Scenario Planning Approach for Automated Vehicle Scenarios

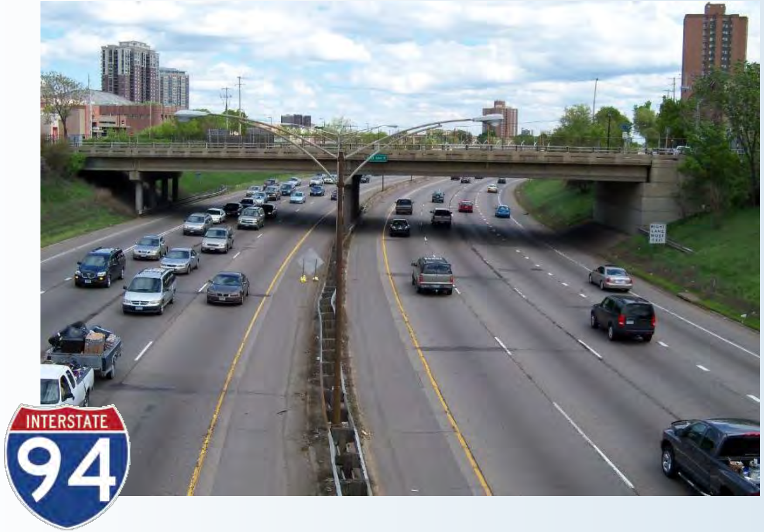
SCAG Model Users Group

May 24, 2017

Agenda

- Reimagining I-94 Study Overview
- Potential Impacts of Automated Vehicles
- Scenario Planning Overview and Objectives
- Results of Literature Research
- Analysis Approach
- Modeling Methodology
- Results
- Next Steps

Genesis of AV planning for I-94

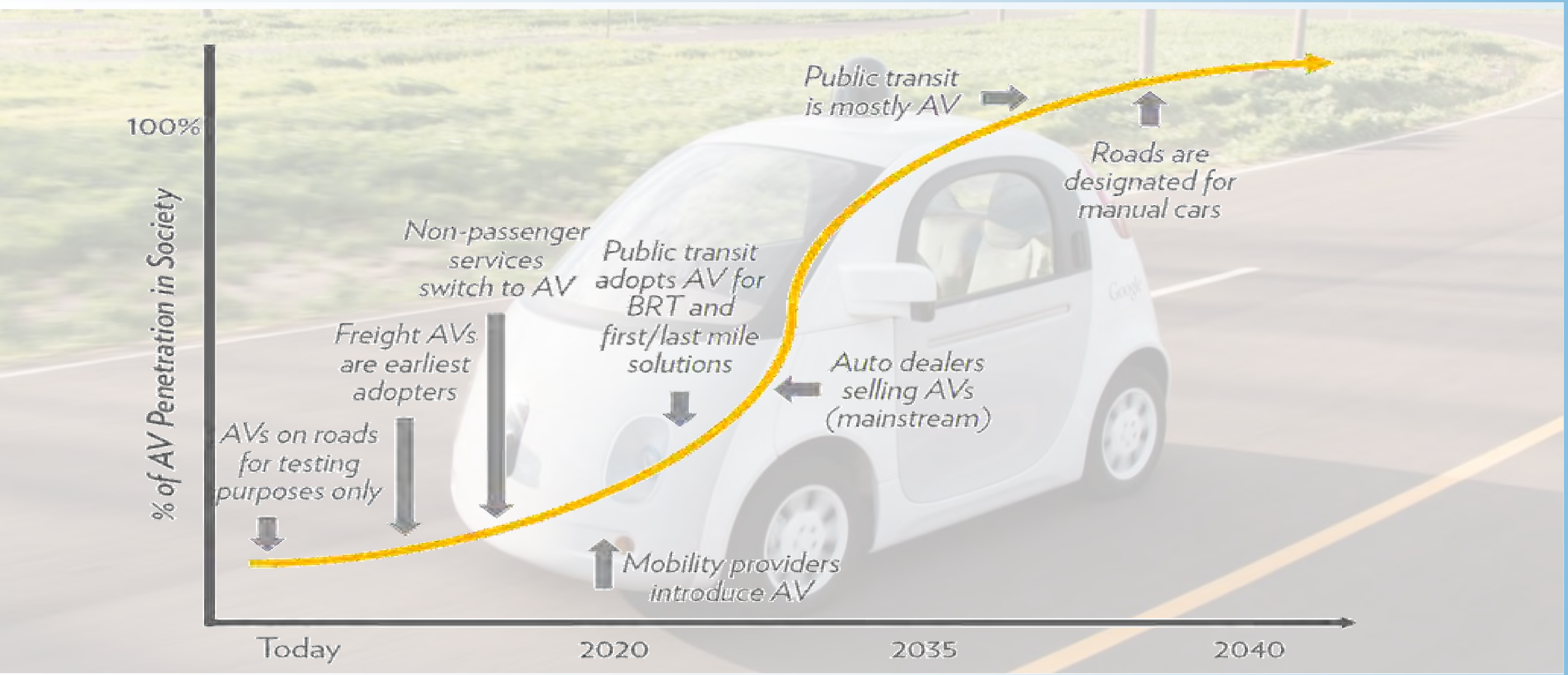


- Significant investment in highway infrastructure in the Twin Cities
- Emphasis on improving transit flow, HOT operation
- Questions regarding the impact of Automated Vehicles (AV) on both the need for infrastructure and the function of transit in the future

