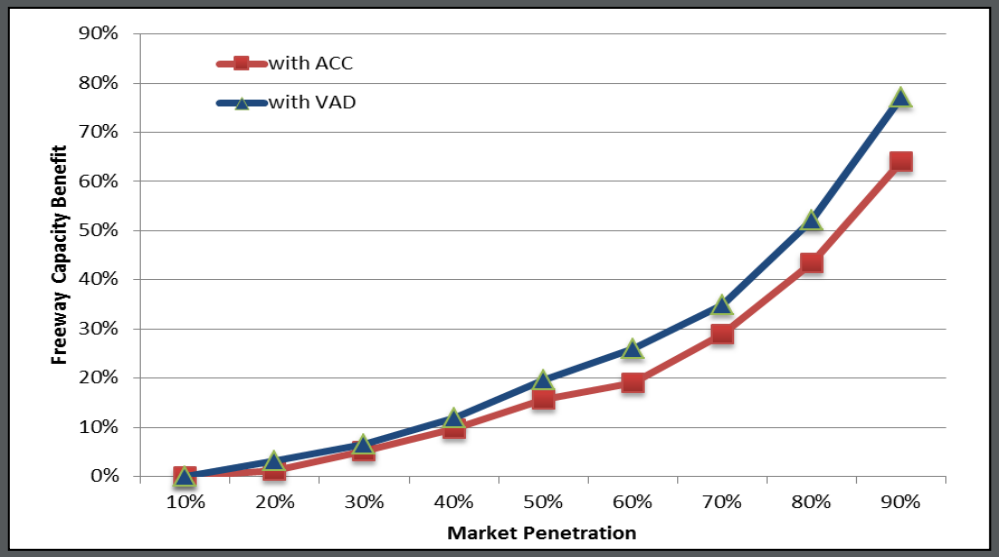
Source: Wang, Mostafizi, Dong, Oregon State University, 2016

- Travel Impacts of Automation

Capacity Benefits



Source: Tientrakool, Ho, and Maxemchuk , Columbia University, 2011



Source: Shladover, Su, and Lu , 2012

Potential Drawbacks to AV/CVs

New Sources of Congestion:

- More People Making Trips
- People Choosing Longer Trips
- Empty Cars Driving Themselves

- Summary of Automation Research

2040 Market Penetration

- ~ 30-70% of fleet

2040 System Capacity Benefits

- ~ 10-70% improvement
- Dampened if VMT and trips increase

2040 to 2050 might be period of significant fleet turnover

- Timing Leads to Increased 20-30 Year Planning Horizon Uncertainty

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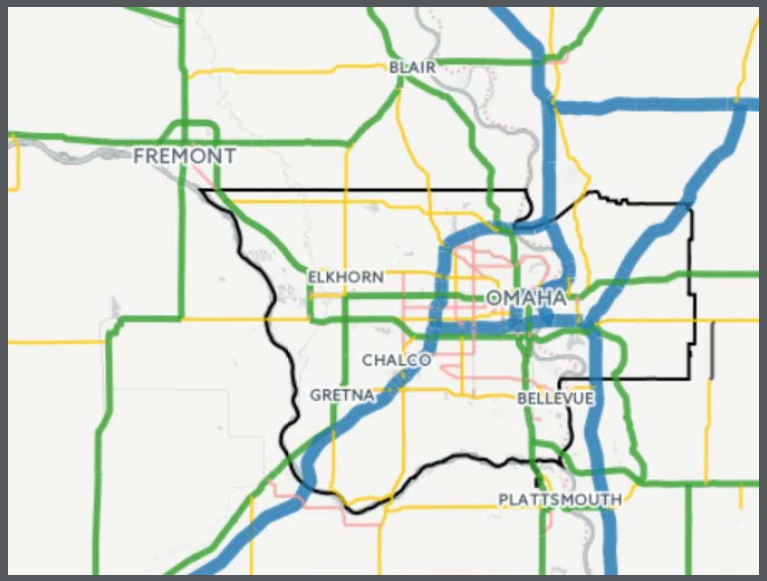
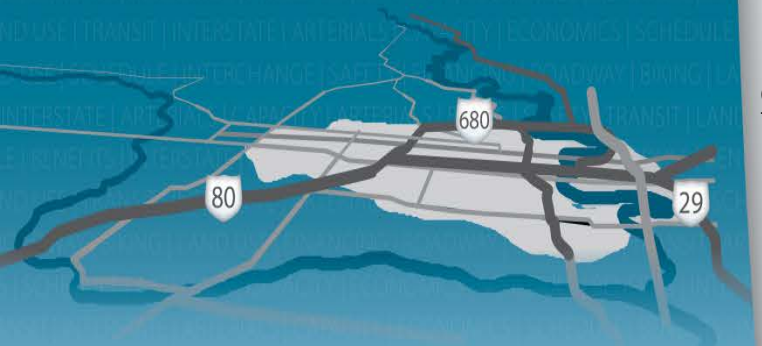


Regional Application - MAPA AV/CV Scenario Planning

What are Other MPOs Doing?



Puget Sound (PSRC) Automated Vehicle Scenario

Scenario	Description
1: Increased Capacity	• 30% Freeway and Major Arterial Capacity Improvement
2: Increased Capacity and Value of Time Change	• 30% Capacity Improvements • Travel Time "Cost" is 65% of actual for High VOT HH Trips
3: All Cars are Automated	• 30% Capacity Improvements • Travel Time Cost is 65% for *all* trips • 50% parking cost reduction
4: All Cars are Automated with Actual Costs Charged to User	• No Capacity Improvements • No Personal Car Ownership • Driving Cost = $1.65 / Mile

Childress, Nichols, Charlton, Coe. *Using An Activity-based Model To Explore Possible Impacts Of Automated Vehicles.* Transportation Research Board 2015 Annual Meeting, Washington, D.C

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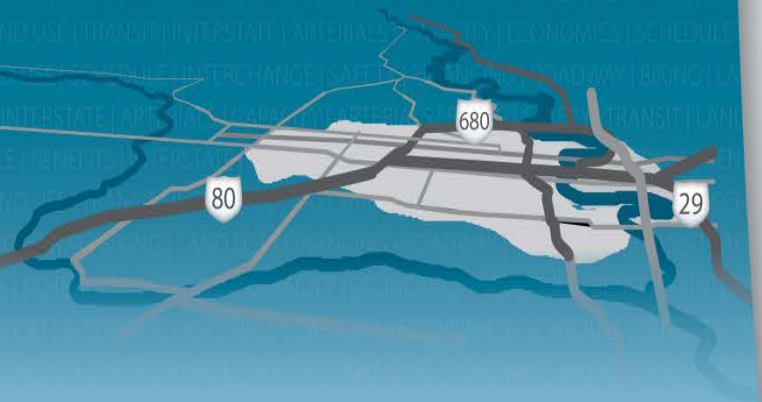
What are Other MPOs Doing?



Puget Sound (PSRC) Automated Vehicle Scenario

Measure	Value	Base	1	2	3	4
VMT	Total Daily	78.7 M	81.5 M	82.6 M	94.1 M	50.8 M
	% Change (Versus Base)	---	**3.6%**	**5.0%**	**19.6%**	**-35.4%**
VHT	Total Daily	2.82 M	2.72 M	2.76 M	3.31 M	1.67 M
	% Change	---	**-3.9%**	**-2.1%**	**17.3%**	**-40.9%**
Trips	Trips/Person	4.1	4.2	4.2	4.3	4.1
Distance (miles)	Average Trip Length	6.9	7	7.2	7.9	5.8
	Work Trips	12.4	12.9	12.9	20	11.5
	School Trips	5.8	5.8	5.8	6.7	4.7
Delay (1000 hours)	Daily Average	846.0	700.0	727.2	996.1	350.2
	Freeways	288.1	201.2	218.3	338.7	56.4
	Arterials	557.9	498.8	508.9	657.5	293.8
Speed (mph)	Daily Average	27.9	30	29.9	28.4	30.4
	Freeways	40	44.7	44.2	40.8	49.2
	Arterials	22.5	23.2	23.1	22.3	24.3
Mode (%)	SOV Share	43.7	43.7	42.7	44.8	28.7
	Transit Share	2.6	2.7	2.7	2.4	6.2
	Walk Share	8.6	8.6	8.4	6.8	13.1

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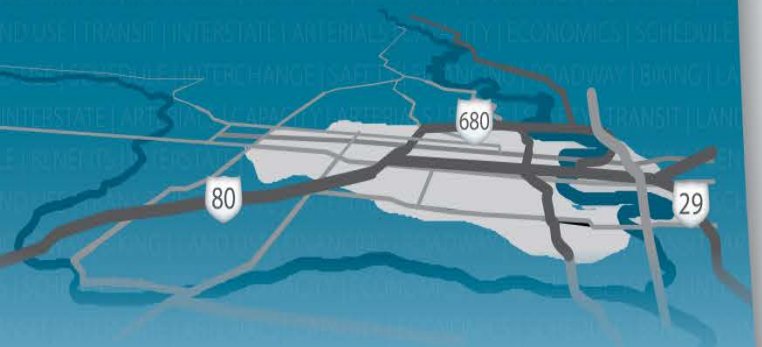
What are Other MPOs Doing?



Atlanta (ARC) Automated Vehicle Scenario

Scenario	Description
C: Capacity Benefits	• 50% System Capacity Improvement
CT: Capacity Benefits and Time Cost Reductions	• 50% Capacity Improvements • Travel Time "Cost" is reduced (IVT – 50%)
CTO: Capacity Benefits and Time and Operating Cost Reductions	• 50% Capacity Improvements • Travel Time Cost reduced 50% • Vehicle Operation Cost is reduced (71% reduction)
CTOP: Capacity Benefits and Time, Operating, and Parking Cost Reductions	• 50% Capacity Improvements • Travel Time Cost reduced 50% • Vehicle Operation Cost is reduced 71% • Parking Costs set to $0

Kim, Rousseau, Freedman, Nicholson. *The Travel Impact of Autonomous Vehicles in Metro Atlanta through Activity-Based Modeling.* 15th TRB National Transportation Planning Applications Conference. 2015

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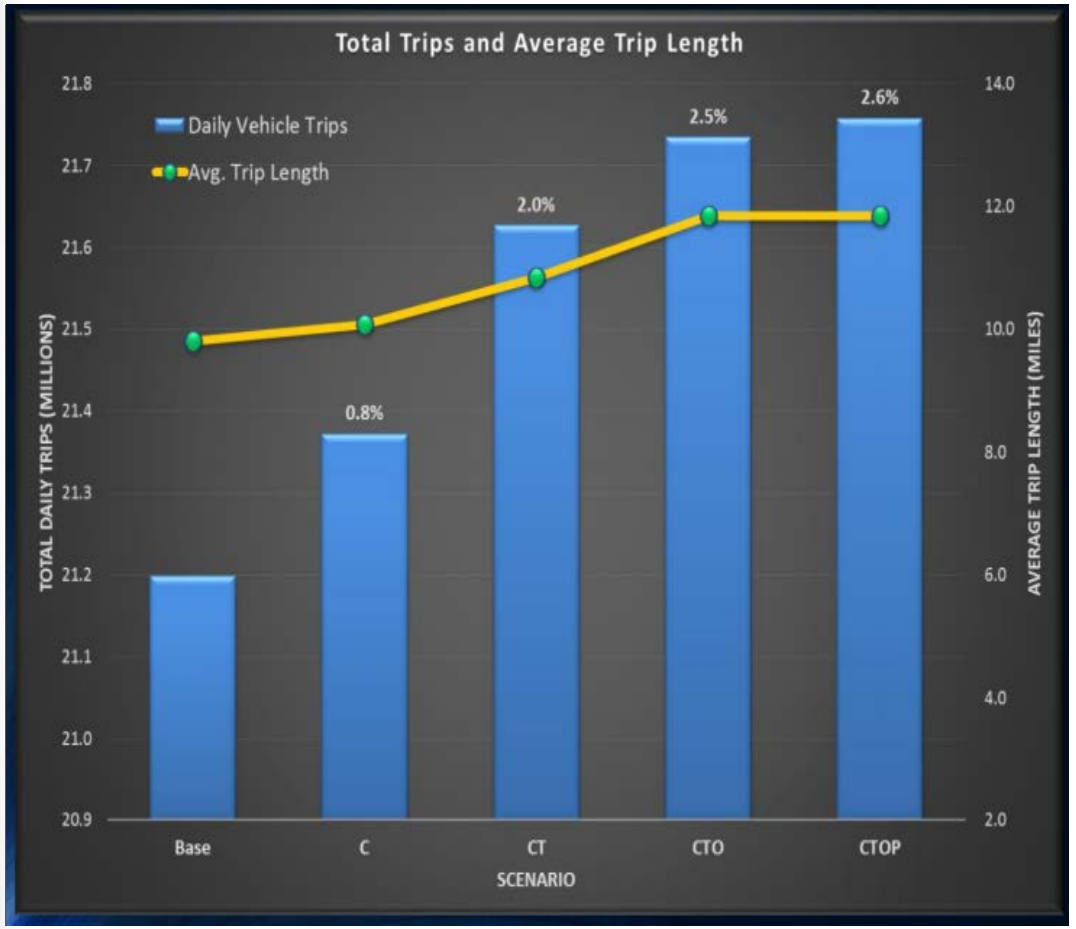
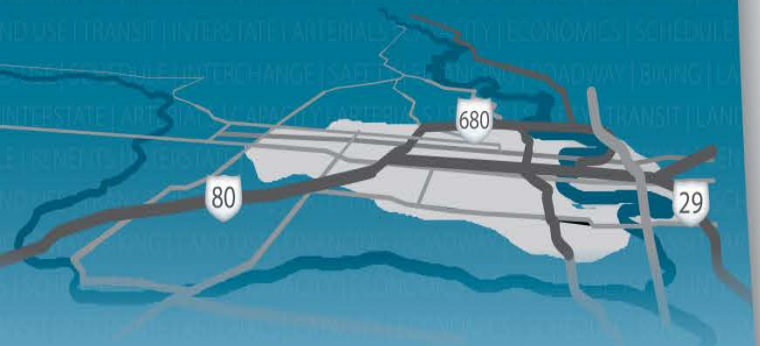
ARC Scenario Results

