ODOT CAV Research and Analysis

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September 9, 2022

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Presentation Overview

- Background
- Literature Review
- Marysville Model Development
  - Modeling CAVs
  - US 33 Overview
  - Data Collection
  - Traffic Simulation
- Marysville Model Scenario Analysis
  - Regionwide Results (TDM)
  - Systemwide Results (Vissim)
  - Post Peak Performance
  - Simulations
- Findings and Recommendations

Background and Study Team

- Rebekah Straub – ODOT PM
- Literature Review
  - CDM Smith
  - Steve Shladover
  - Delft University
  - HDR
  - Caliper Corporation
- Base Model & Scenario Models
  - HDR
  - CDM Smith

Lit Review Insights

Big Picture Insights from Literature Review

- 2019 Status
- Long implementation time
- VMT will likely increase
- Technology gaps
- Priority research needs IDed
- Scenario analysis using models
- CAV rollout will be transformational and disruptive.
- Costs will impact rollout time.
- Private ownership is up in the air.

Modeling Insights from Literature Review

- TDM/Simulation process is needed.
- Review of capacity and other key parameters
- Specific adjustments to VISSIM and TransModeler identified
- Simulation will allow key parameters to be tested and tweaked.
- Scenarios identified based on
  - Model year
  - Penetration rates
  - MAAS variability
- Need for risk analysis

ODOT CAV Simulation Literature Review

- Spreadsheet of relevant documents
- Results published in TFResource Wiki
  - https://tfresource.org/topics/Content_Charrette_Autonomous_Vehicles.html

Modeling CAVs

Travel Demand Modeling

- Modeling in the Past:
  - Travel behavior and mode choice trends for next 20-30 years relatively stable
  - Model calibration calibrated with survey data and validated with existing mode usage
- Now with CAVs:
  - New mode(s) with different behavior, different impacts
  - Travel Demand Modeling is being changed by the new analytical demands
- Travel Demand Models can be enhanced to handle most CAV uncertainties:
  - Models help understand range of futures and potential policies
  - CAV treated as a mode
  - This study utilized the 3C models developed by ODOT and WSP

How CAVs Impact Modeling

- Travel Demand:
  - Decreased financial cost of trip (shared vehicles)
  - Decreased value of time lost to commutes
  - Ability for new users to travel
  - Zero occupancy travel
- Potential Factors:
  - Level of autonomy
  - Adoption of shared transportation
  - User age limits
  - Road user charges
- Traffic Operations:
  - Platoon formation
  - Highway entry and exit
  - Signal operations
  - Crash reduction and coordinated incident response
- Potential Factors:
  - Fleet adoption
  - Sophistication of AV sensors
  - V2V communications
  - Availability of V2I communications

How Specific Applications Impact Traffic Operations

AV Applications	Traffic Operations	CV Applications
Vehicle inputs	**Platooning with Reduced Headways**	V2V coordination, V2I speed harmonization
Traffic signal recognition, vehicle inputs	**Signalized Corridor Operations**	SPaT data, adaptive signal control, green light glide path
Lane and object recognition, vehicle inputs	**Merging Operations**	V2V coordination, routing intent
Lane assignment recognition, vehicle inputs	**Managed Lanes**	Dynamic lane assignment
Incident recognition, vehicle inputs	**Incident Management**	V2I alerts and coordinated responses

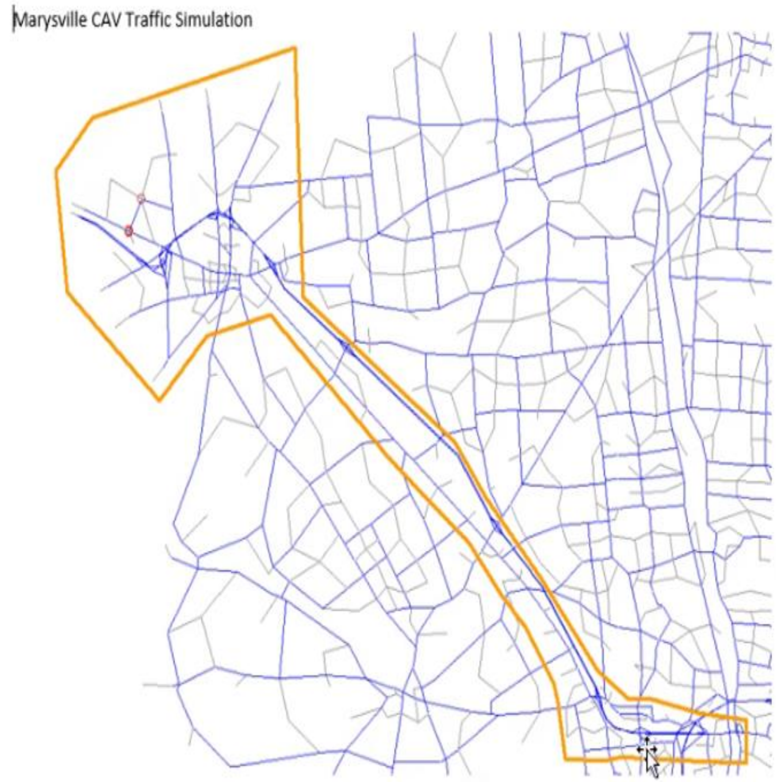
Simulation of CAVs in Ohio

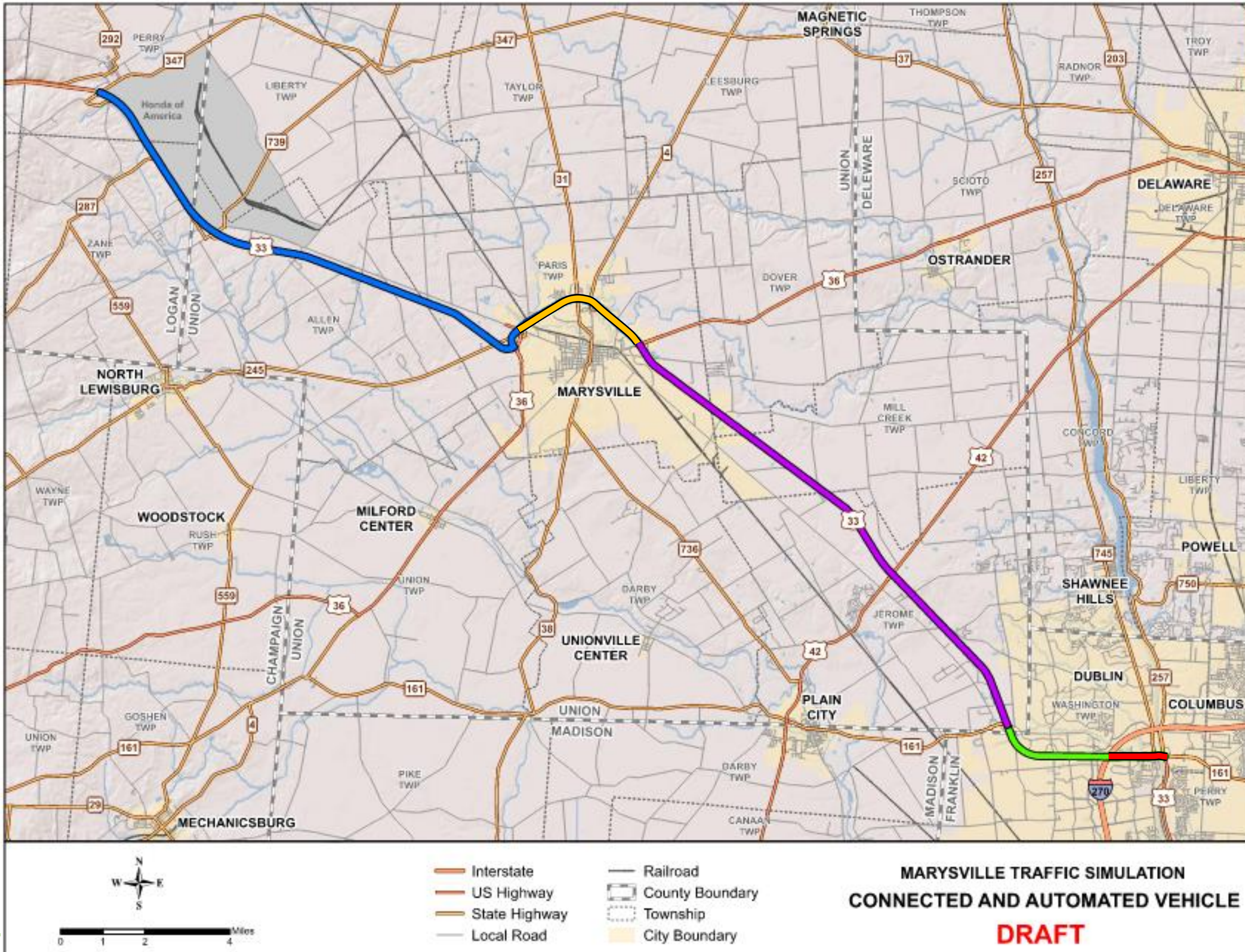
- *Vissim*
- Adjustments to internal parameters and Car Following made. Used in numerous CAV-related research studies.
- Marysville corridor (US-33 near Columbus)