The Race to Driverless

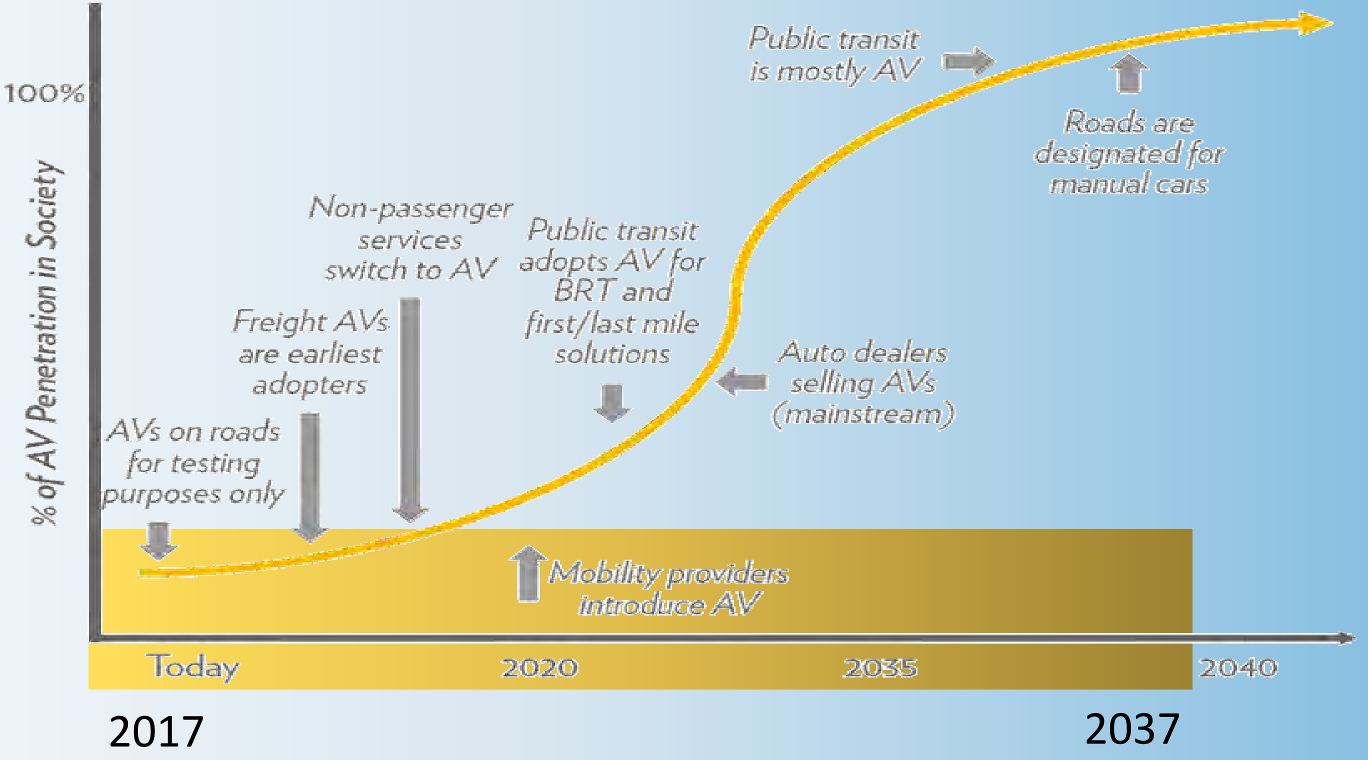
Source: Google

The Race to Driverless



For decades, travel forecasting based largely on extrapolating historic trends

Today: disruption in the trend line *within* our planning horizon



Traffic Safety

What if cars (and trucks, and buses...) no longer crashed?

Is this Our Future?

AV changes in vehicle-miles traveled (VMT)

When driving time is “regained”, how far might you ride in your car to work?

Changes in Demand & Opportunity

Will new segments of the population become "drivers?"

Changes in car ownership model

What if this…

Changes in car ownership model

What if this…

…increasingly became this

How do we plan with so much uncertainty?

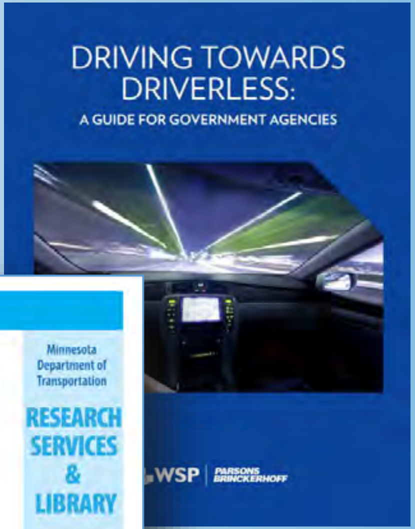
OR

Scenario Planning

- Roadway capacity
- Travel behavior
- Vehicle occupancy
- Timeframe of introduction
- Rate of fleet penetration

Background study of AV impacts

- **Transportation Futures Project: Planning for Technology Change**
  - Prepared for MnDOT by U of MN Center for Transportation Studies
  - Published early 2016
  - Examines impacts of:
    - Autonomous vehicles
    - Mobile/Telecom
    - Mobility-as-a-Service
    - Electrification and Alternative Fuels
    - Road Pricing



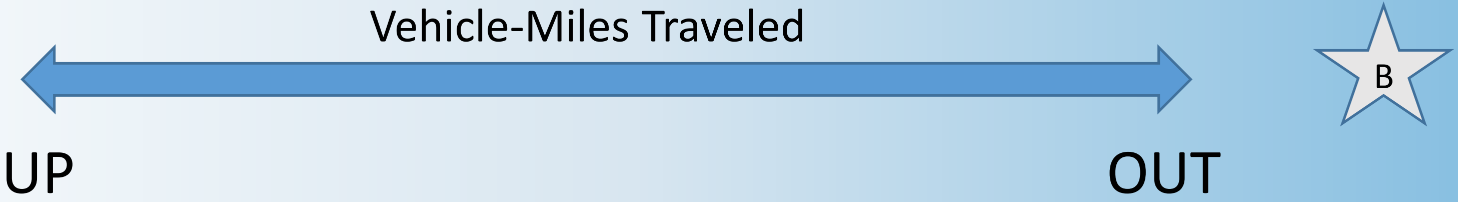
Two scenarios articulated

- **OUT Scenario**
  - Continuation of vehicle ownership model – each household owns their own automated vehicle
  - Affordability is key to market penetration – both vehicle cost and operating cost
  - Appeals to low-density households and/or suburban/exurban locations
- **UP Scenario**
  - Mobility as a Service (MaaS)
  - Cost to user is a function of
    - vehicle capital cost,
    - service life and
    - operating cost
  - Tradeoff between
    - Driverless miles and
    - Vehicle fleet size