Model Results





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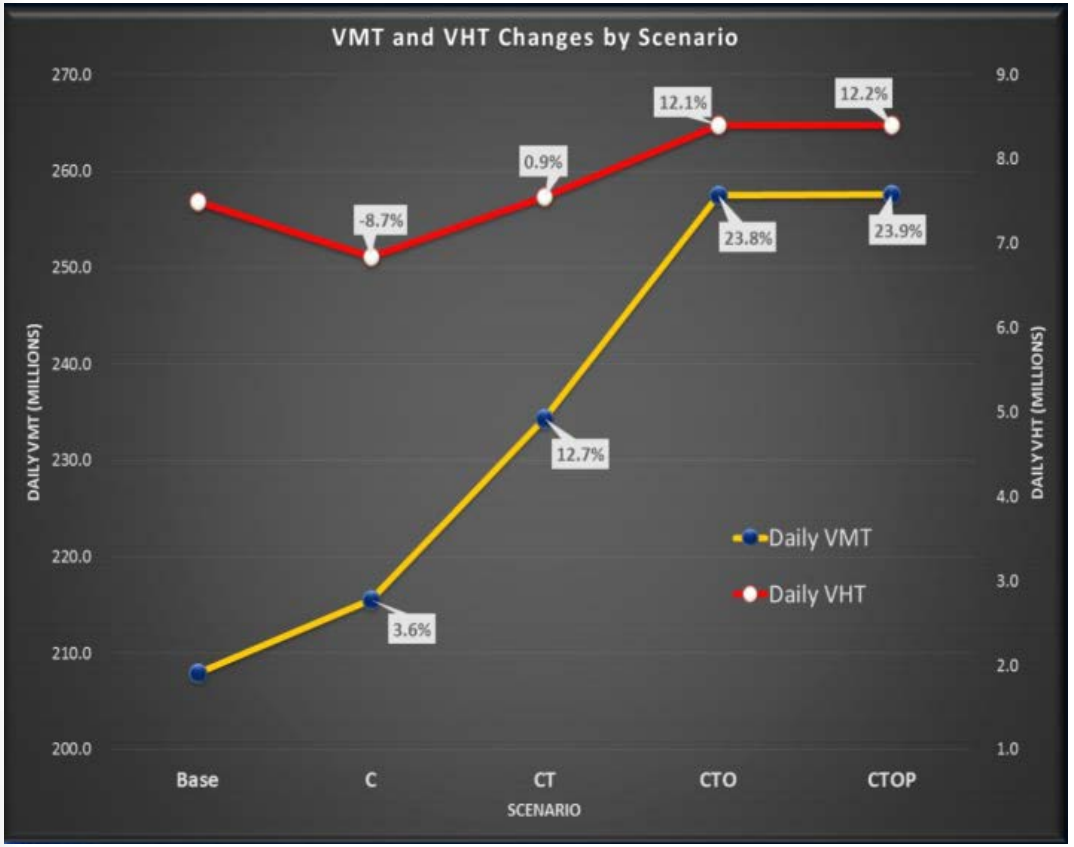
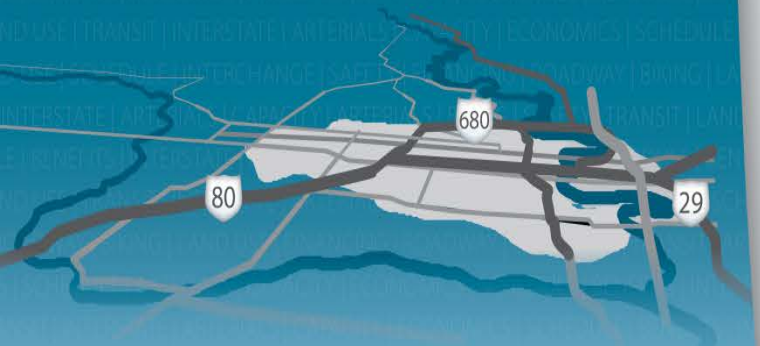
ARC Scenario Results

Model Results





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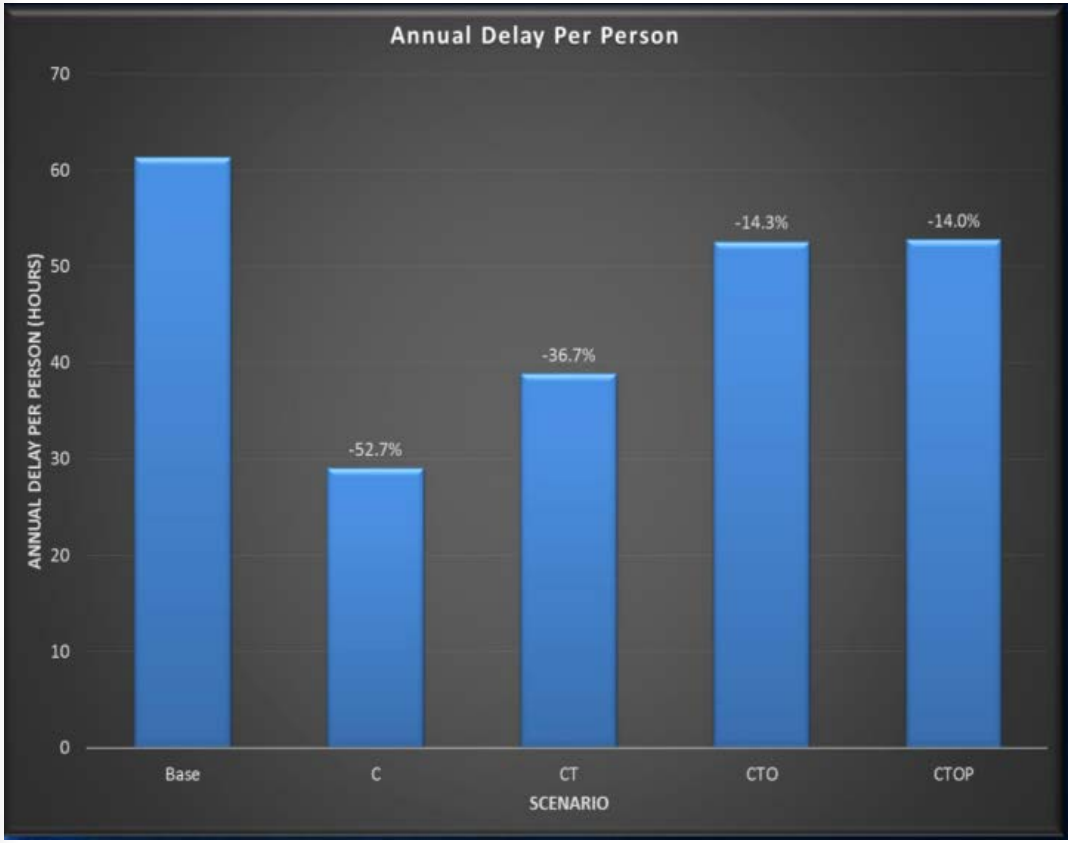
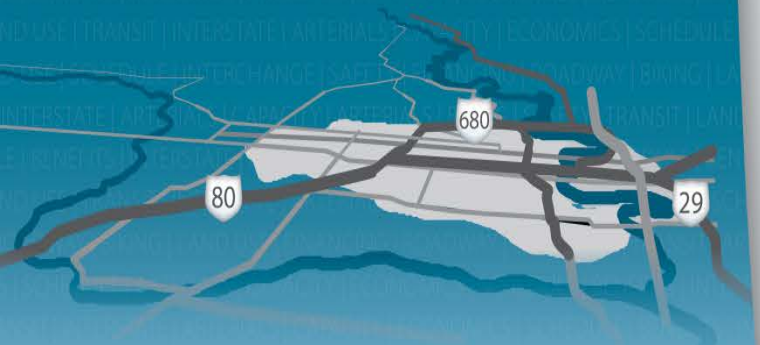
ARC Scenario Results

Model Results





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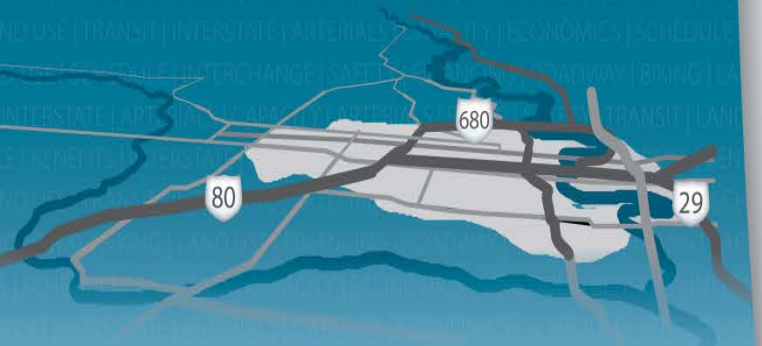
Travel Impacts of Automation



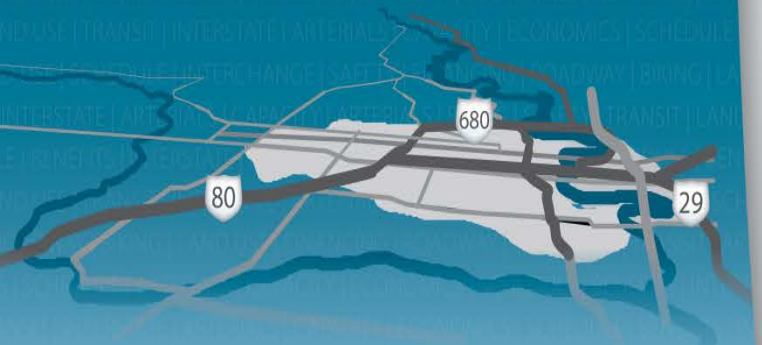
New / “Induced” Trips

- PSRC ABM:
  - 0% to 4.9% increase in trips made
- ARC ABM:
  - 0.8% to 2.6% increase in trips made

Reduced Value of Time

- Both ARC and PSRC Evaluated this:
  - ARC used time value factor of 0.5
  - PSRC used time value factor of 0.65 for AV trips

Travel Impacts of Automation



Secondary Impacts

- Transit Mode Share:
  - ARC: – 1% to -42%
  - PSRC: -12% to + 130%
- Trip Length / VMT:
  - ARC VMT: +4% to +24%
  - PSRC VMT: -35% to +20%
- Delay:
  - ARC Delay: -14% to -53%
  - PSRC Delay: -59% to + 18%

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Travel Impacts of Automation
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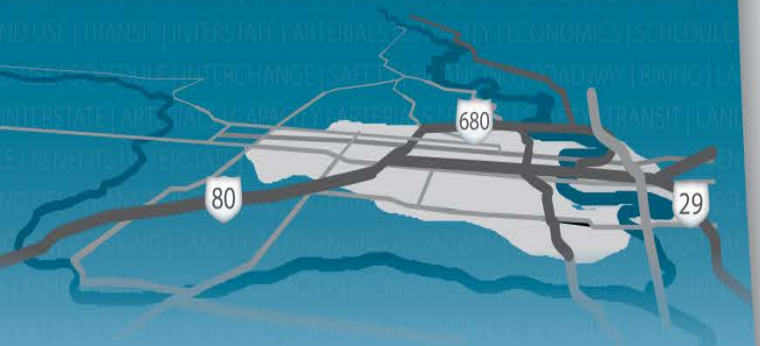

Other Unmodeled Factors

- "Deadheading" Cars (no occupants)
- Vehicle Ownership Model (shift to car-sharing?)
- Parking and Development Pattern Changes
- Safety Benefits = Increased System Reliability

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Omaha – Council Bluffs AV/CV Scenarios Variables Assessed

AV/CV Benefits

- More “Capacity” from Existing Roads

AV/CV Benefits and Drawbacks

- More “Capacity” from Existing Roads
- New “Induced” Trips
- Passenger-less “Deadheading” Trips
- Longer Trips due to Decreased In-Vehicle Time Value