- *TransModeler*
- Allows new vehicle classes equivalent to SAE levels. Used with adjustments documented in FHWA study
- Brent Spence Bridge (I-75/I-71 in Cincinnati)

US 33 Introduction

Ohio Corridor Studies – Statewide and Marysville (US 33)




MAGNETIC SPRINGS
THOMPSON TWP
PERRY TWP
Honda of America
LIBERTY TWP
TAYLOR TWP
LEESBURG TWP
RADNOR TWP
TROY TWP
UNION
DELEWARE
SCIOTO TWP
DELAWARE
DELAWARE TWP
ZANE TWP
PARIS TWP
DOVER TWP
OSTRANDER
LOGAN
UNION
ALLEN TWP
NORTH LEWISBURG
MARYSVILLE
MILL CREEK TWP
CONCORD TWP
WAYNE TWP
LIBERTY TWP
WOODSTOCK
RUSH TWP
MILFORD CENTER
POWELL
UNION TWP
DARBY TWP
SHAWNEE HILLS
JEROME TWP
CHAMPAIGN
UNION
UNIONVILLE CENTER
DUBLIN
WASHINGTON TWP
COLUMBUS
PLAIN CITY
UNION
MADISON
GOSHEN TWP
UNION TWP
PIKE TWP
DARBY TWP
MADISON
FRANKLIN
PERRY TWP
CANAAN TWP
MECHANICSBURG
Interstate
US Highway
State Highway
Local Road
Railroad
County Boundary
Township
City Boundary
Miles
MARYSVILLE TRAFFIC SIMULATION
CONNECTED AND AUTOMATED VEHICLE
DRAFT

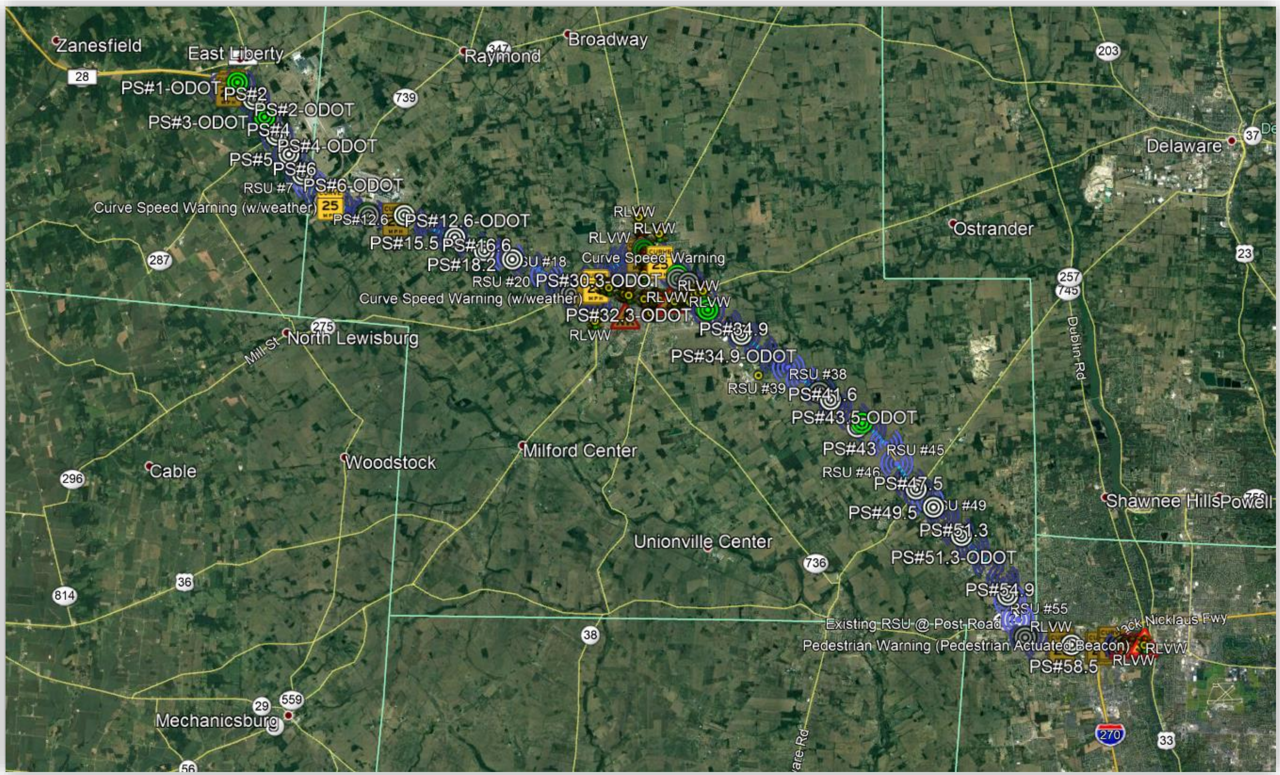
US 33 Factoids

- Columbus to Marysville
  - City of Dublin (east of I-270) to West of Marysville
  - 35miles long, 62 intersections and interchanges
- Honda plant in West has spurred many innovations including wiring the entire corridor (signals and stop signs)
- Other studies going on concurrently include
  - US 33 Corridor Study/20-year LRTP
  - Ohio’s Smart Mobility Corridor