High-Level Approach

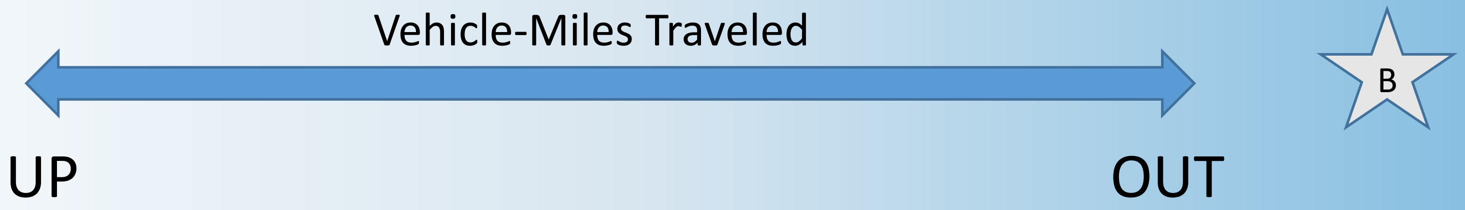
- Adopt the OUT and UP scenarios as the opposite ends of the spectrum of possible futures
- 100% Ownership or 100% MaaS
- Identified model factors to affect conditions with each scenario:
  - Transportation network changes
  - Travel Behavior changes
- Conducted research to quantify model factors assumptions
- Compare “baseline” to range of AV futures

Testing baseline against the range of outcomes



Baseline VMT outcome is higher than all AV futures outcomes

Testing baseline against the range of outcomes

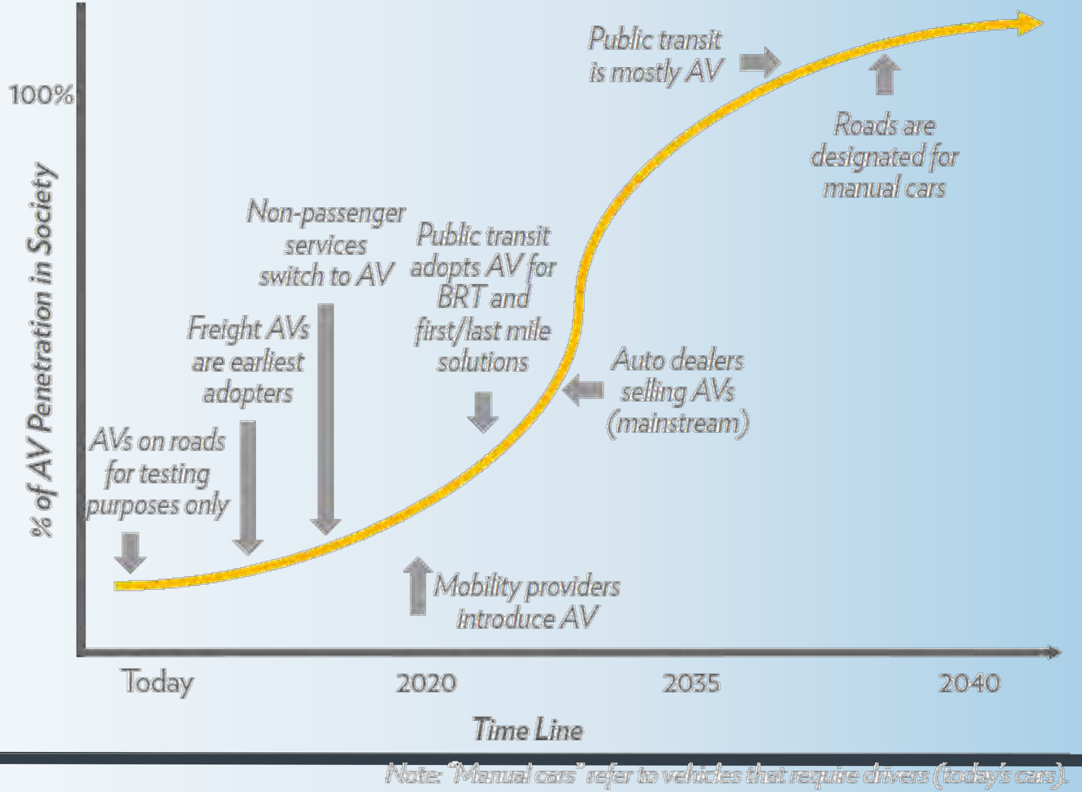


Baseline VMT is at the low end of the range of AV futures – likelihood that future VMT will exceed baseline

Research summary

- **Extensive publications on the subject, but little technical basis for most analysis**
- **Most well-studied and quantified factor is highway capacity**
  - Range from 20% to 300% increase in capacity
  - Most testing has ranged from 30-100%
  - ***Recommended 50% increase***
- **Other factors require sensitivity testing to narrow down appropriate treatment in the model**