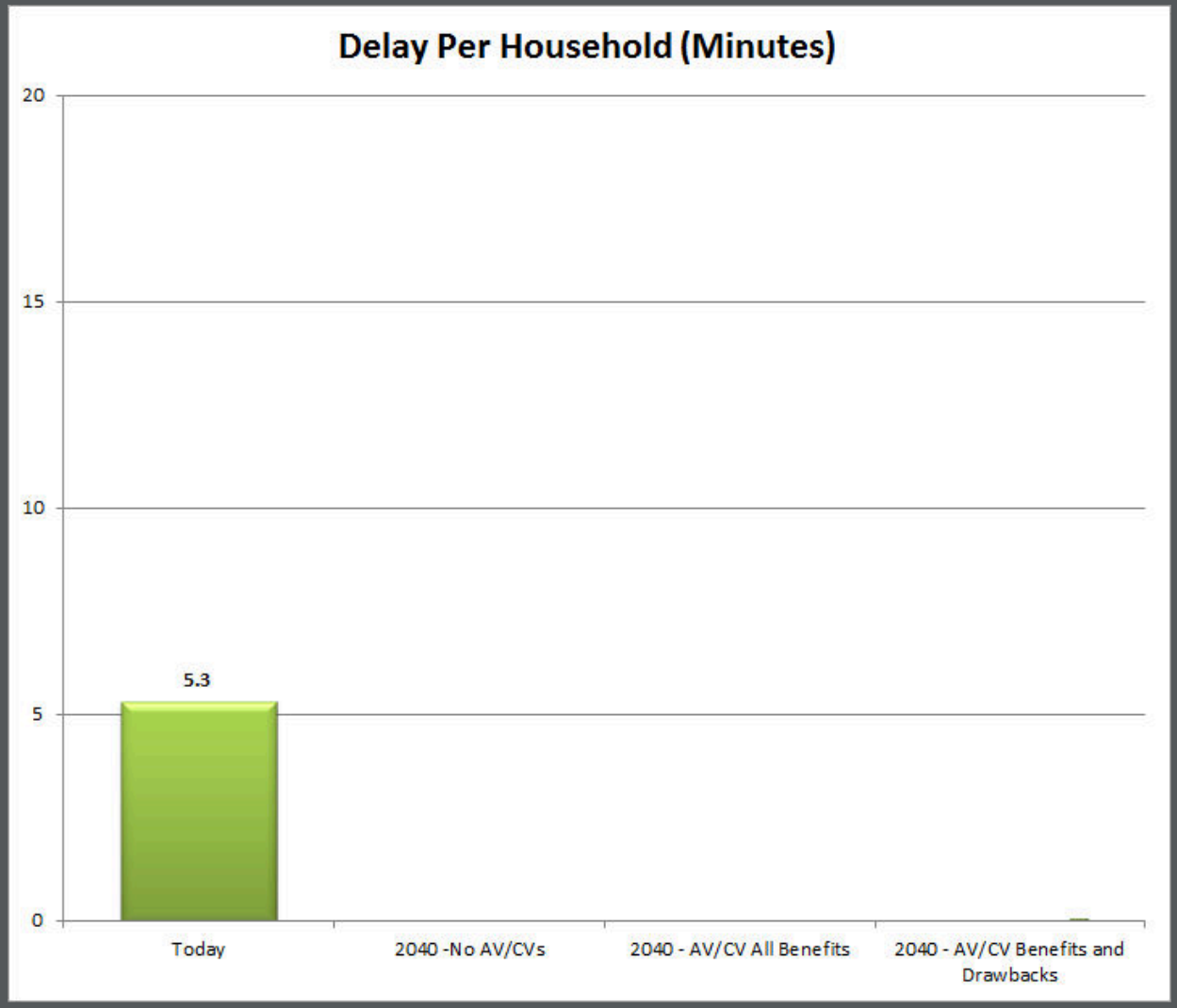
Omaha – Council Bluffs AV/CV Scenarios
Scenario Details

Scenarios							
Variable	Base	1	2A	2B	2C	2D	3C
Induced Trip Change	-	-	-	+4%	+4%	+4%	+15%
Deadhead VMT Change	-	-	-	+15%	+15%	+15%	+15%
Value of Time Change	-	-	-	-	-20%	-20%	-20%
Capacity Change	-	+30%	+50%	+50%	+50%	+50%	+50%

What We Tested

- How Much Congestion Occurred?
- How Many People Used Transit?
- What Roads Needed Widened?

Planning Scenario Results – Congestion Example



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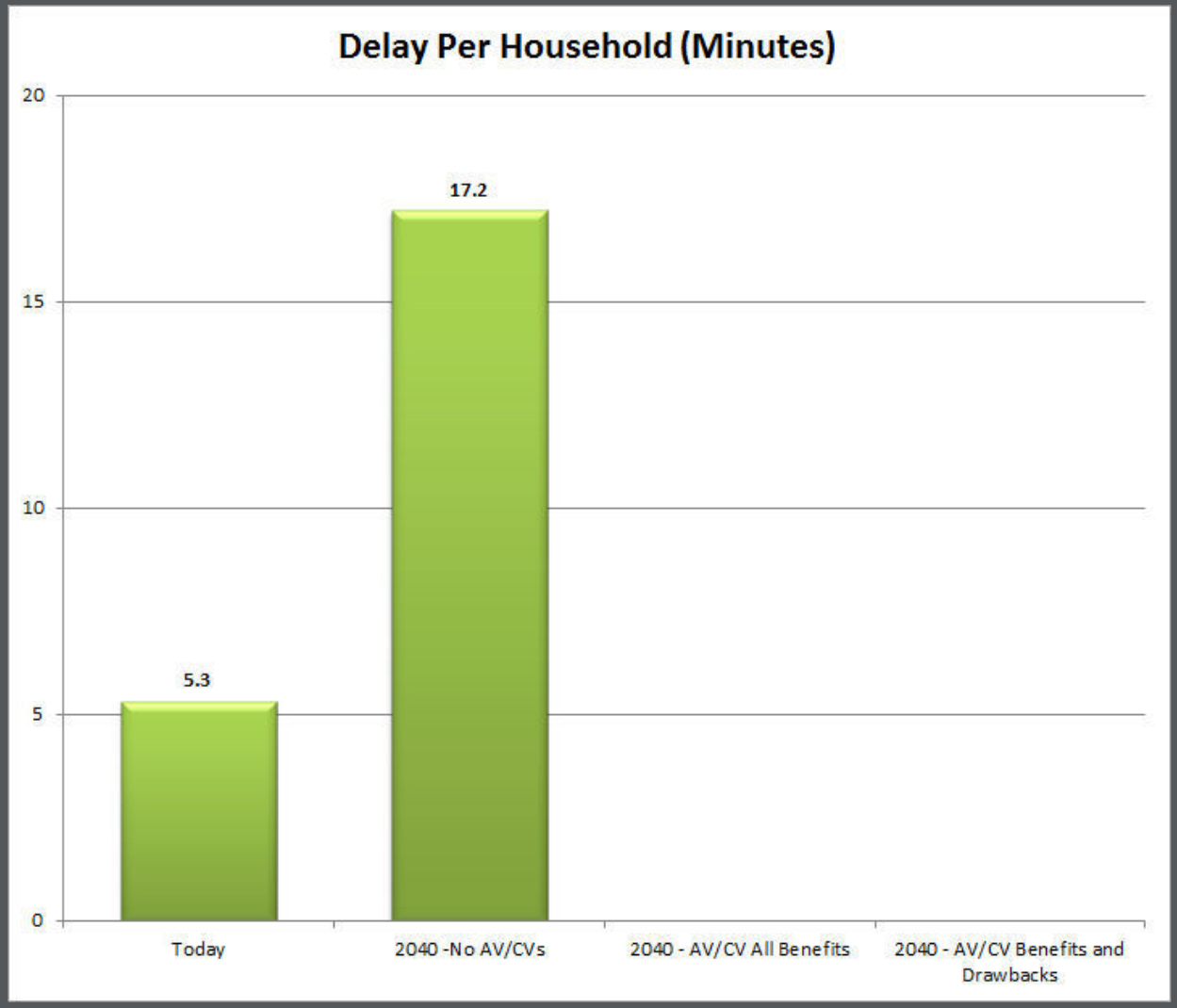

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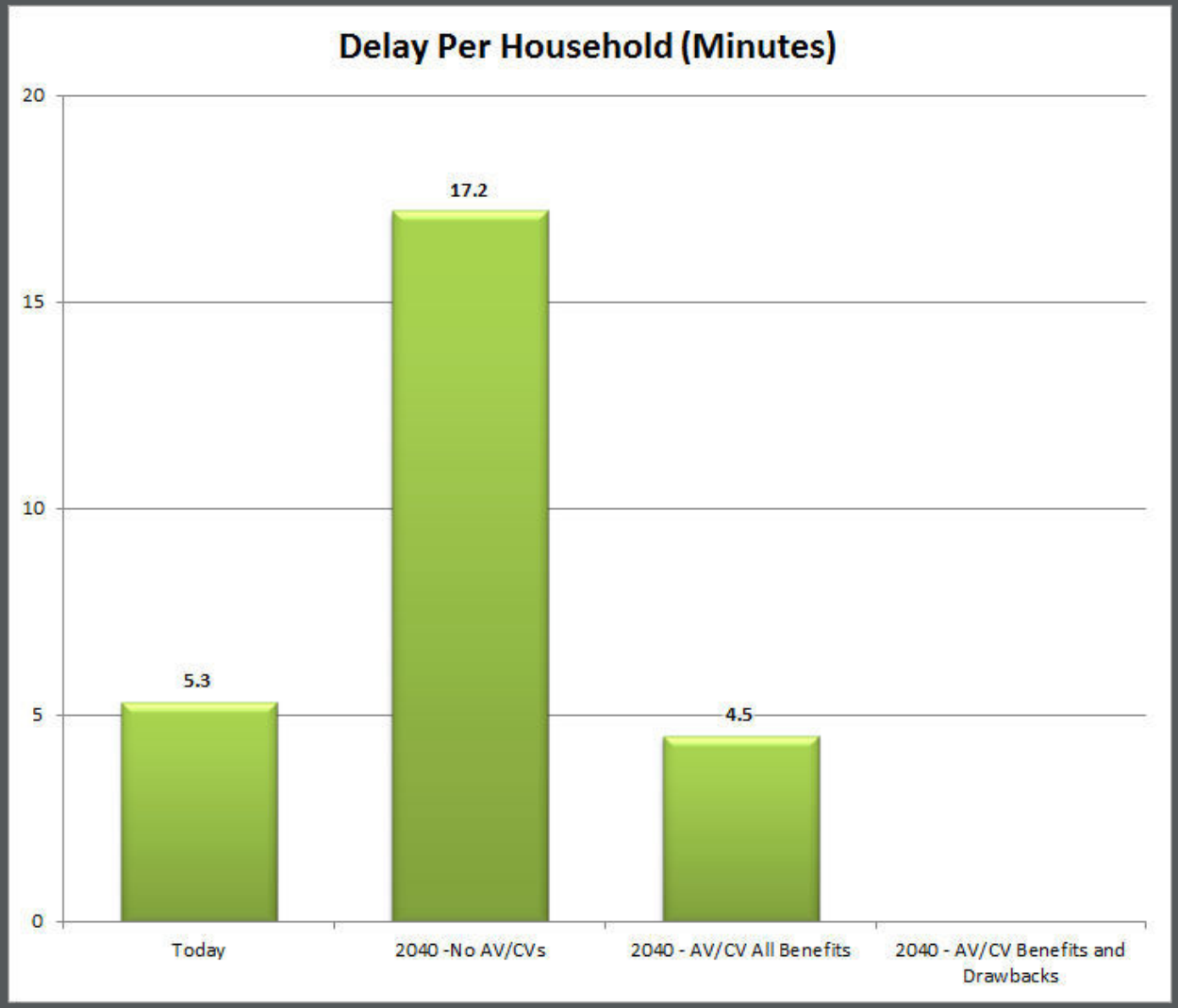