Parallel Project

- Ohio's 33 Smart Mobility Corridor

  https://www.33smartcorridor.com/



Existing and Proposed Smart Infrastructures

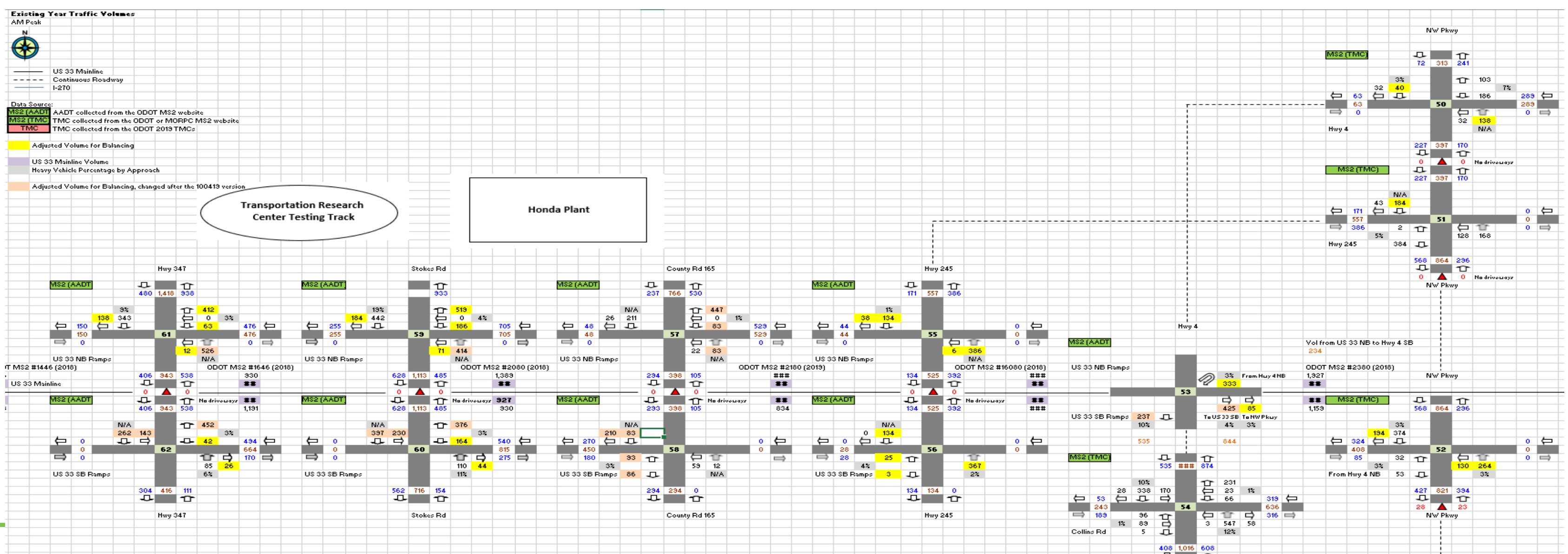
Data Collection

Data Collection

- Traffic counts
- Signal info and speeds
- MORPC Model (Regional model) Work
  - SE Data
  - Model expansion
  - Select links

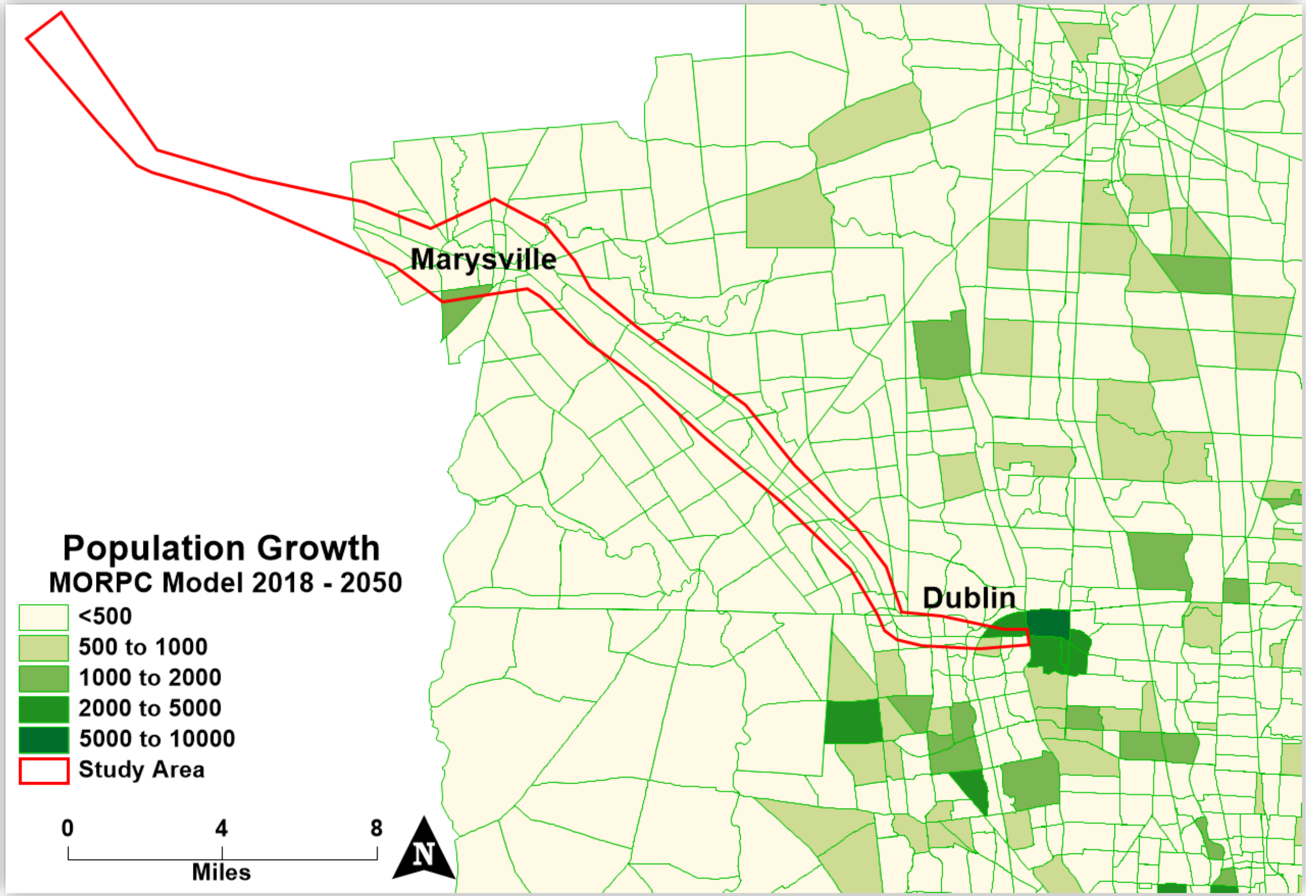
Traffic Counts

- Data sources
  - ODOT 2019 TMCs. Classified counts for 20 intersections.
  - MS2 ODOT – online count database
- Data smoothing/factoring
  - Growth rates
  - Balancing
  - Used PM only



MORPC Model Socioeconomic Data

- MORPC assumptions on population and employment are used and show light growth from 2018 to 2050 (16-19%).