Timeline for AV Market Penetration

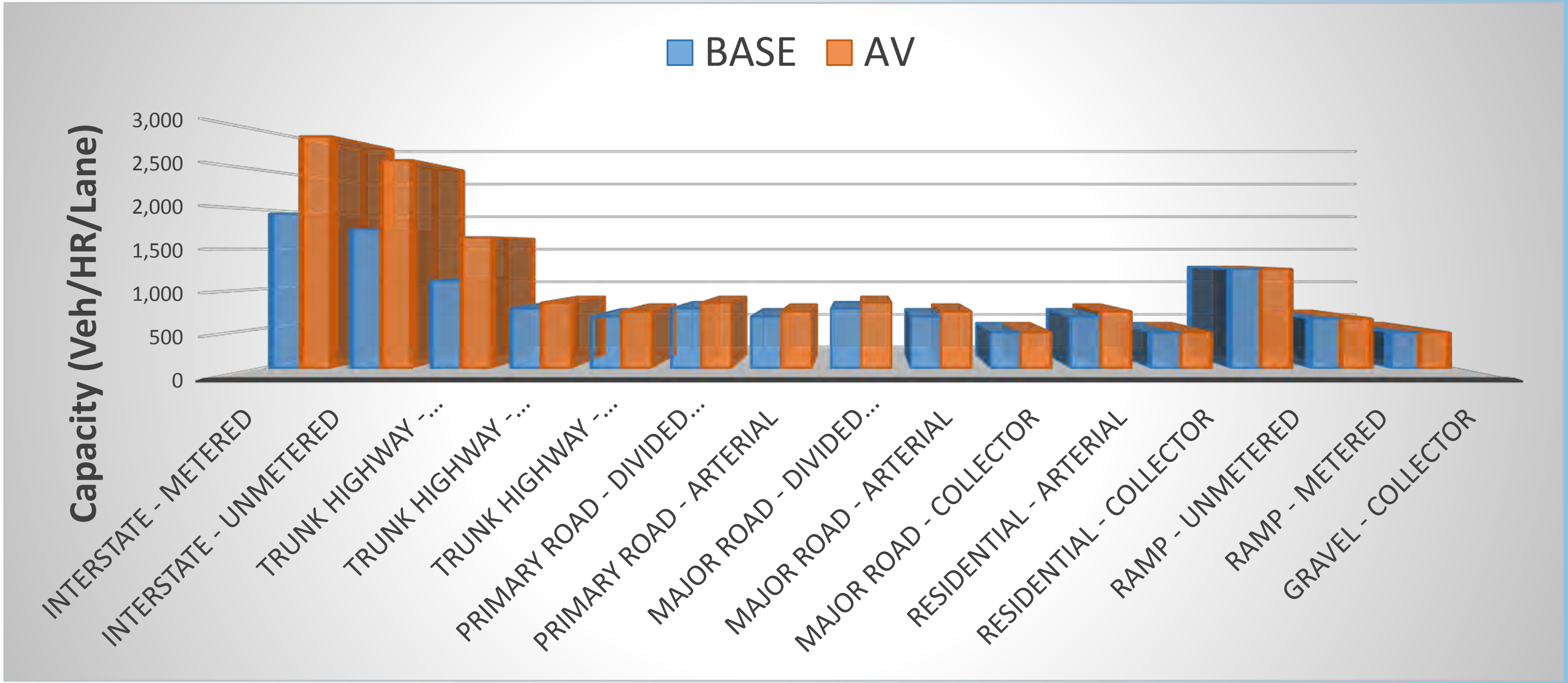


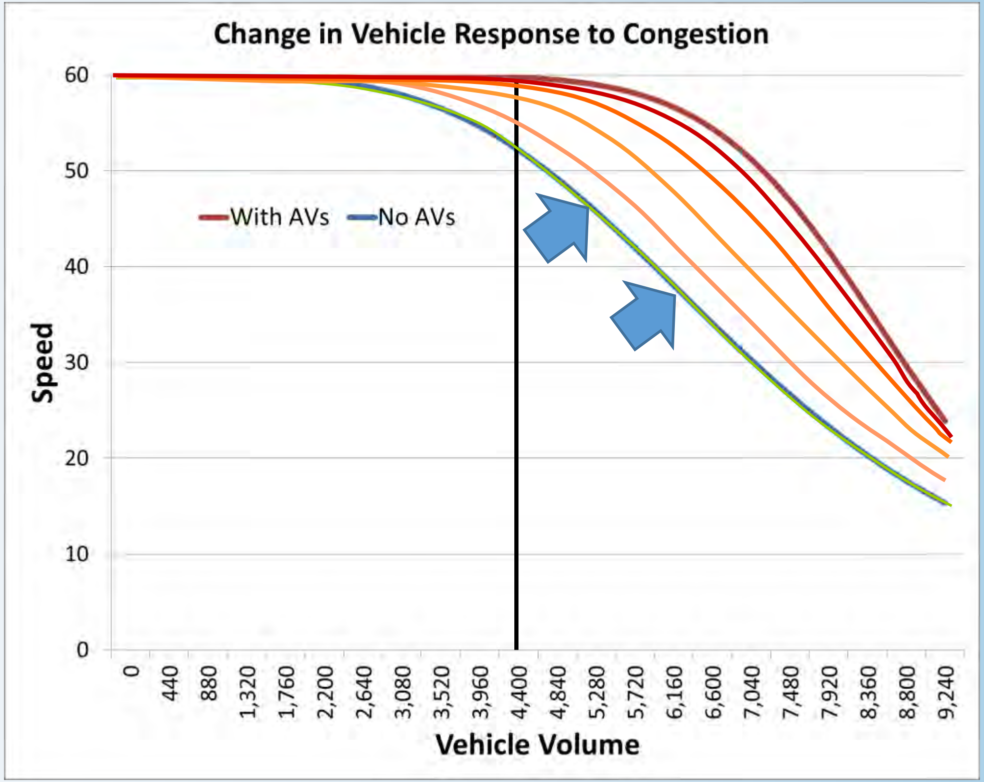
Isaac, Lauren, "Driving Towards Driverless: A Guide For Government Agencies. WSP|Parsons Brinckerhoff. 2016. Page 13.

Test 1: Capacity

- **AV use will increase capacity by**
  - Ability to maintain shorter headways on freeways and express ways
  - AV's have the ability to mitigate the effects of congestion on travel time
- **Model Adjustments – *Out & Up Scenarios***
  - Increase capacity by 50% for freeways and expressways
  - Increase capacity by 10% for Arterials
  - Modify the relationship between volume and speed to be more "forgiving" with regard to demand

Capacity Adjustment for AVs




Change in Vehicle Response to Congestion
Speed
60
50
40
30
20
10
0
With AVs
No AVs
0
440
880
1,320
1,760
2,200
2,640
3,080
3,520
3,960
4,400
4,840
5,280
5,720
6,160
6,600
7,040
7,480
7,920
8,360
8,800
9,240
Vehicle Volume

Test 2: Auto Operating Cost and Parking Cost

- **AVs may have higher operating costs if shared,**
- **Avs may also have higher initial costs if owned – more travel/vehicle**
- **AV’s can avoid pay parking**
- **Model Adjustments:**
  - Auto Operating Costs – Current $0.15/mile
    - *Adjust to: $0.30/mile*
  - Parking Costs:
    - *Remove all parking cost associated with Work Tours*