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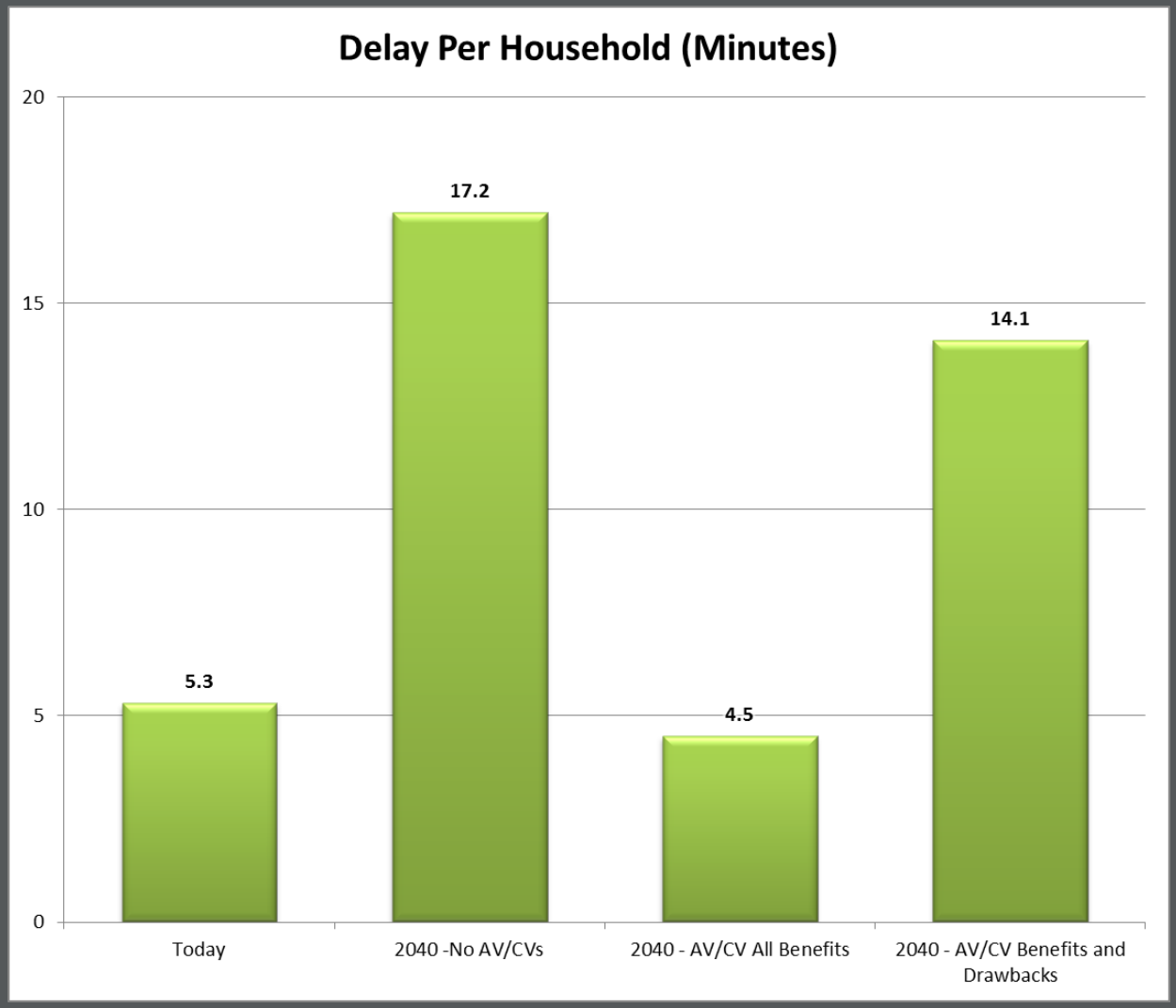
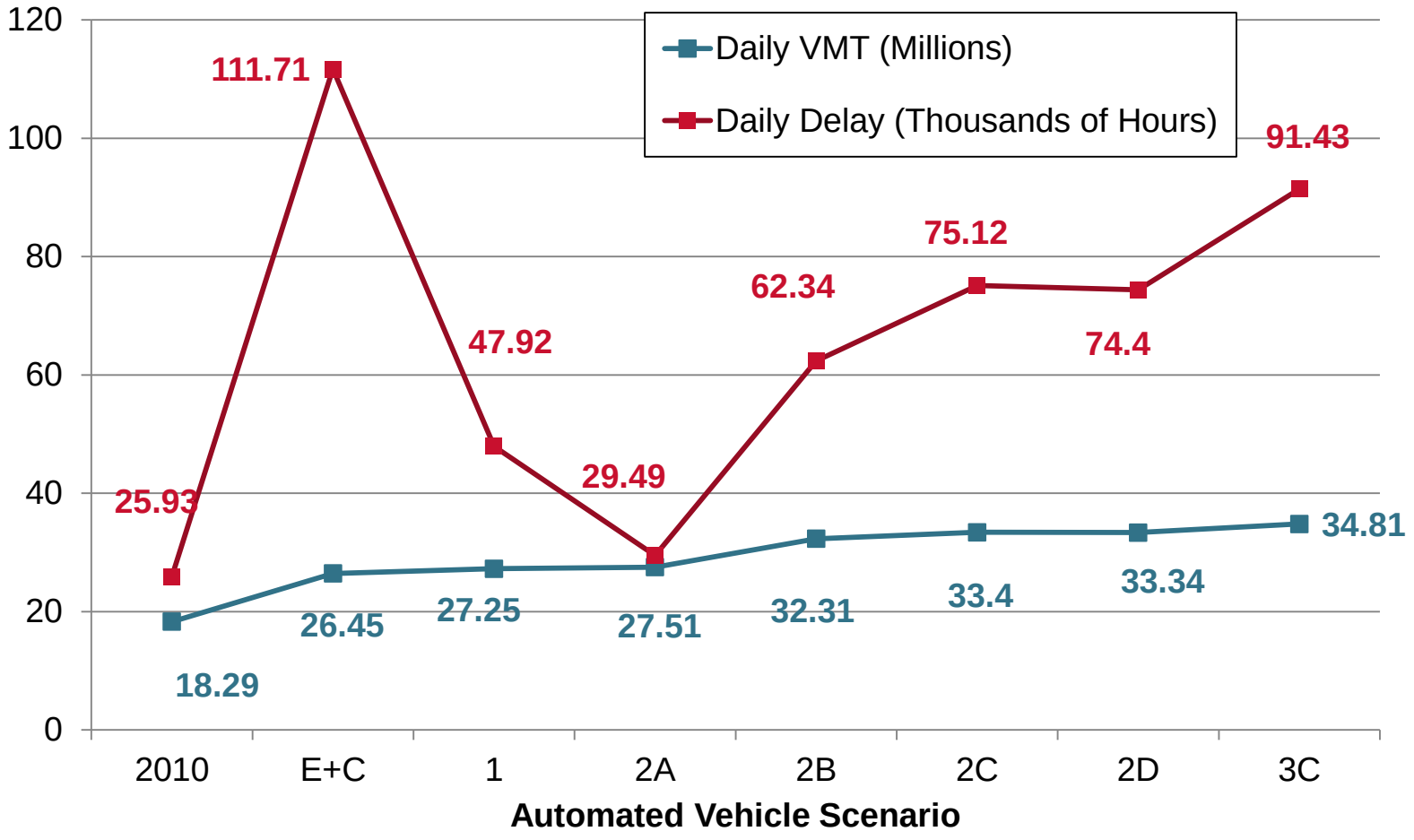
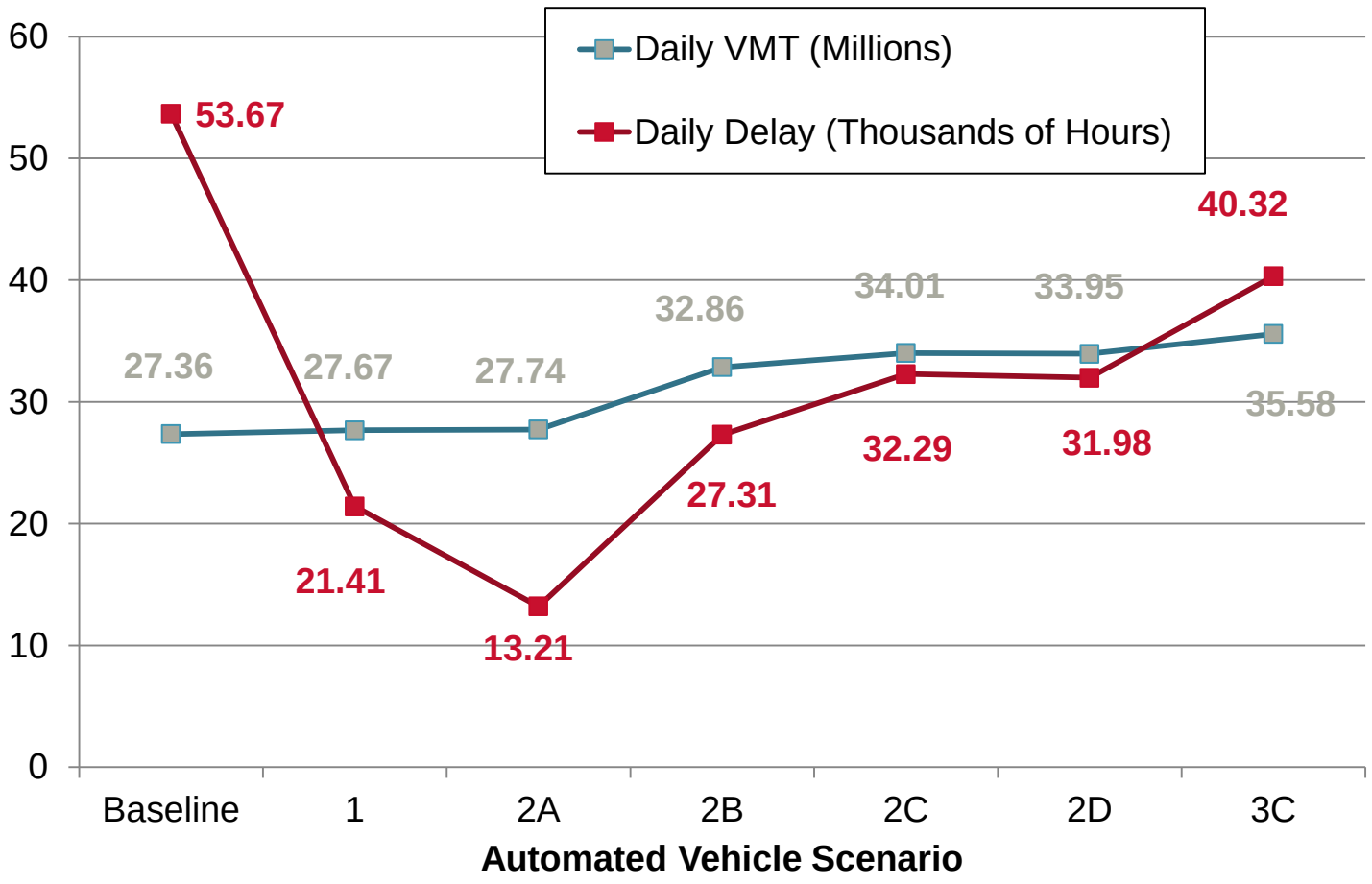


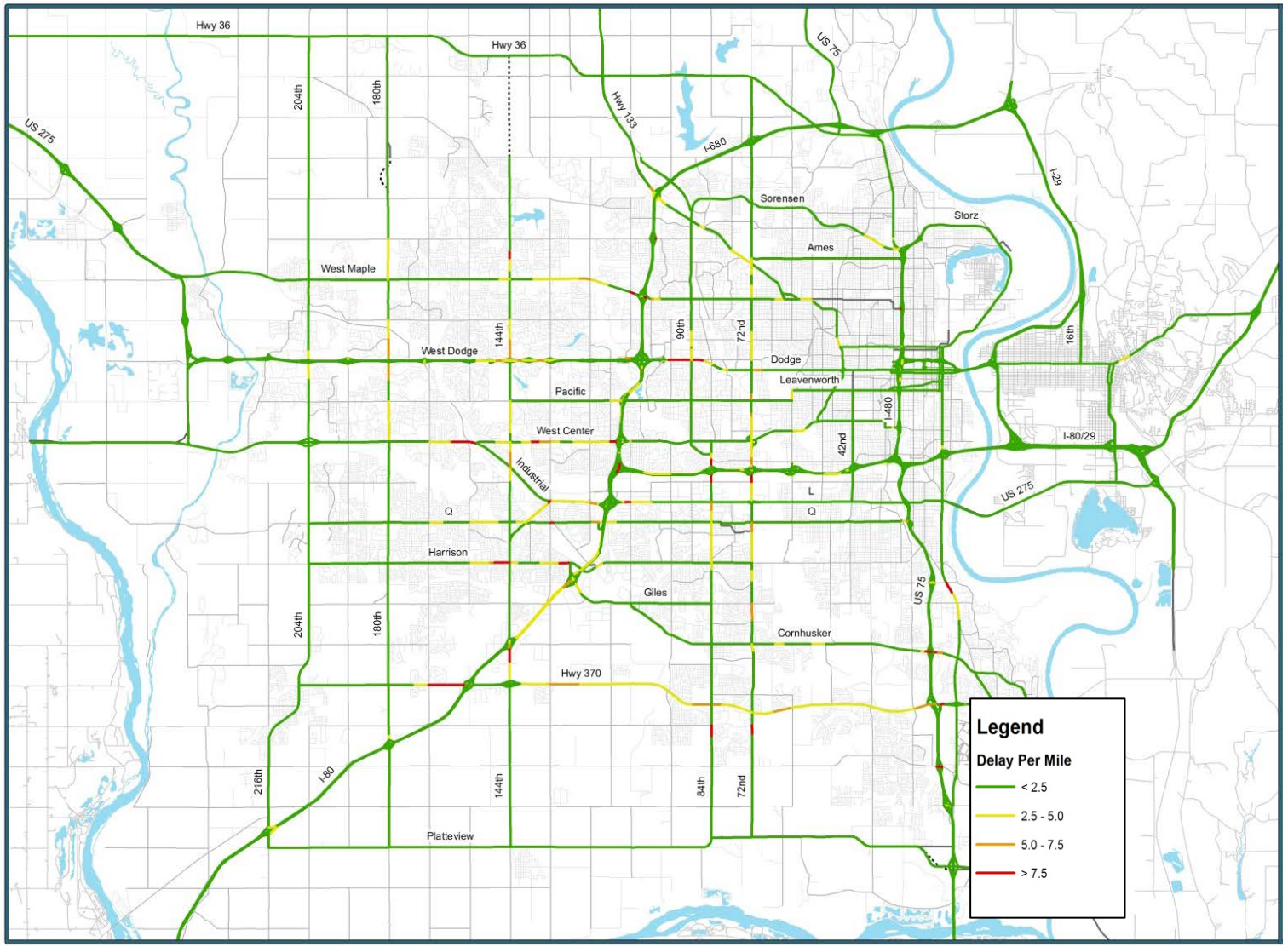
AV/CV Results (Existing System + Near-Term Committed Projects)