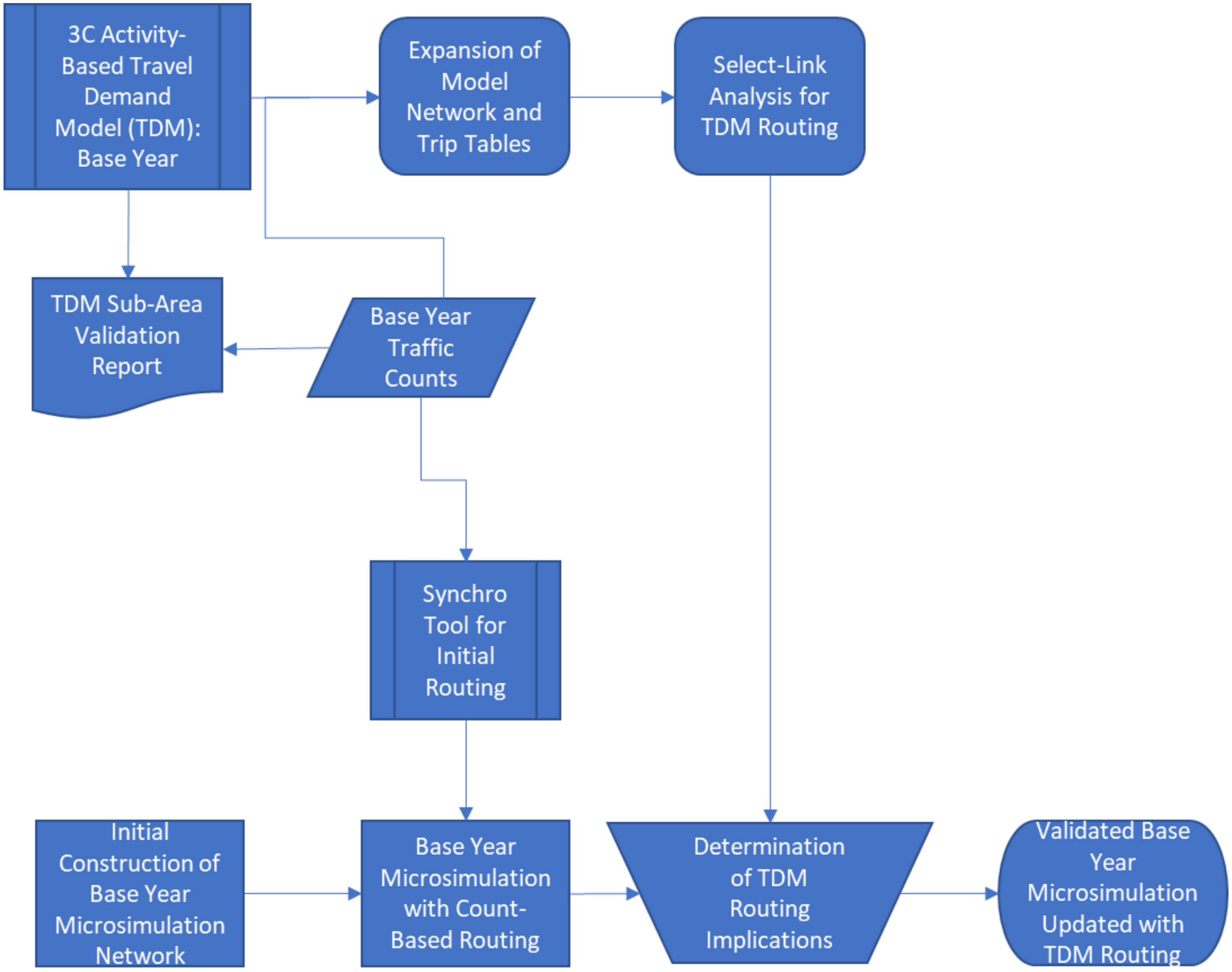


Traffic Simulation

Modeling Flow

- Model preparation
  - MORPC (MPO) model – study area expansion, SE modifications, review of CCs and network
  - US 33 simulation model
    - Create Base Year model – extensive data collection
    - Validate using MPO ODs and other sources
- Run scenarios (14)
- Produce Performance Measures

Base Year Microsimulation Model Development



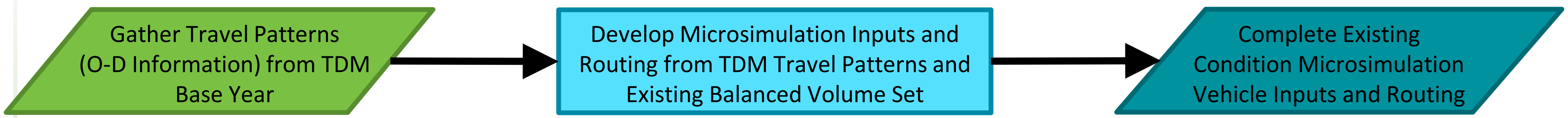
Base Year Model Development

- Base model – includes geometry, signal info, traffic data and speed data.
- Validation
  - Used MORPC study area expansion volumes and select links for routing review
- CAV customization
  - Adding platoon logic – slide on platoon formation follows
  - Future may include dynamic elements
    - Speed zones
    - Conflict areas that activate on vehicle to infrastructure messaging

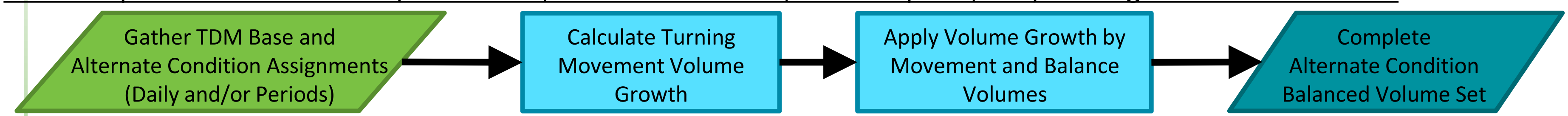
Steps to Develop Microsimulation Model Vehicle Inputs and Routing

1. Develop Existing Condition Balanced Turning Movement Volumes

2. Develop Existing Condition Microsimulation Vehicle Inputs and Routing

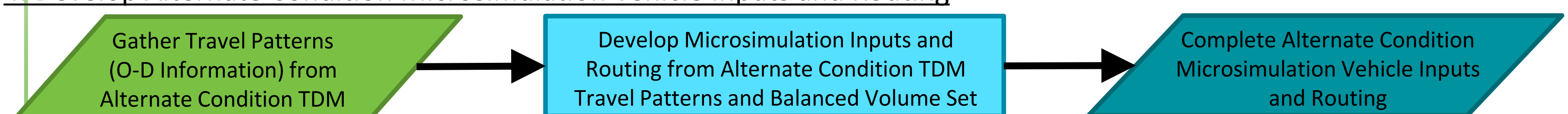


3. Develop Alternate Condition (Future Year, Geometric Variant, CAV Adoption, etc.) Turning Movement Volumes



See Ohio Traffic Forecasting Manual for Process

4. Develop Alternate Condition Microsimulation Vehicle Inputs and Routing

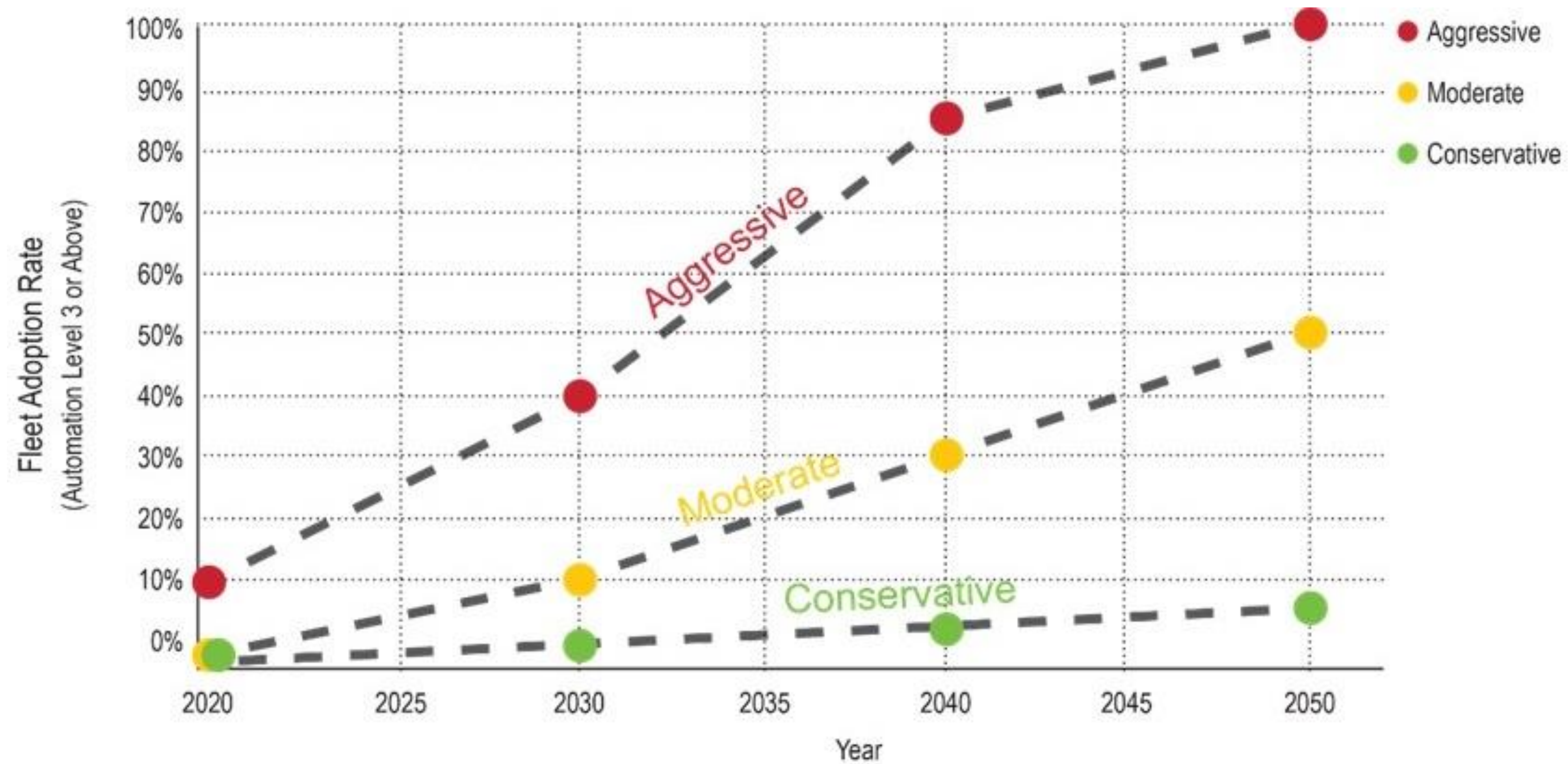


Marysville Scenario Analysis

Developing and Using CAV Scenarios

- Stakeholders – OHIO DOT, DriveOhio, MPOs
  - *Involve* stakeholders in review and detailed definitions of scenarios
  - Penetration rates, TNC levels, SE changes,
- Performance Measures
  - *Define* measures to use in analyzing scenarios
  - Typical:
    - Vehicle Miles Traveled (VMT)
    - Vehicle Hours Traveled (VHT)
    - Travel time
  - Others: equity,
- Use TDMs and simulation models to produce output.