Modify ABM Global Parameters

From file: Globals.py

Change From

autoOpCost = 15 # cents per mile

To:

autoOpCost = 30 # cents per mile

Modify Parking Cost by Zone

Zone	PARK_COST
1325	11.9000
1326	7.5000
1327	10.5000
1328	0.0000
1329	12.0000
1330	25.0000
1331	11.3000
1332	11.6000
1333	9.6000

Zone	PARK_COST
1325	0.0000
1326	0.0000
1327	0.0000
1328	0.0000
1329	0.0000
1330	0.0000
1331	0.0000
1332	0.0000
1333	0.0000

Test 3: Auto Availability

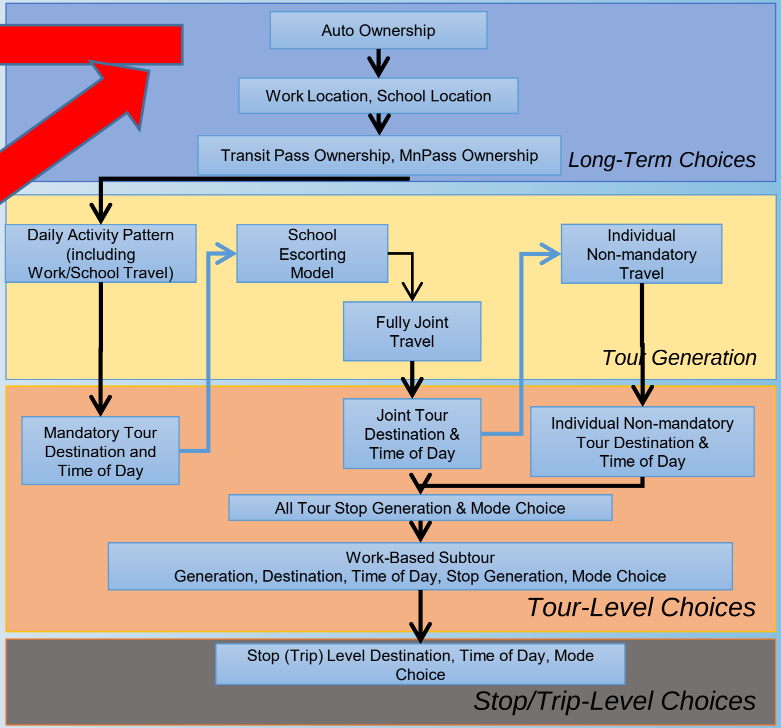
- **AVs will allow access to autos for populations that previously did not have access:**
  - Elderly and disabled
  - Children
  - Low income (partially)
  - Auto-deficient households
- **Model Adjustments**
  - Adjust inputs so that 95% of Households above lowest Income (>25k) have sufficient autos to serve adult population. Adjust to 50% for lowest income group.

Auto Sufficiency

- A household is auto sufficient if autos>=Adults
- Merge input household file with estimated household autos file and re-compute autos, if necessary, for each household
    1. If Autos<Adults, then
        1. If HHINC <=$25k, then set Autos=Adults at a 50% probability
        2. If HHINC >$25k, then set Autos=Adults at a 95% probability
    2. Else if Autos>=Adults, no change
- Auto Fleet increased by about 26%

Auto Sufficiency, Placement in Model Stream

- Auto Sufficiency was adjusted after base model was run through feedback, but prior to tour generation and all other model steps



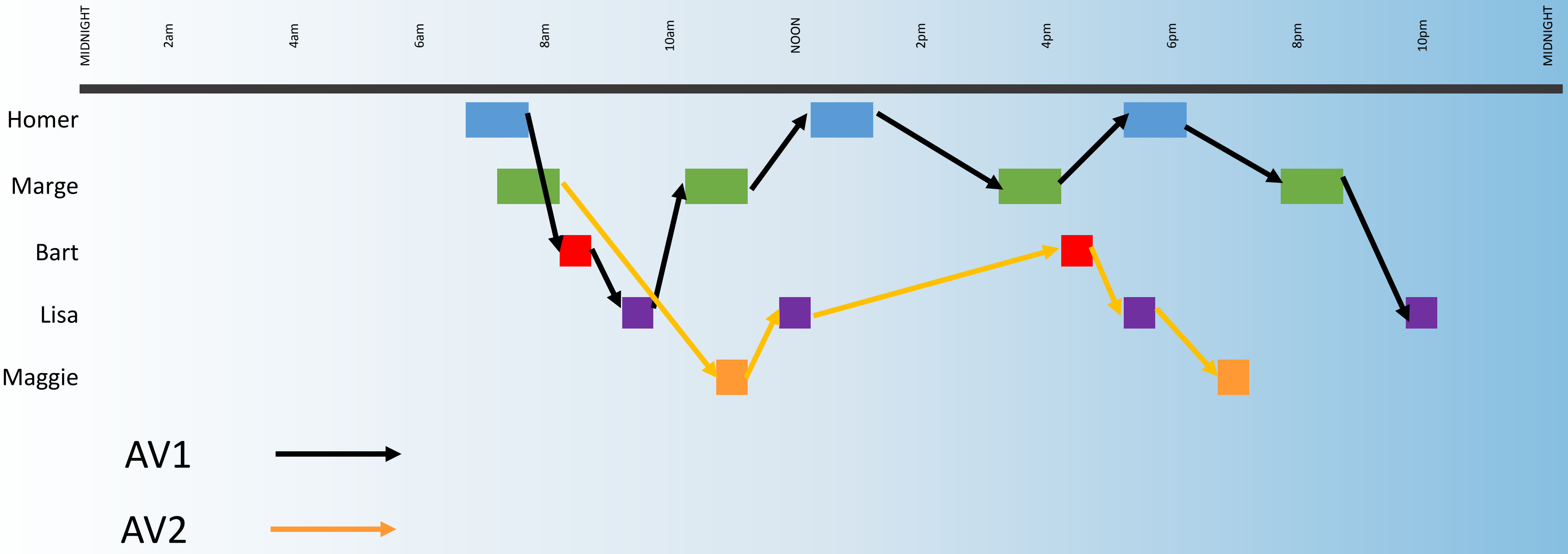
Test 4: Vehicle Positioning

- **Automated Vehicle will re-position themselves after serving passengers:**
  - Travelling to and from remote, and presumably free parking lots
    - *Up & Out scenario*
  - Travelling to and from home
    - *Out scenario*
  - Circulation to serve another unrelated passenger
    - *Up scenario*