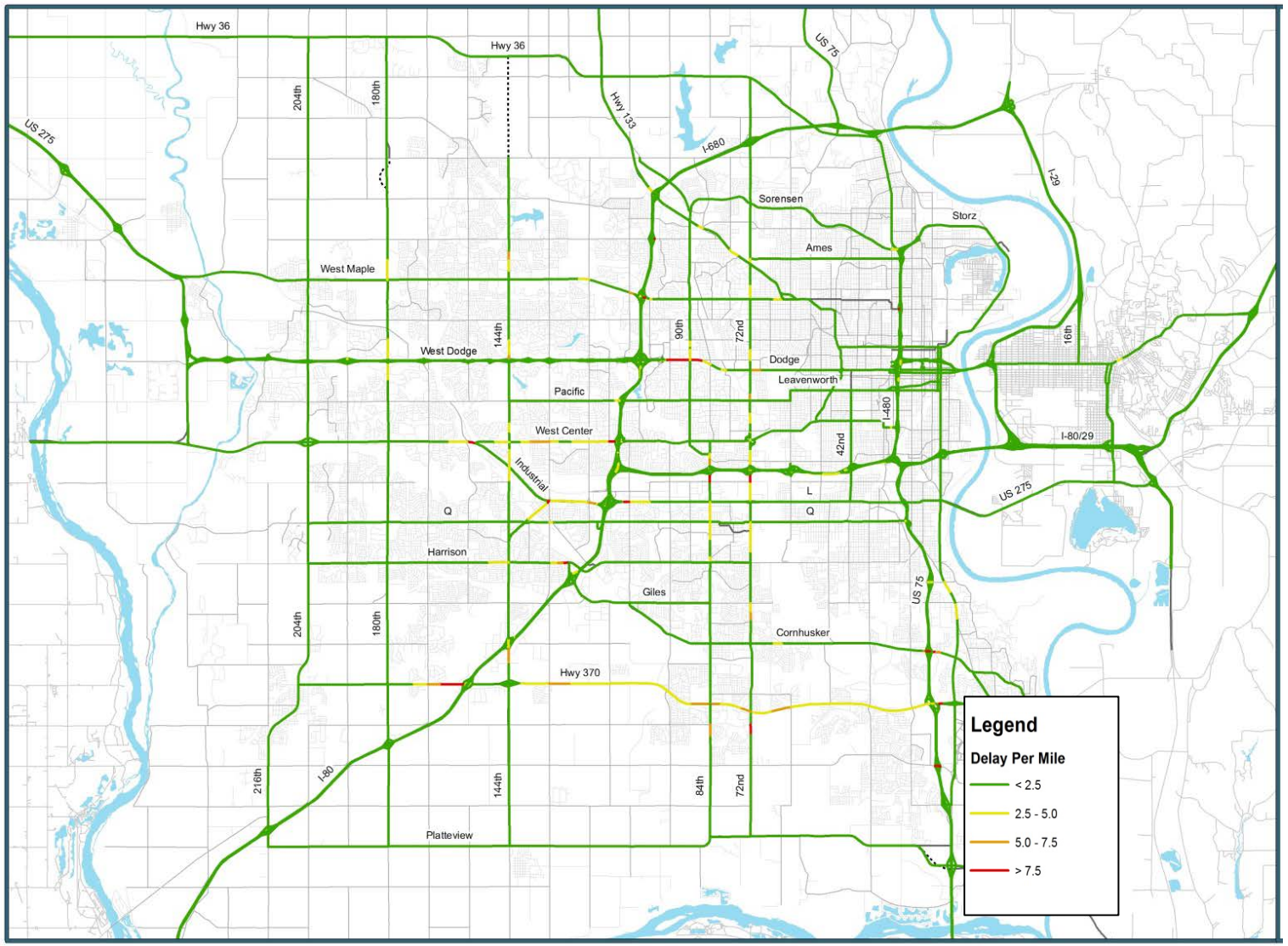
AV/CV Results (Vision Plan)

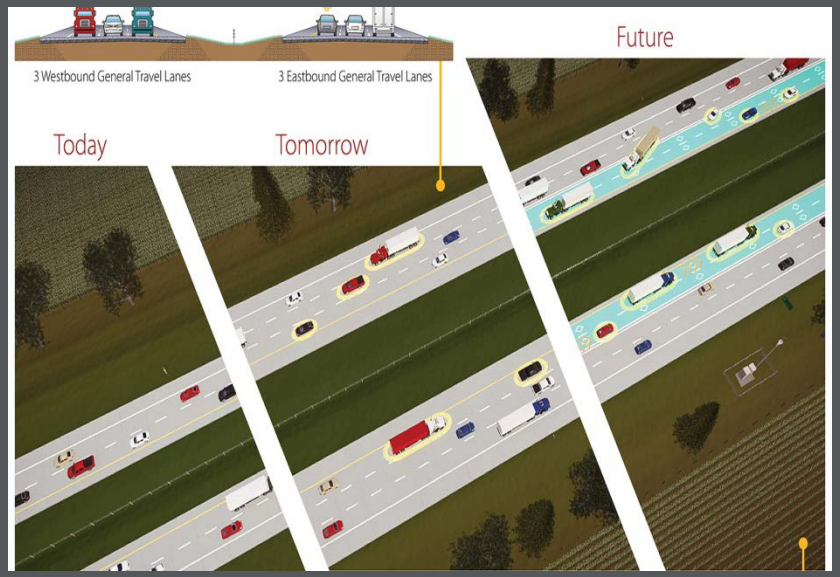


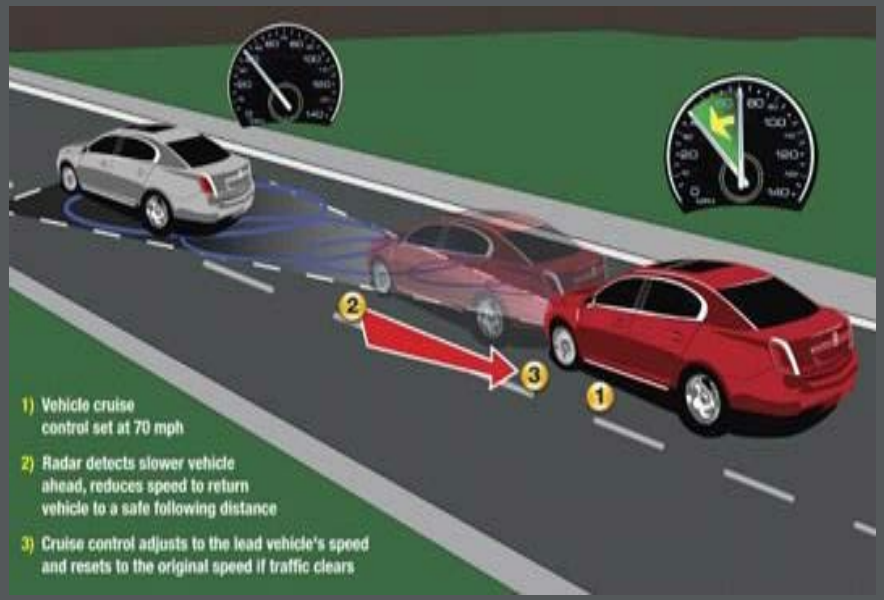
2040 Future Plan Congestion – No AV/CVs



2040 Future Plan Congestion – AV/CVs (Scenario 2c)





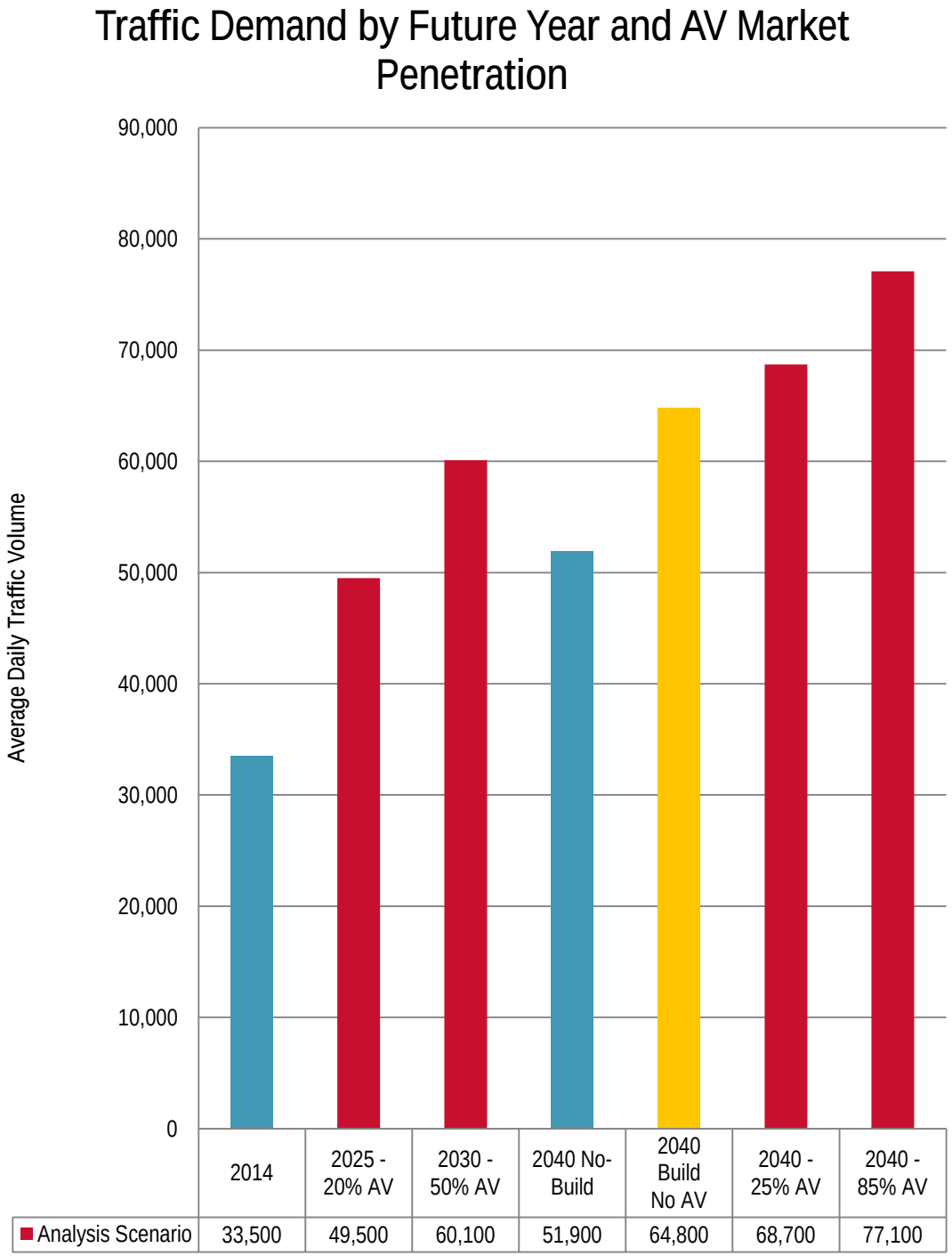


02 Corridor Application – I-80 PEL Automated Corridors Study

Traffic Analysis

- DOT Statewide travel model runs
  - 2040 4-lane I-80
  - 2040 6-lane I-80

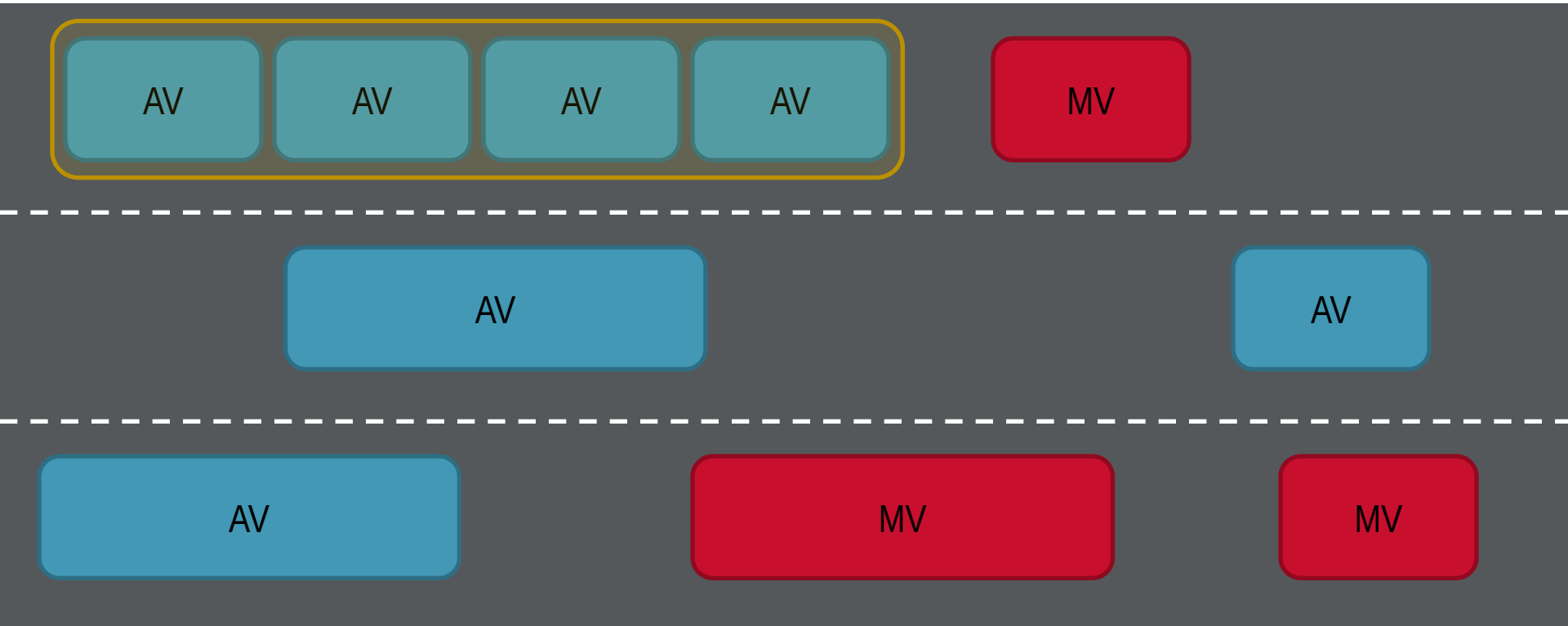
- Research on AV impact to demand
  - Induced trips due to AV
  - Potentially longer trips as well