AV Adoption Rate Scenario Levels



Source: HDR

Analysis Scenarios – Part 1

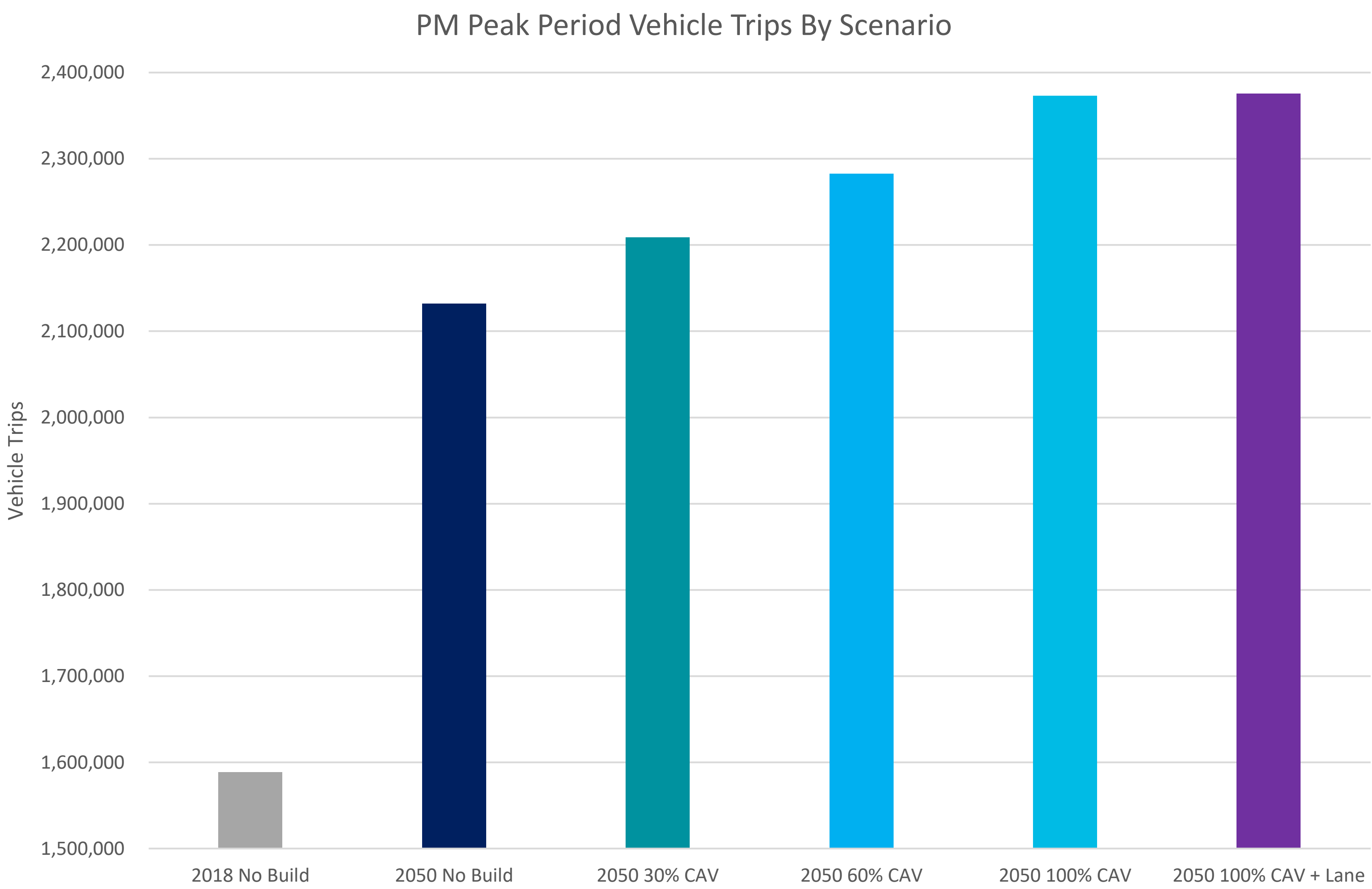
	Scenario Name	Year	%HH with level 5 CAV	CAV Proportion of TNC fleet	TNC CAV Price Discount (%)
No Build Scenarios					
11	No Build	2035			
12	**No Build**	**2050**			
2035 Mid-Range Scenarios					
1	Slow CAV growth	2035	5%	5%	30%
2	Conservative TNC Adoption	2035	5%	10%	30%
3	DriveOhio Mid Term CAV	2035	10%	20%	30%
3X	No Build (scenario 11) Volumes	2035	10%		
2050 Mid-Range Scenarios					
6	DriveOhio Long Term CAV	2050	10%	80%	50%
7	**Moderate Private CAV Adoption**	**2050**	**30%**	**20%**	**50%**
7X	No Build (scenario 12) Volumes	2050	30%		
8	**Aggressive CAV Adoption**	**2050**	**60%**	**80%**	**50%**
8X	**No Build (scenario 12) Volumes**	**2050**	**60%**		
8X All Knowing	**No Build (scenario 12) Volumes**	**2050**	**60%**		
Increase Scenarios					
9	Road Capacity Increase	2050	10%	40%	30%
10	Population Increase	2050	10%	80%	50%

Analysis Scenarios – Part 2 (100% Penetration)