Test 4: Vehicle Positioning *(Continued)*

- **Out Scenario Model Adjustments**
  - Use ABM household trip records to create driverless vehicle trips
  - Generate a mix of driverless trips connecting to home <u>or</u> nearby potential parking lot locations
- **Up Scenario Model Adjustments**
  - Generate a driverless service trip starting at the end of <u>any</u> trip and ending at the start of another trip at a later time.
  - Park driverless cars when not needed right away.

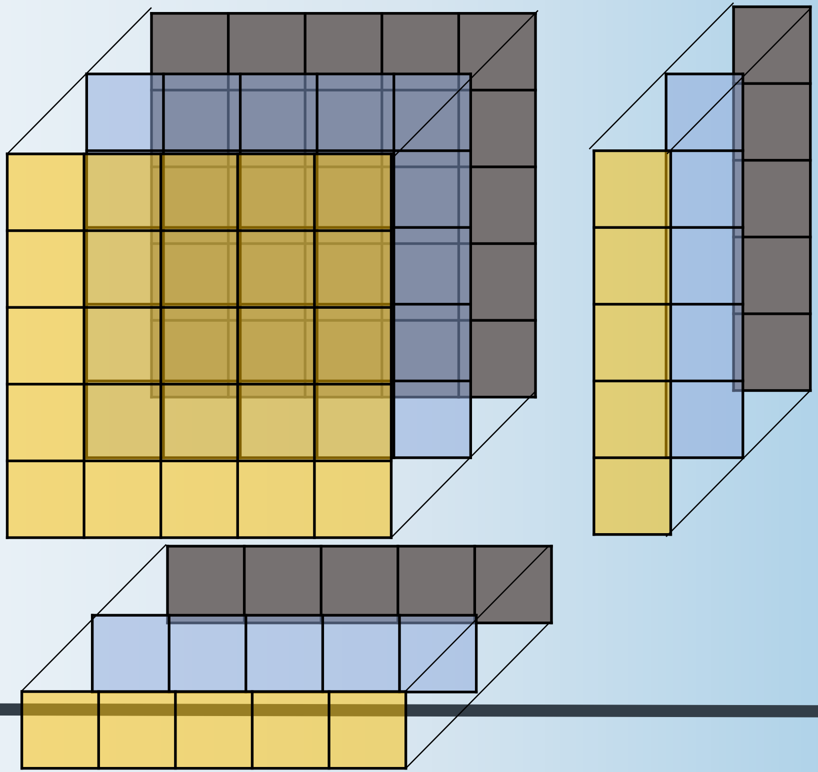
Vehicle Positioning for Out Scenario



Vehicle Positioning for UP Scenario

3-Dimensional Matrix Balancing

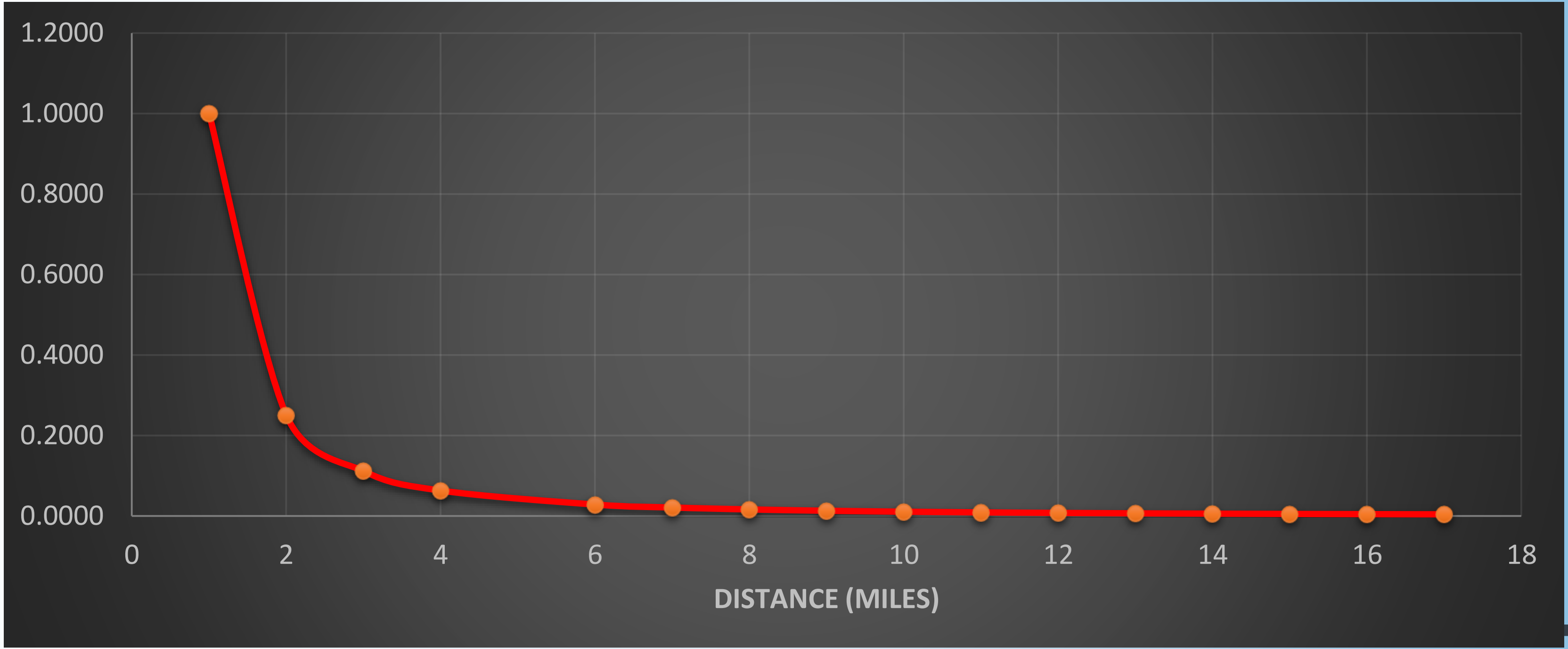
- Trip Starts x
- Trip Ends x
- Time



Vehicle Positioning for UP Scenario, Continued