Traffic Operations Approach

- Develop VISSIM models based on existing operating conditions
- Develop a concept of operations for technology
  - Implement in VISSIM using COM scripting
- Compute / compare scenario quality of service and capacity

Manually-operated Vehicle (MV)
Automated Vehicle (AV)



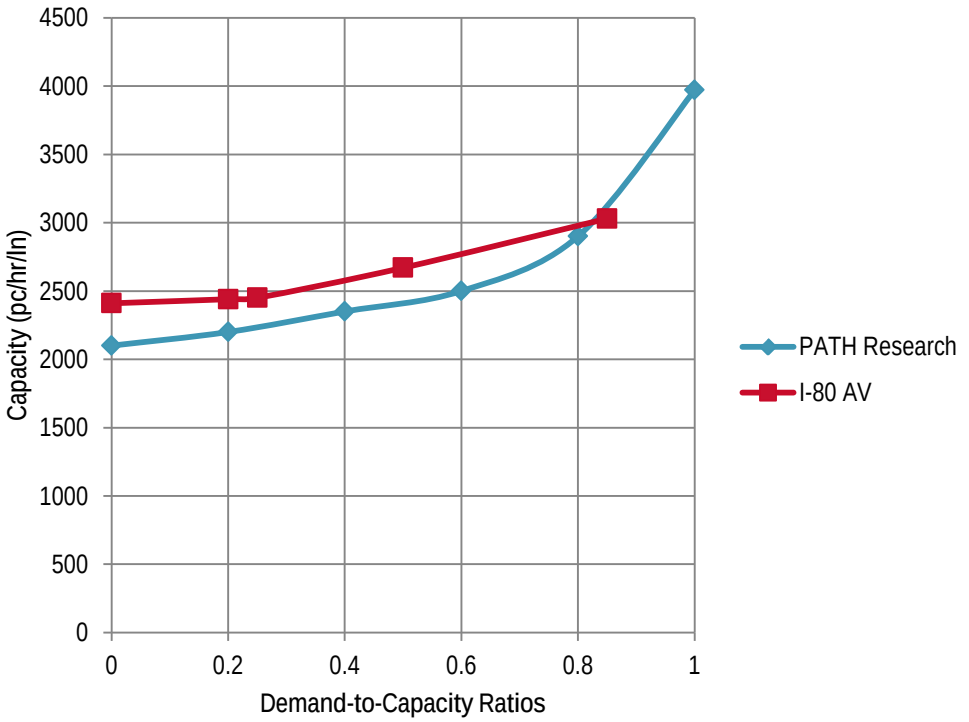
Traffic Analysis Results

- Simulated capacity with AV
  - Default VISSIM driver behavior
  - AV traffic mixes with non-AVs in all lanes
- Benefits reach substantial level at 50% AV

- 85% AV – A 6-lane freeway can serve roughly 1,800 additional vehicles during the peak hour

- Dependent on vehicle following / platooning code; likely to change over time

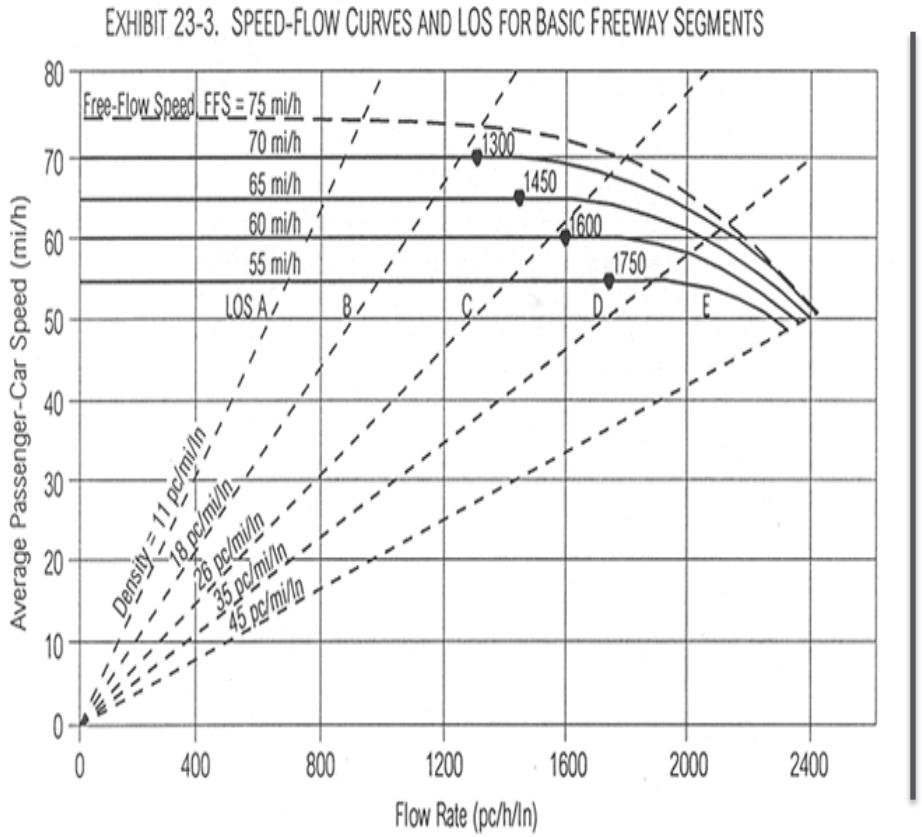
Scenario	% AV	Capacity (pc/mi/ln)	
No-Build	0%	2,410	(+0%)
Scenario 1	25%	2,450	(+2%)
Scenario 2	50%	2,670	(+11%)
Scenario 3	20%	2,440	(+1%)
Scenario 4	85%	3,030	(+26%)



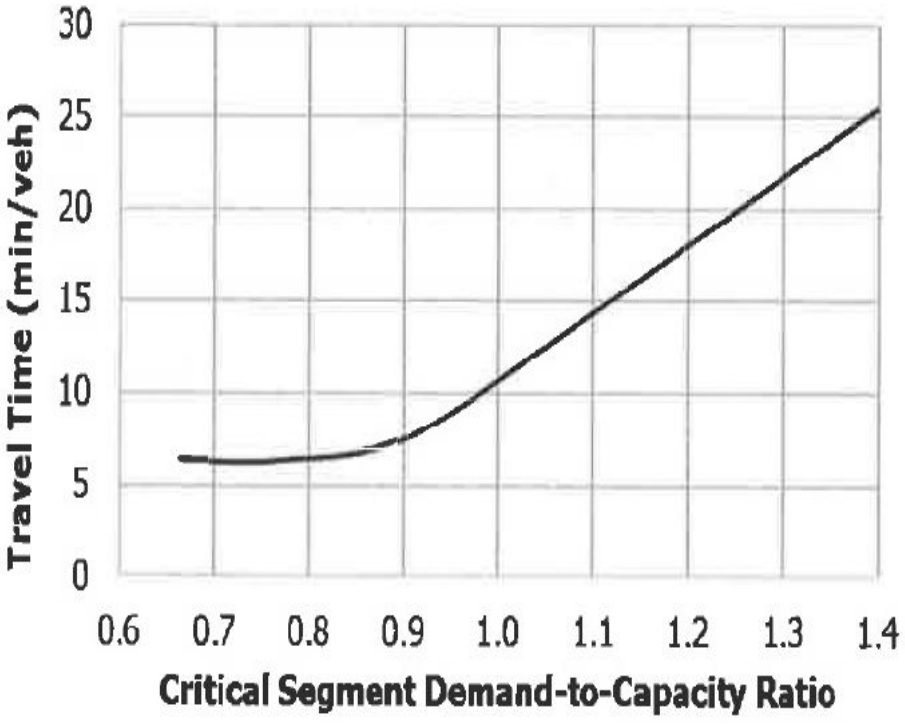
Traffic Operations Approach

- How do you measure traffic benefits?
  - Level of service not sensitive to AVs

LOS Vs. Demand-to-Capacity Ratio



Source: HCM 2015 Freeway Facilities Exhibit



DRAFT Traffic Analysis Results – Iowa City to Quad Cities

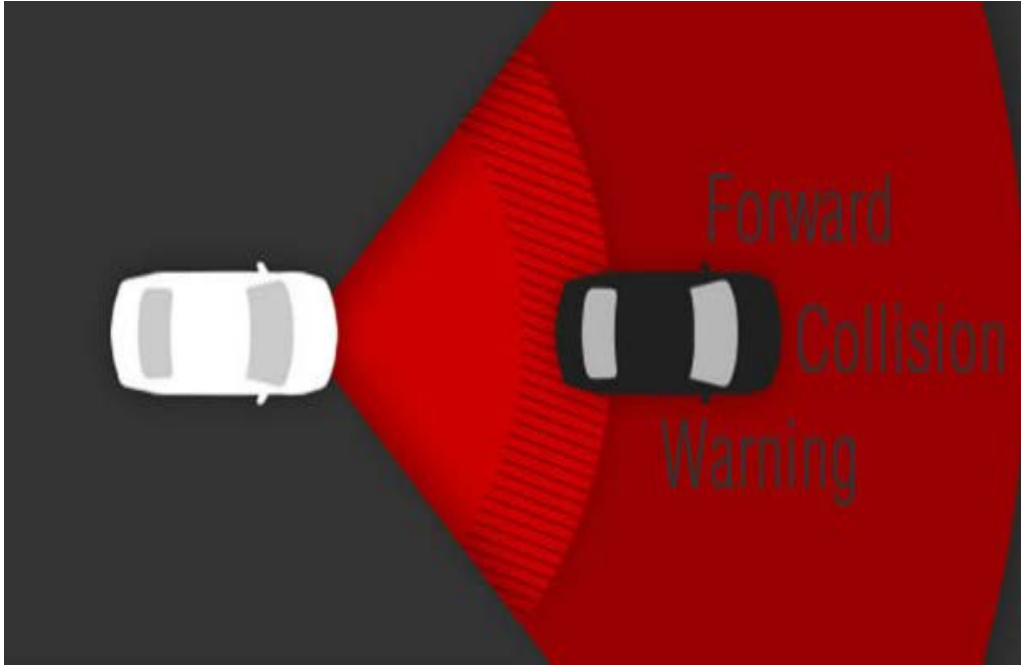
EB / WB	Volume (pce)	AV %	Average Speed (mph)	Average Density (pc / mi / ln)	D/C
Existing	2,030 / 1,800	0%	65.4 / 65.7	28.1 / 24.9	0.42 / 0.37
2025 Scenario 1	3,005 / 2,660	25%	66.8 / 66.6	40.6 / 36.5	0.41 / 0.36
2030 Scenario 2	3,645 / 3,230	50%	66.6 / 66.6	49.5 / 44.4	0.46 / 0.40
2040 No-Build	3,150 / 2,785	0%	62.3 / 63.4	45.8 / 40.1	0.65 / 0.58
2040 Scenario 3	4,165 / 3,685	20%	65.8 / 65.7	57.1 / 51.2	0.57 / 0.50
2040 Scenario 4	4,675 / 4,140	85%	66.7 / 66.6	63.3 / 56.6	0.51 / 0.45

Safety Analysis

Automated Vehicle Safety

- Safety applications
  1) Forward Collision Warning
  2) Lane Change Warning
  3) Cooperative Adaptive Cruise Control

1)