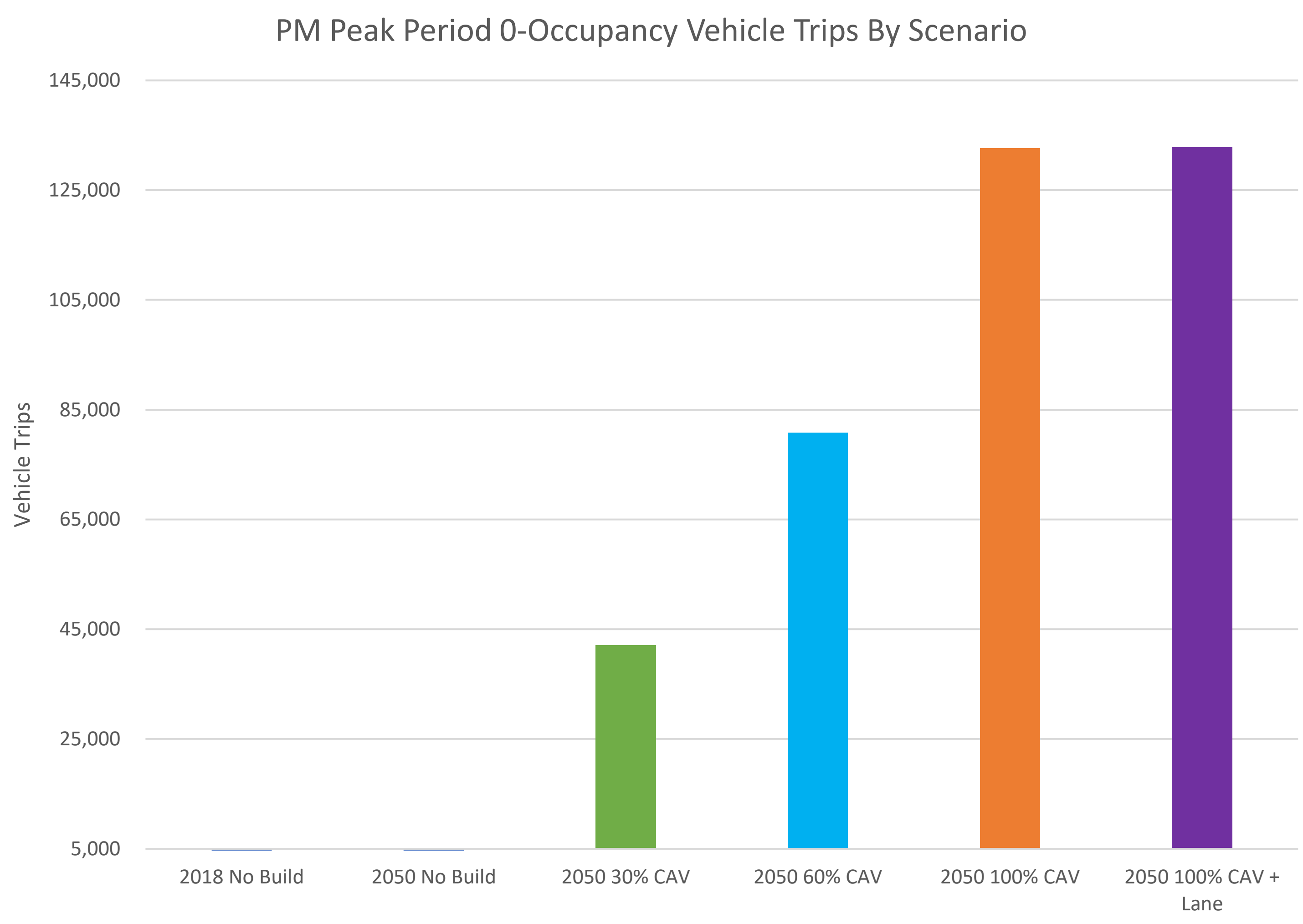
A1*	2050 No Build 100% CAV	2050	2050 No Build	100%	NA	NA
A2	2050 No Build 100% CAV with CAV Behavior Changes Behavior	2050	2050 No Build	100%	NA	NA
A3*	2050 No Build 100% CAV with CAV Behavior Changes and Capacity Improvements	2050	2050 No Build	100%	NA	NA
B1*	2050 100% CAV	2050	2050 100% CAV	100%	NA	NA
B2	2050 100% CAV with Capacity Improvements	2050	2050 100% CAV	100%	NA	NA
C1*	2050 100% CAV with Additional Lane	2050	2050 100% CAV + Lane	100%	NA	NA
C2	2050 100% CAV with Additional Lane and Capacity Improvements	2050	2050 100% CAV + Lane	100%	NA	NA

Regionwide Results (TDM)