- K-factors used to prohibit/discourage unreasonable trips in time
- Time-Stratified Skims are used to compute when connections cannot be made in time
- Balancing is done separately for both Start and end of driverless trip so we can see where and when surplus vehicles might occur – Driverless trip ends must be satisfied, however
- Matrix balancing uses a steep Friction factor curve to encourage short trips
- Later on, a maximum time was imposed

Default Friction Factors



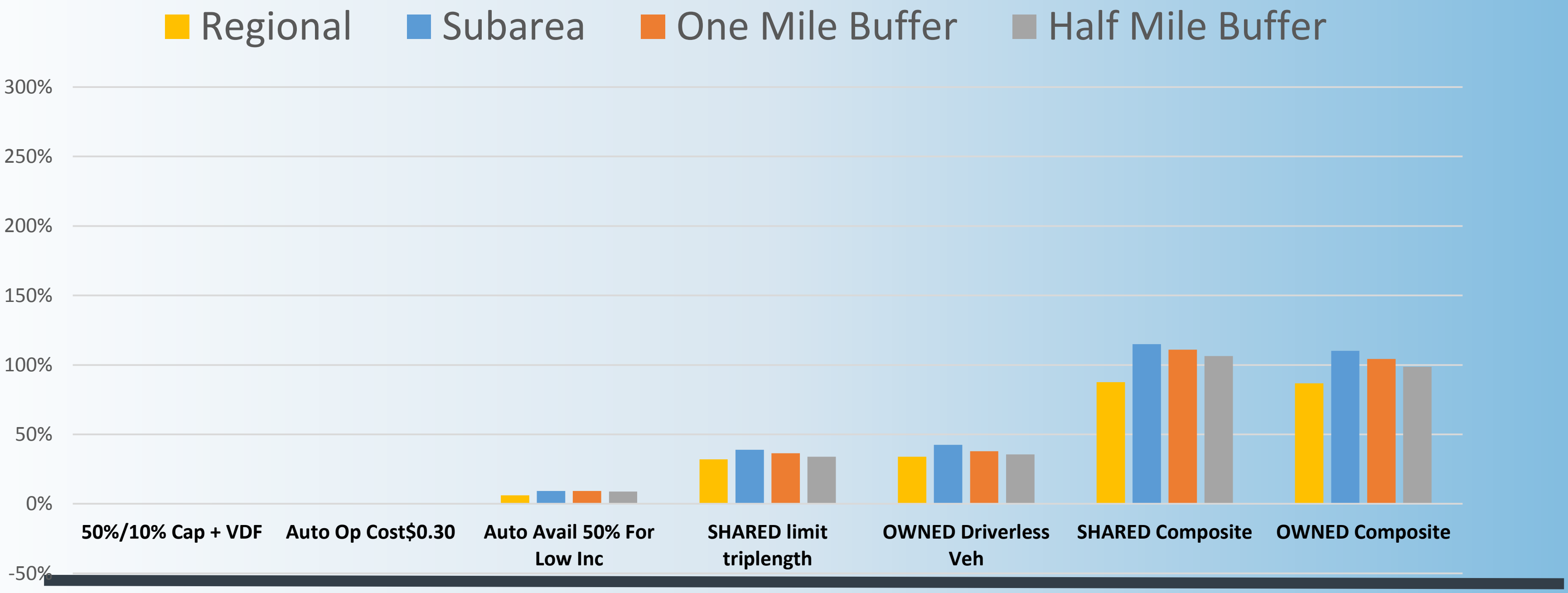
Assignment of Driverless Vehicles

- Initially used a “slave” assignment
- In final runs added driverless vehicles as an additional class – influencing V/C for all vehicles
- Subsequent data available to plot where AVs would dwell when not in use.