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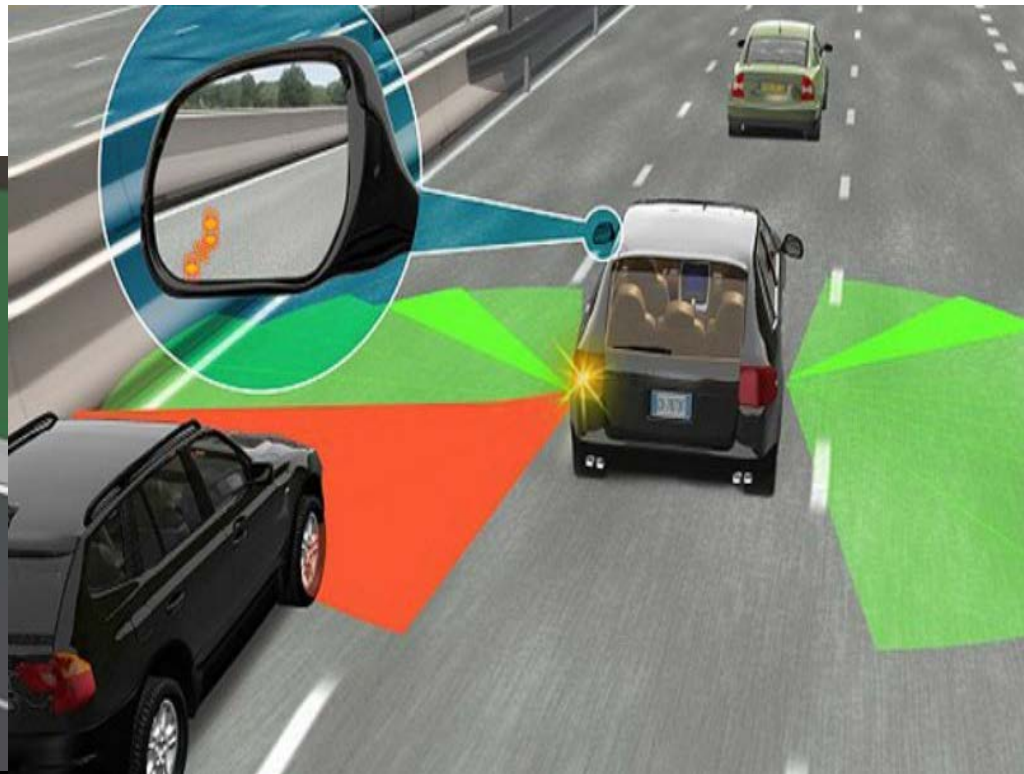

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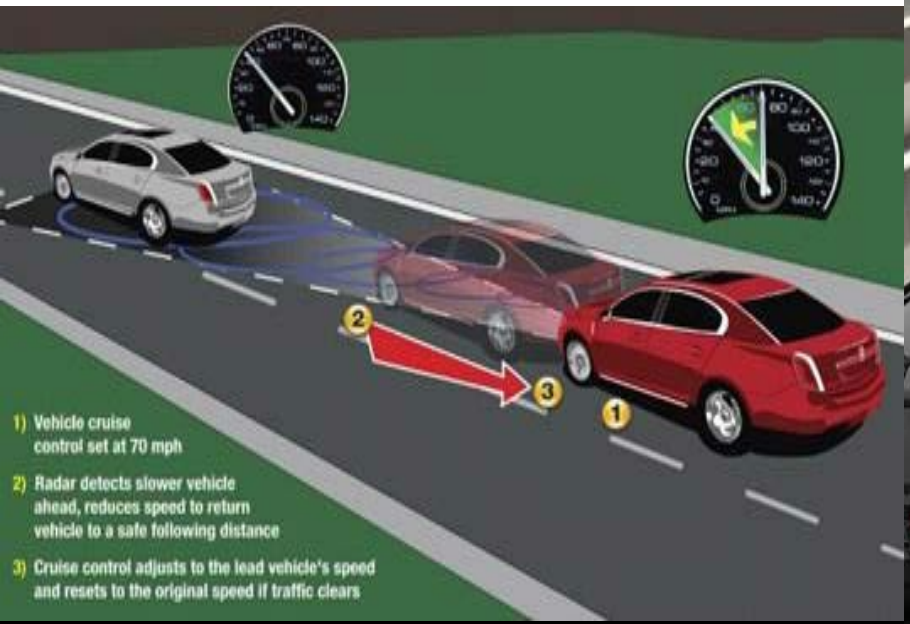
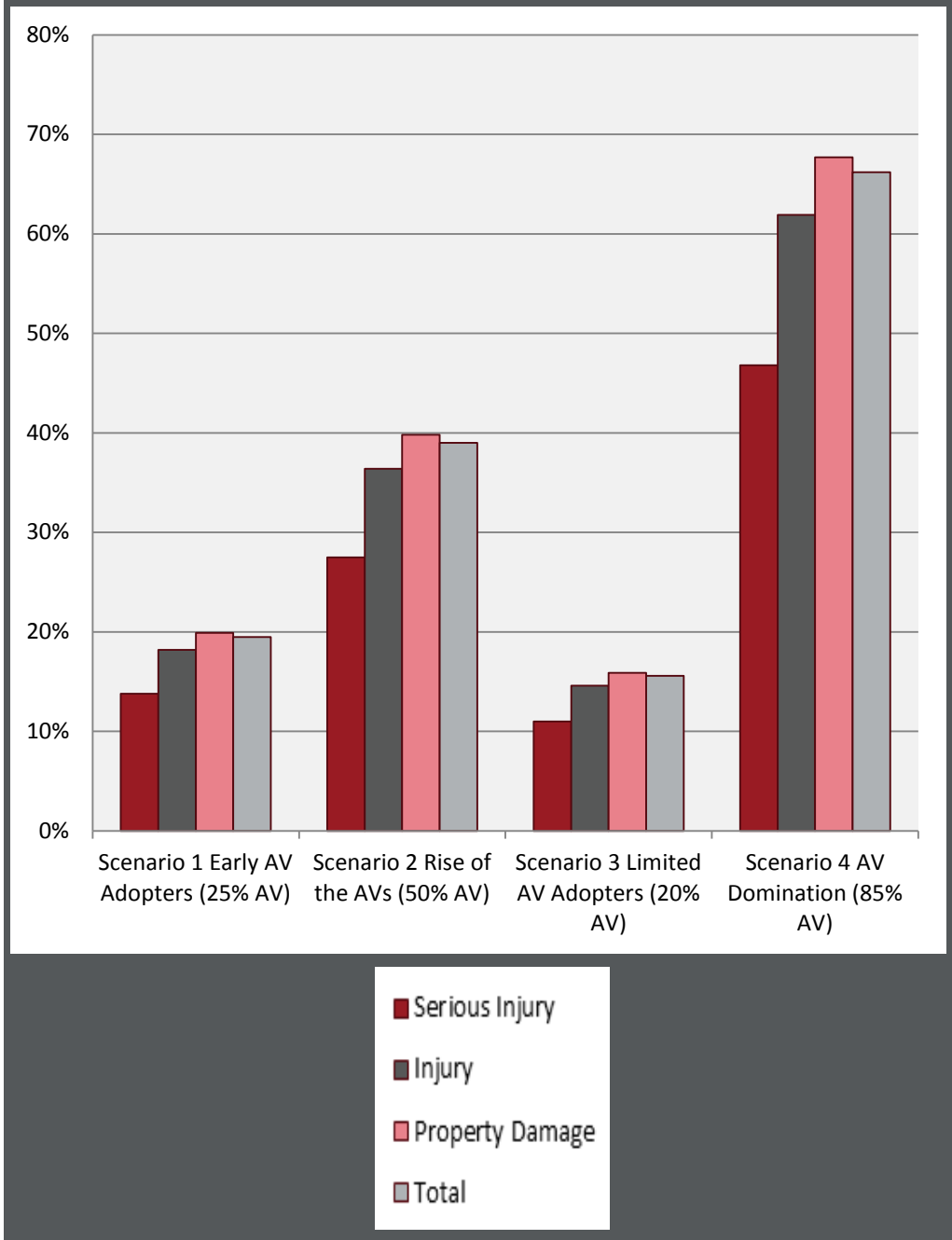


Safety Analysis Results

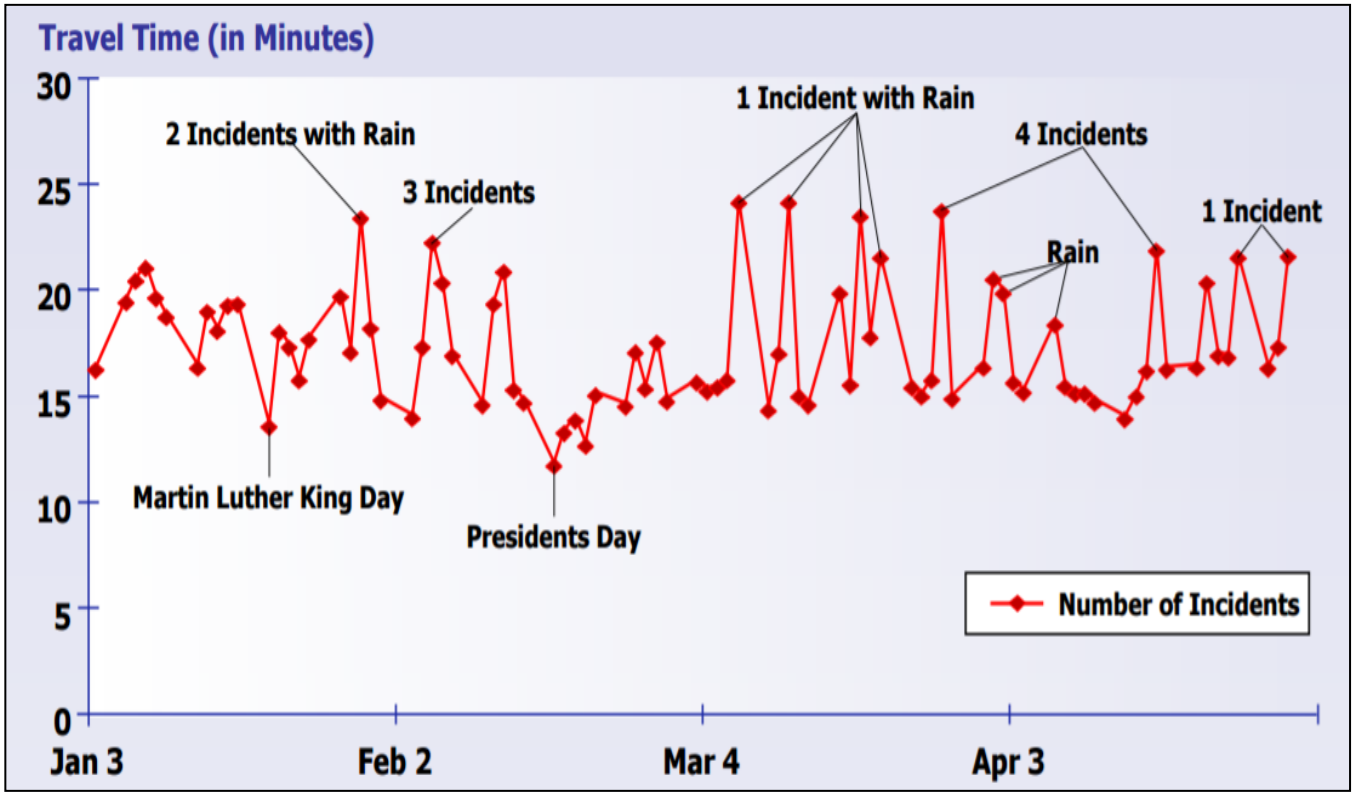
I-80 Predicted Crash Rates

- Introducing automated vehicles reduces crashes
- Reductions near 70% of total crashes for 85% AV
- Location-specific estimate & conservative
  - Future study may show even higher benefits, especially for other locations (e.g. intersections)



Reliability | Introduction

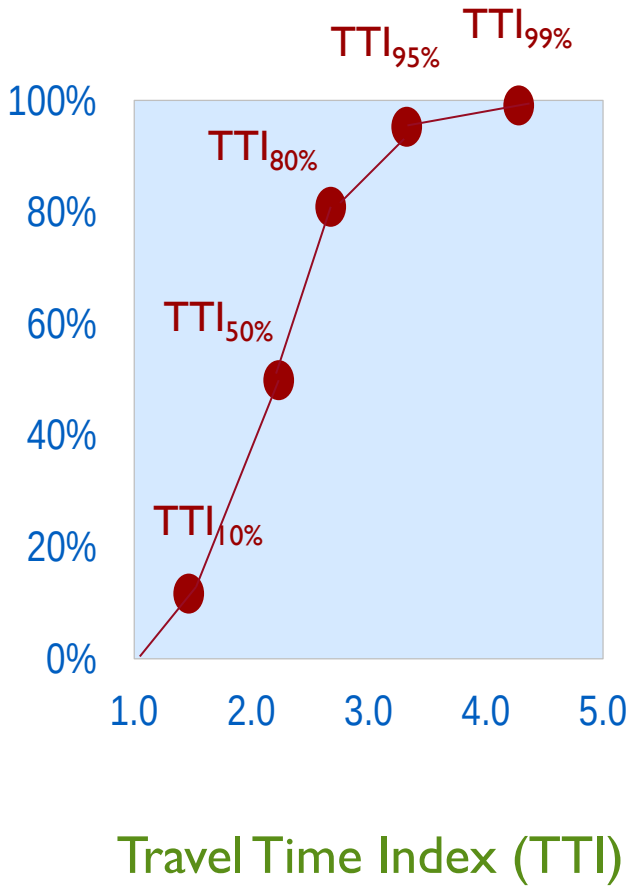
Level of consistency in travel conditions over time, measured by describing the distribution of travel times that occur over a substantial period of time.