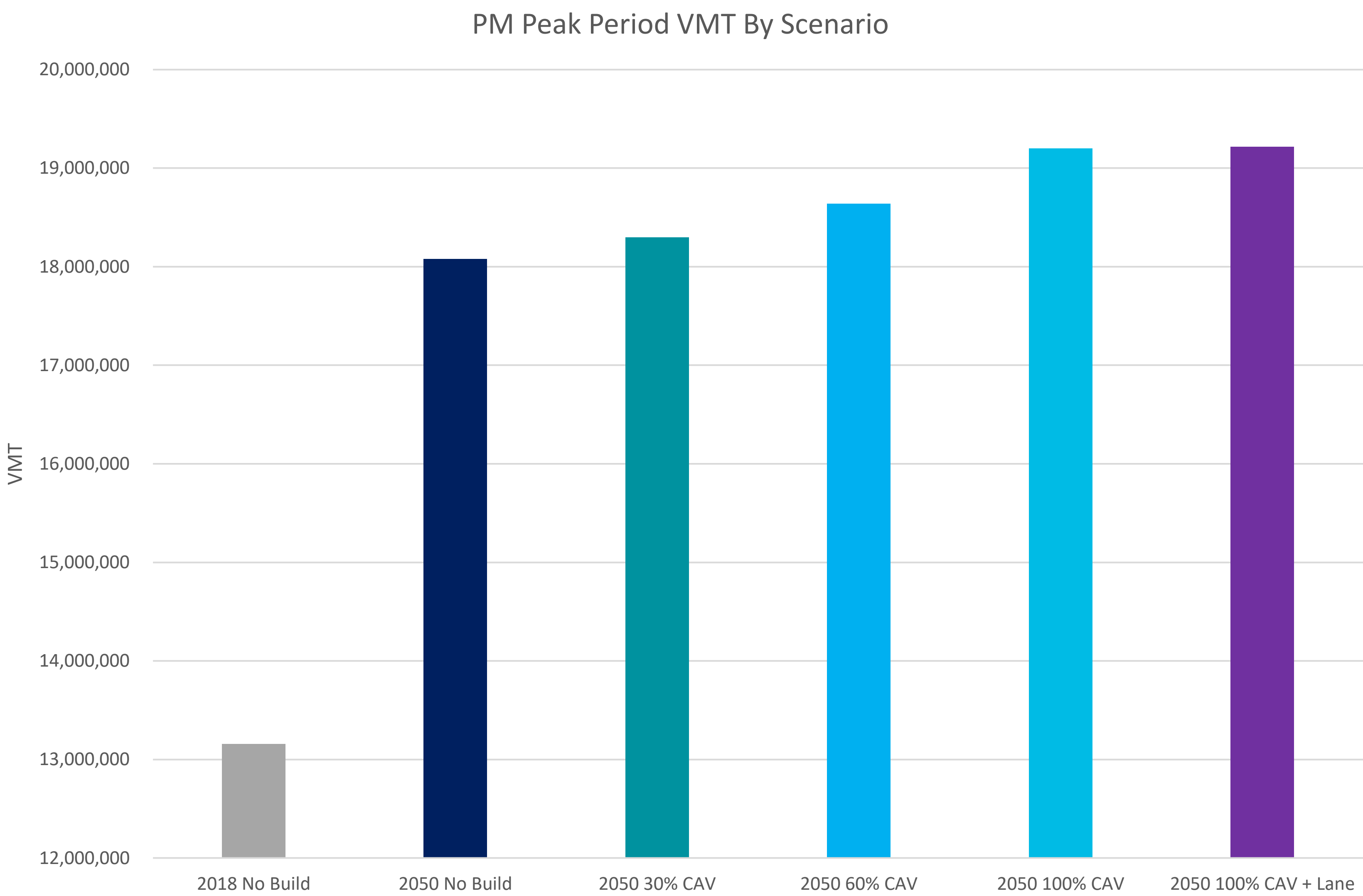
Regionwide TDM Results: Total Trips



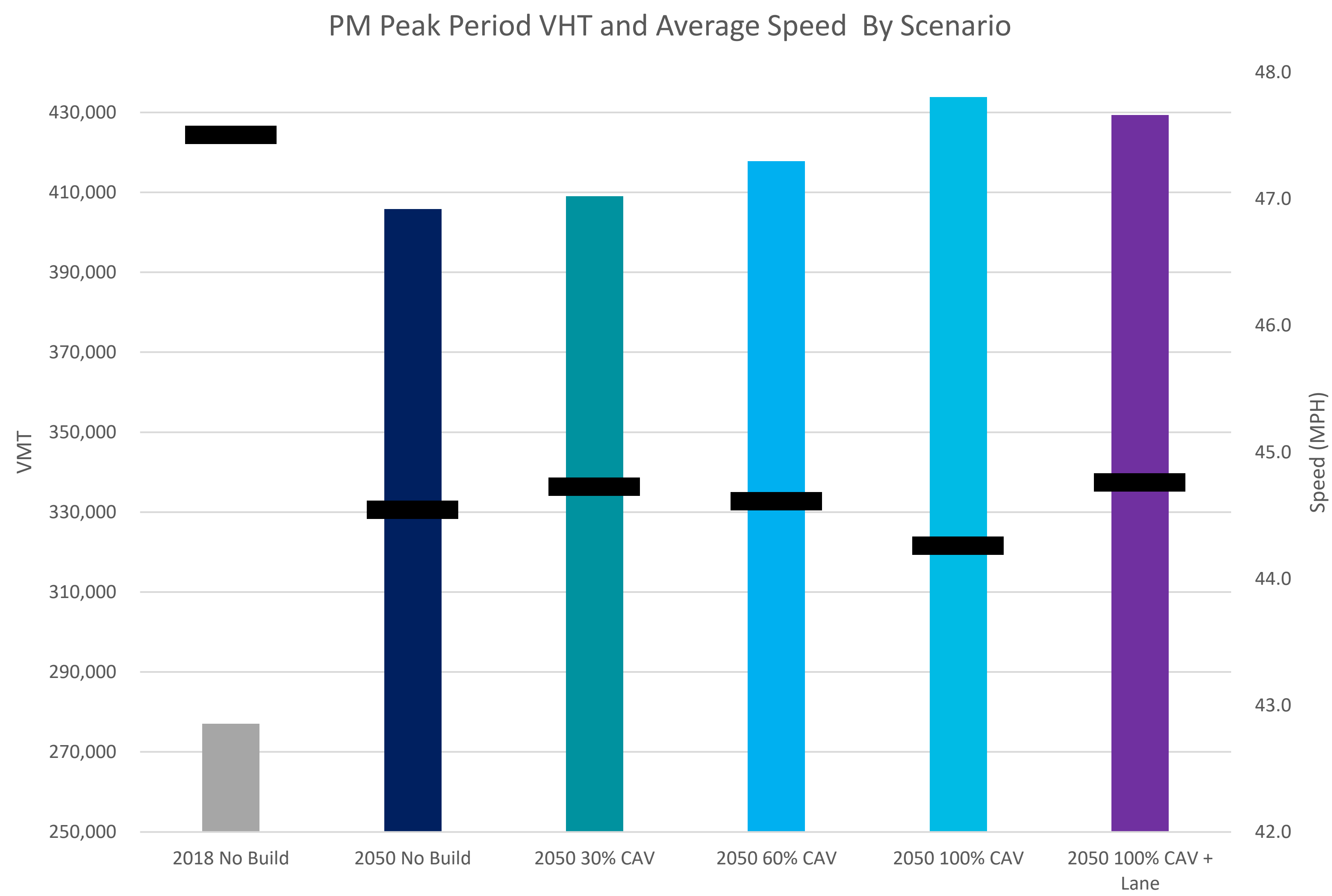
Zero Occupancy Vehicles



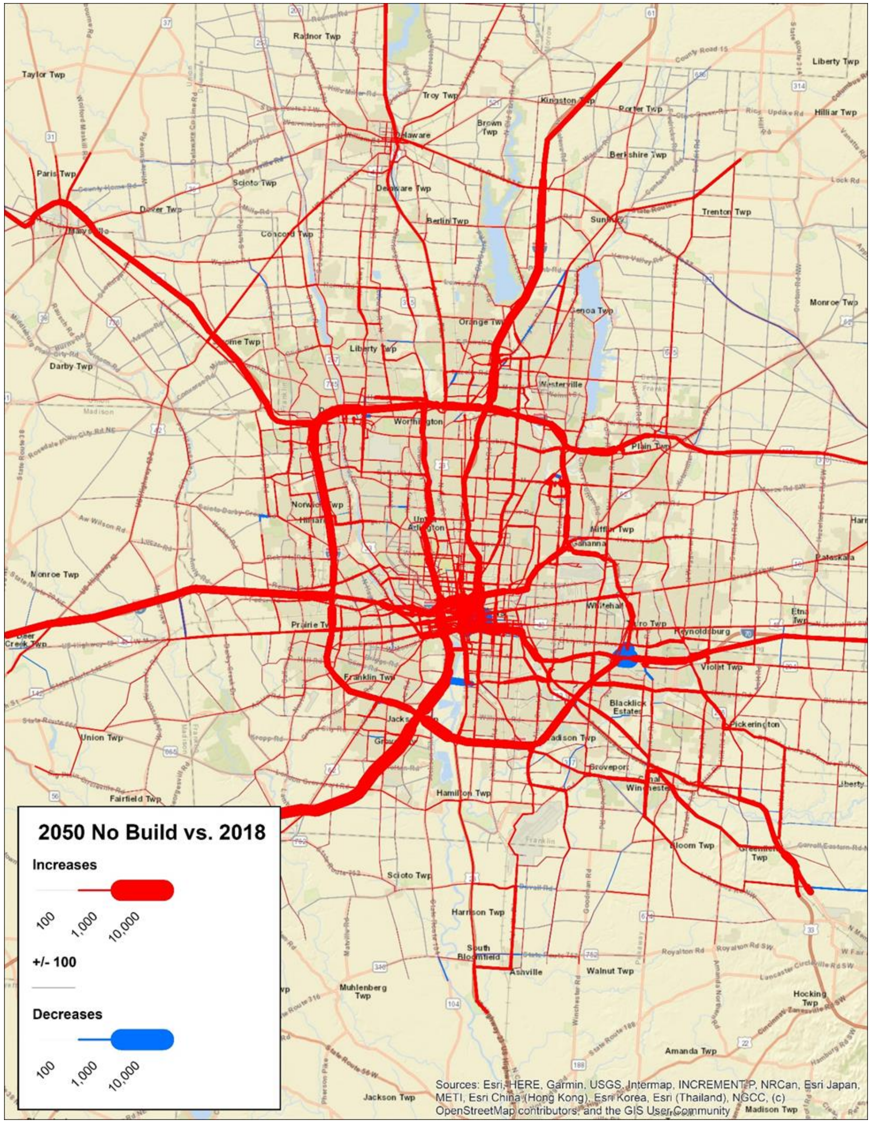
Regionwide TDM Results: VMT



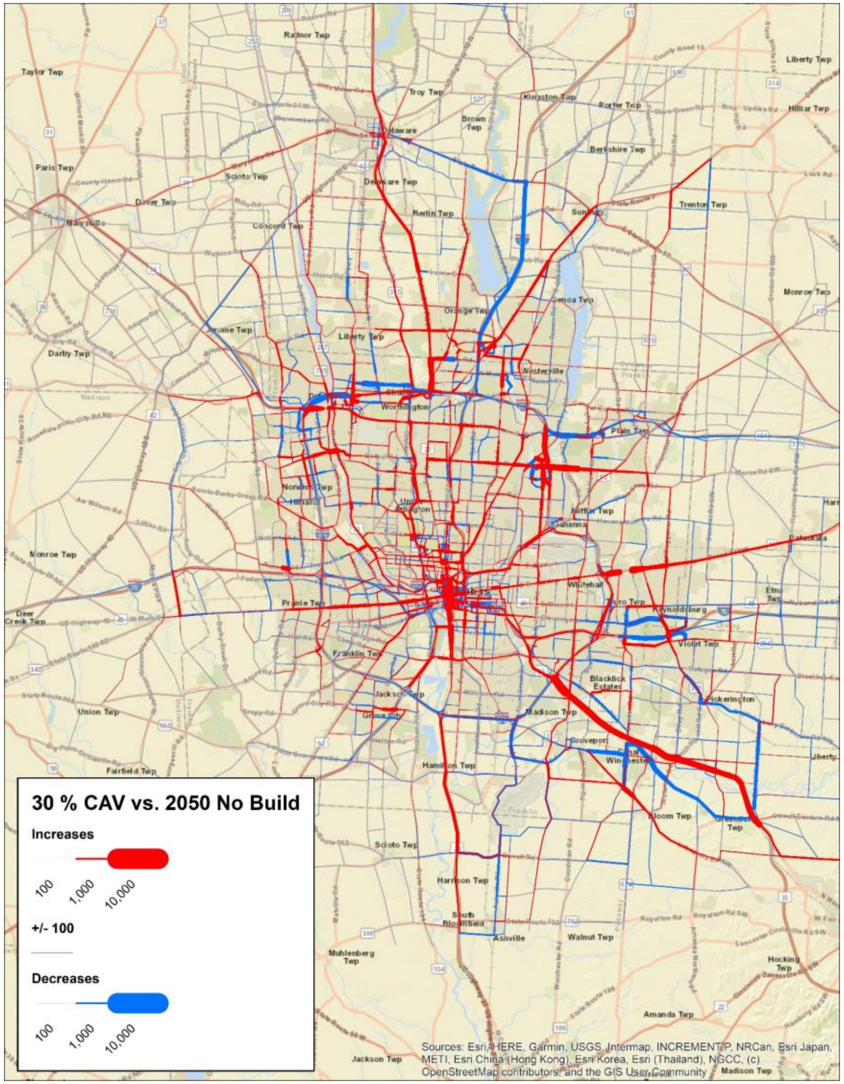