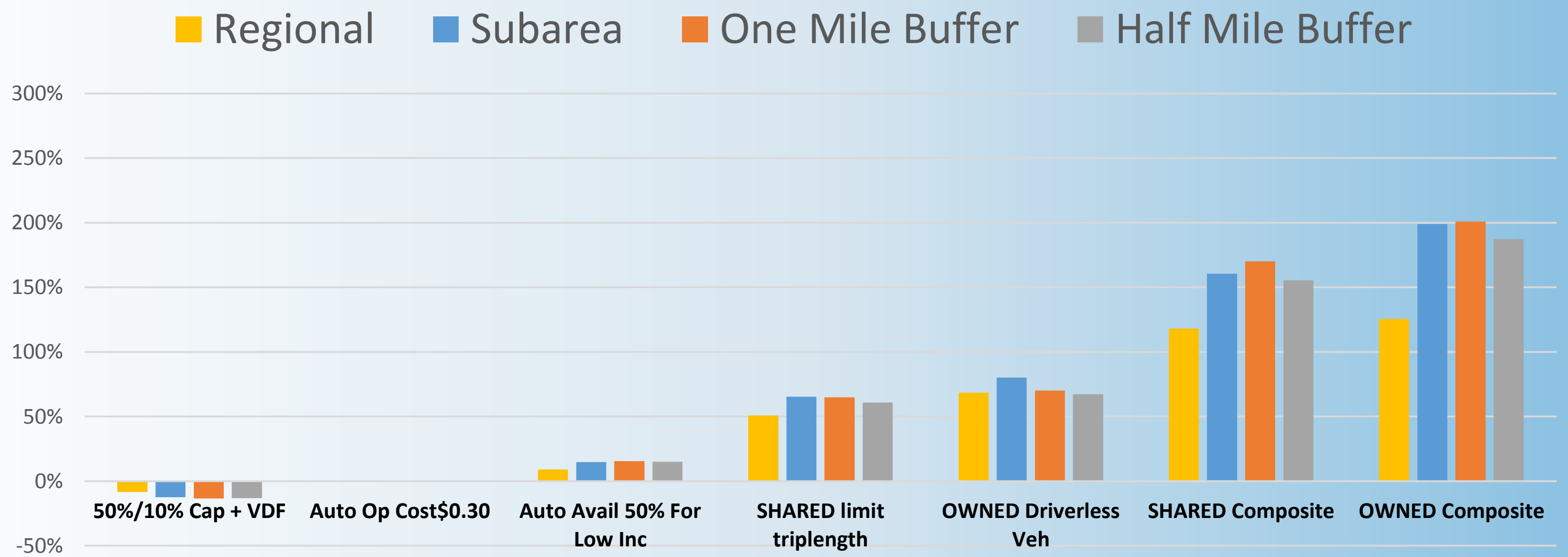
Caveats on Results

- Regional results are preliminary, and do not necessarily reflect the views of the Metropolitan Council of the Twin Cities, or MnDOT
- Goal was simply to decide if AV introduction would be a net benefit or detriment to travel in the I-94 corridor.
- Study-oriented results
- Some elements of AV impacts, such as Land Use, In-vehicle time value, Transit access/egress and other potentially fundamental changes to activity patterns were not considered

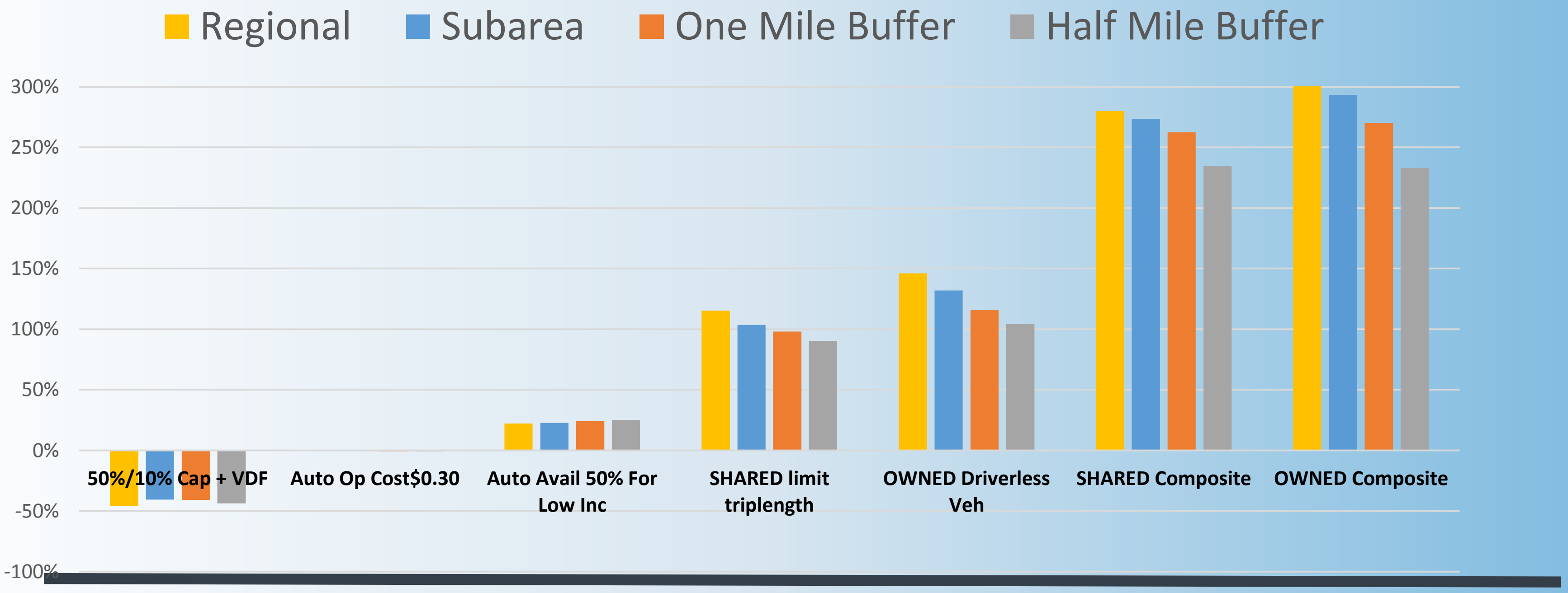
VMT Percent Change from Base, Year 2040



VHT Percent Change from Base, Year 2040



Congested VMT Percent Change from Base, Year 2040



Results Summary

- VMT for UP and OUT scenarios show similar change from no-build
- VHT change higher for OUT scenario compared with UP Scenario -- longer driverless vehicle trips
- Congested VMT slightly higher for OUT Scenario than for UP scenario
- All AV scenarios show much higher impact with all factors – compounding effects with more trips combined with driverless vehicles and delay imposed on occupied trips.

Next Steps

- **Future Refinements Include**
  - *Mix of UP and OUT Scenarios*
  - *Interim Year analysis and partial AV market penetration*
  - *UP Scenario Driverless Vehicle estimates using discrete trip records*
- **Model procedures developed here can be used to test the impact of Automated Vehicles under other conditions:**
  - *Parameter sensitivity testing*
  - *Driverless vehicle demand for parking*
  - *Automated vehicle fleet size estimation*
  - *Costs and impacts*
  - *Transition conditions*

Support for Policy Development

- This approach will also be used to support CV/AV policy development this year for the Metropolitan Council of the Twin Cities

Contact(s)

Steve Ruegg ,PE

Senior Technical Principal

Systems Analysis Group
Steve.Ruegg@wsp.com

Scott Shogun

Vice President

Connected/Automated Vehicle Market Leader, Advisory Services, U.S.
Scott.Shogun@wsp.com

Formerly
WSP | PARSONS BRINCKERHOFF

Question the existing
Imagine the impossible
Create the enduring

wsp.com/usa

QUESTIONS?