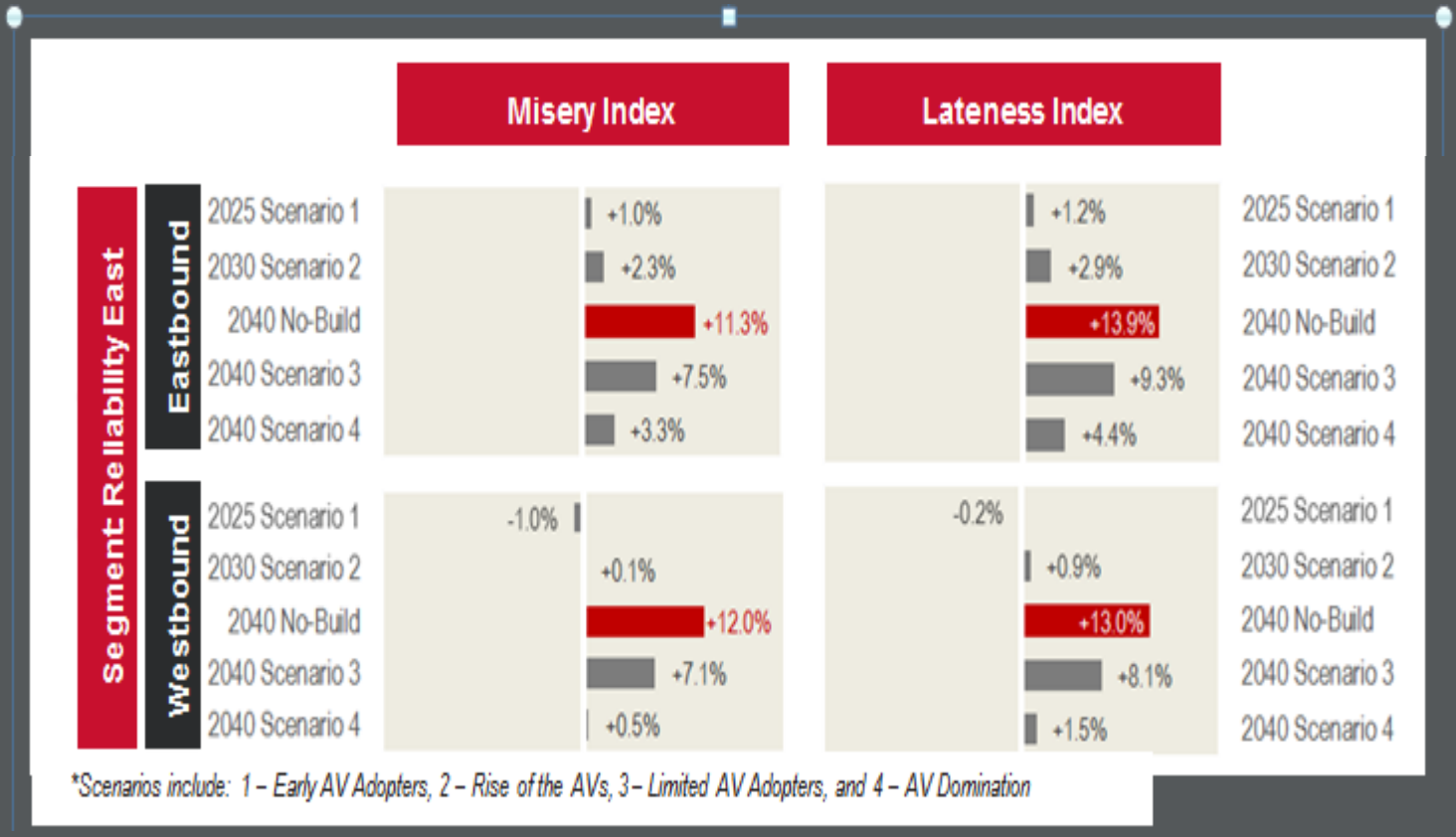
Source: SHRP2 L03

Reliability | SHRP2 L03/L07 Prediction Models

- Predict TTI for five percentiles as a function of:
  - Demand to Capacity (D/C) ratio – AVs improves capacity
  - Incident Lane Hours Lost – based on predicted number of crashes / incidents (reduced with increasing AV/CV)
  - Frequency of rain and snow – research database derived from National Climactic Data Center (NCDC)



Reliability | Results

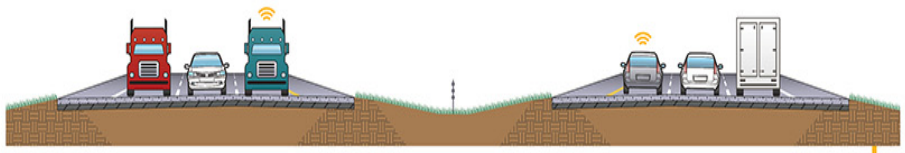


STUDY RESULTS

2040 Scenarios versus Existing Conditions

Data based on studies and analyses of two to five general segments of rural I-80.

	4-Lane I-80 UNIMPROVED IN THE YEAR 2040	6-Lane I-80 IMPROVEMENTS	6-Lane I-80 with AV IMPROVEMENTS
SAFETY	Average **crashes** per mile will **increase 9%** with little change to the number of **fatal** and **major injury crashes*** *(with a 48% increase in volumes)	Average **crashes** per mile will **increase 14%** with little change to the number of **fatal** and **major injury crashes*** *(with a 72% increase in volumes)	Average **crashes** per mile will **decrease 59%** and **fatal** and **major injury crashes** will **decrease 50%*** *(with a 104% increase in volumes)
TRAFFIC CAPACITY	**Vehicle crowding** will increase by **55%** causing **average speeds** to decrease **5%**	**20% less vehicle crowding** and average speeds **remain the same** as today	**35% less vehicle crowding** and average speeds **increase 2%**
RELIABILITY	Overall **travel times** will grow, increasing the **Misery Index 6 to 12%**	**Misery Index** Slight improvement **1 to 8%**	**Misery Index** More improvement **-1 to 3%**



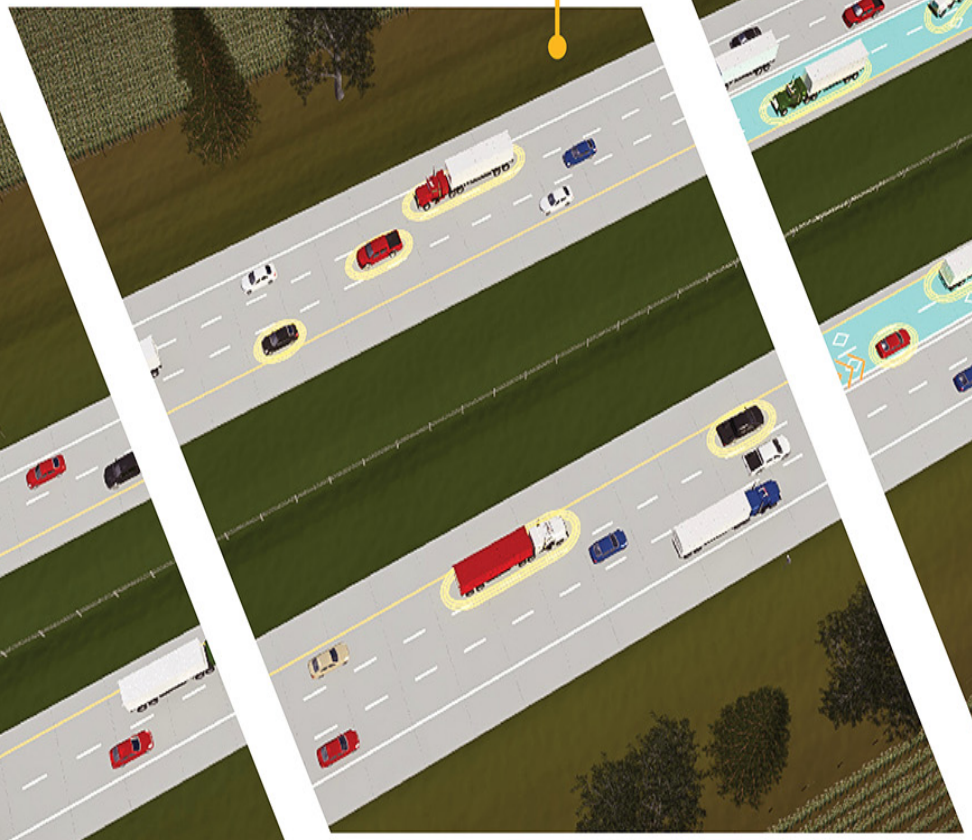
3 Westbound General Travel Lanes

3 Eastbound General Travel Lanes

Today

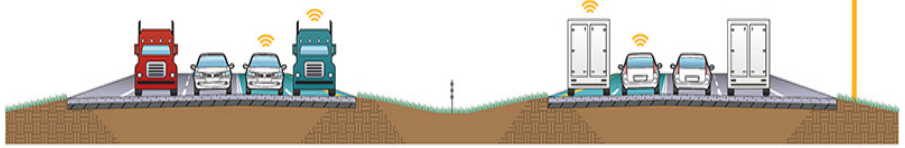
Tomorrow

Future



2 Eastbound AV Lanes

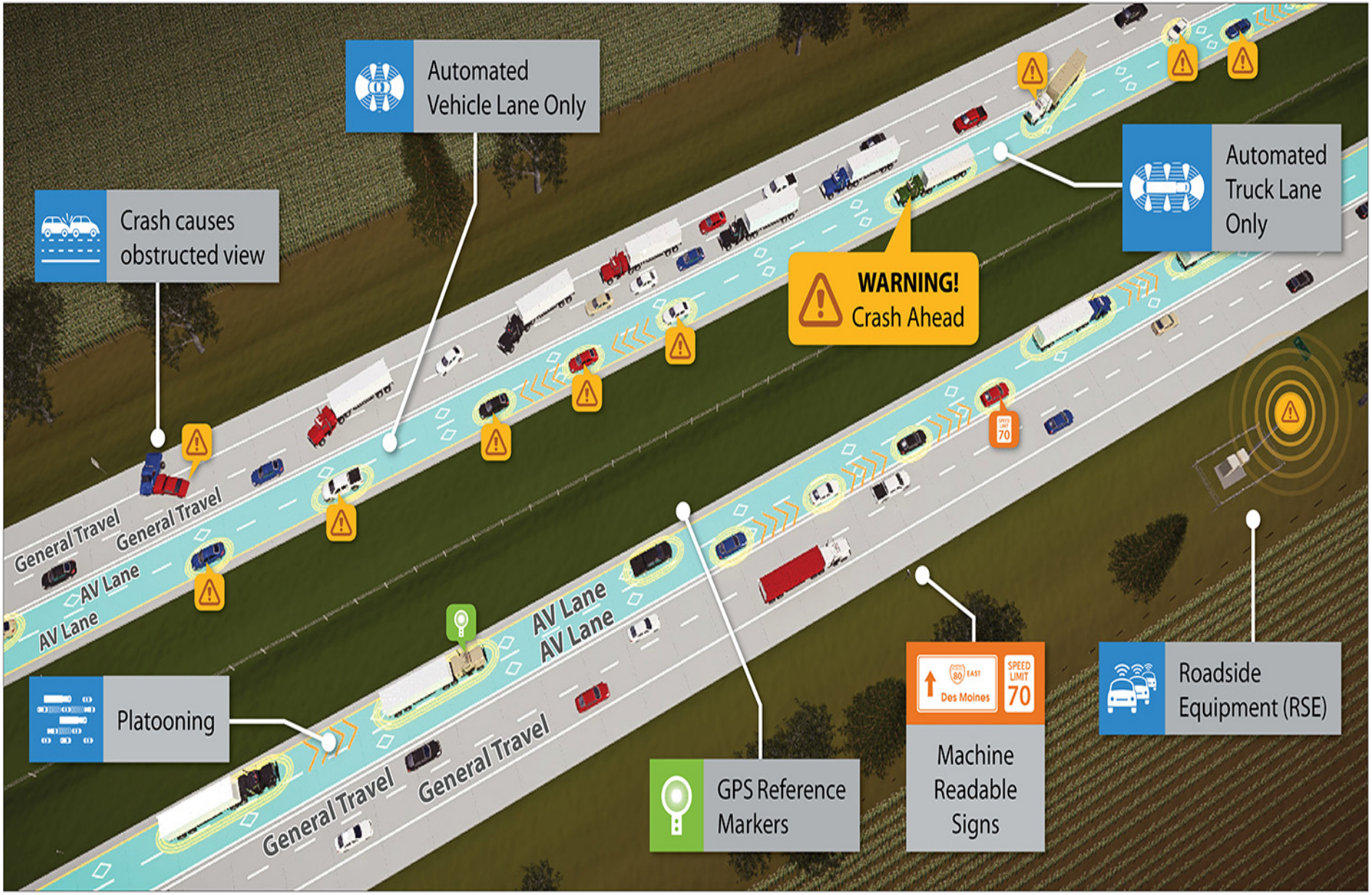
2 Westbound AV Lanes



2 Eastbound General Travel Lanes

2 Westbound General Travel Lanes

Potential Future Transportation Technology



Conclusion

Benefits of AV/CV:

- Safety
- Accessibility for all People
- Enhanced Reliability
- Environmental
- Economic

Challenges of AV/CV:

- How to Plan for Infrastructure needs?
- Easier Travel = More Travel
- Cost / Availability of AV/CV Technology

- Thank You!