Regionwide TDM Results: VHT



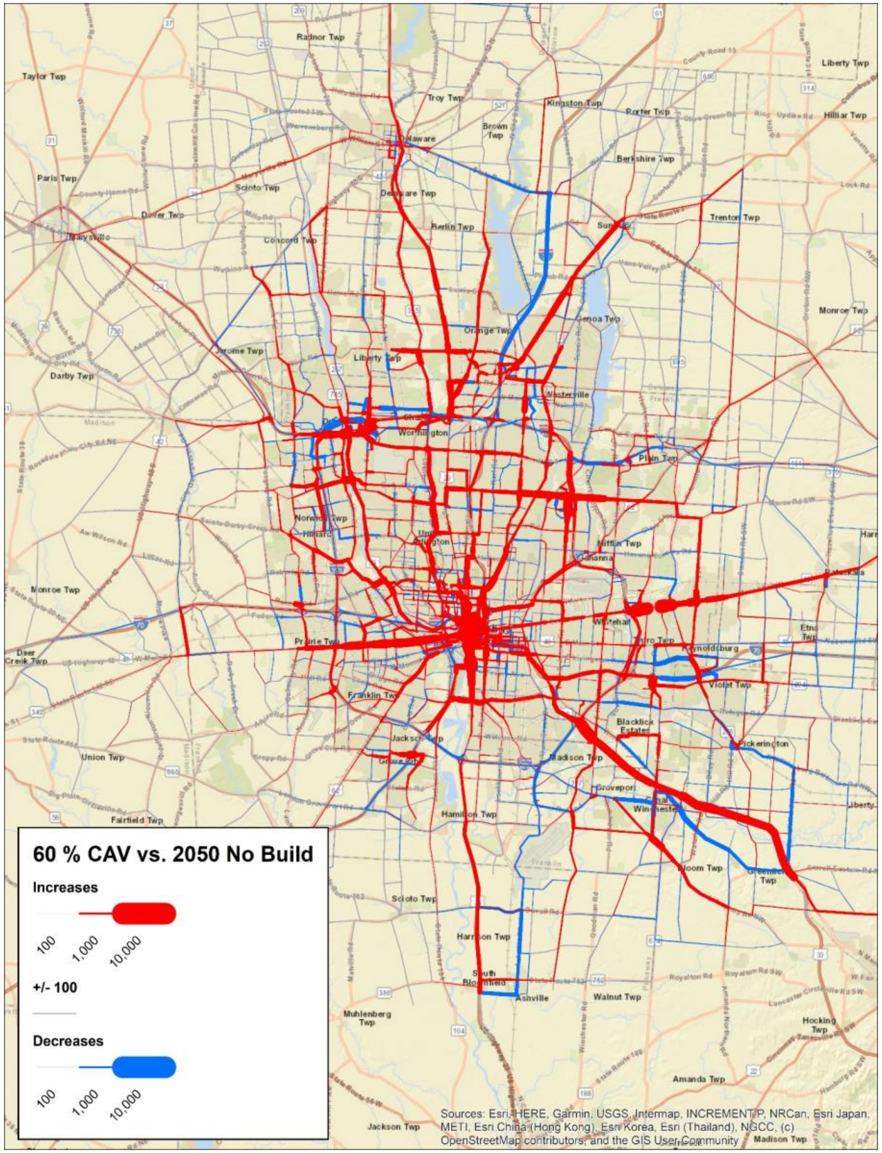
TDM Volume Comparisons



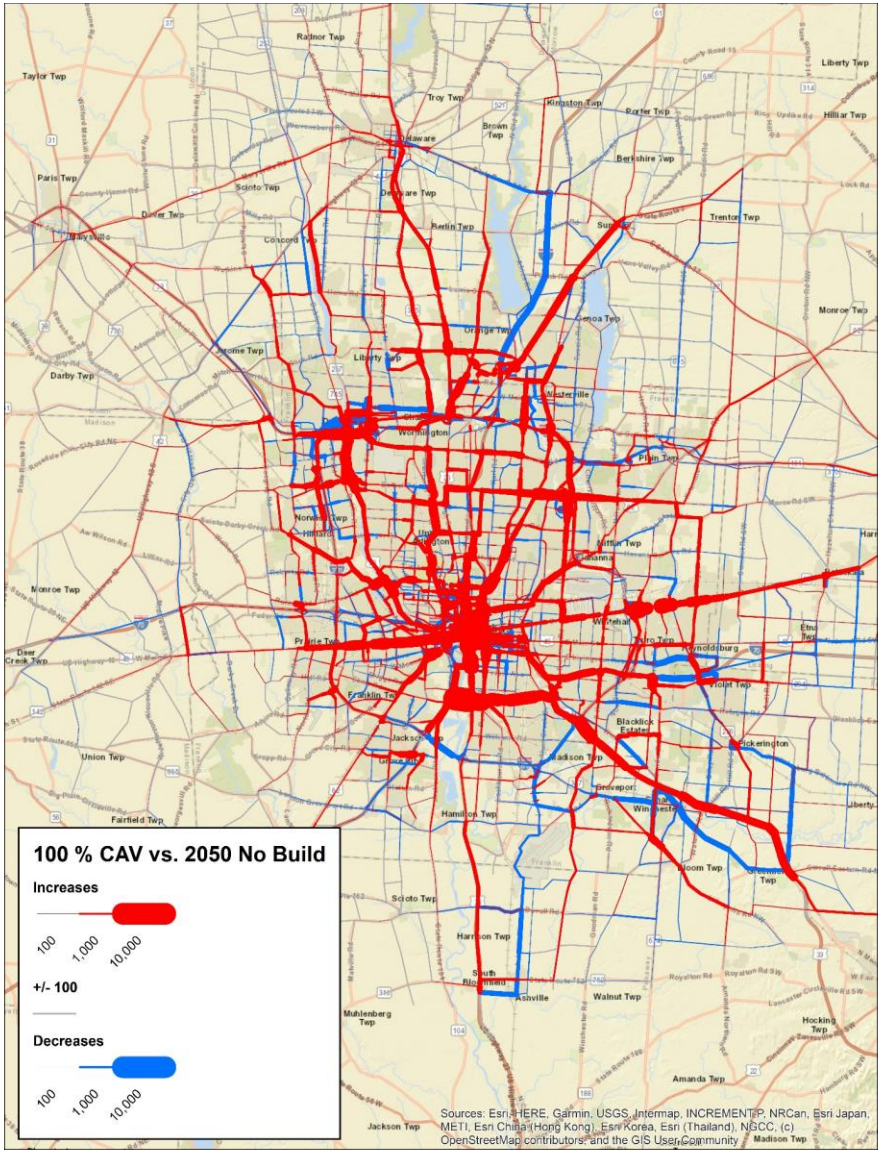
TDM Volume Comparisons



TDM Volume Comparisons



TDM Volume Comparisons



Systemwide Results (VISSIM)

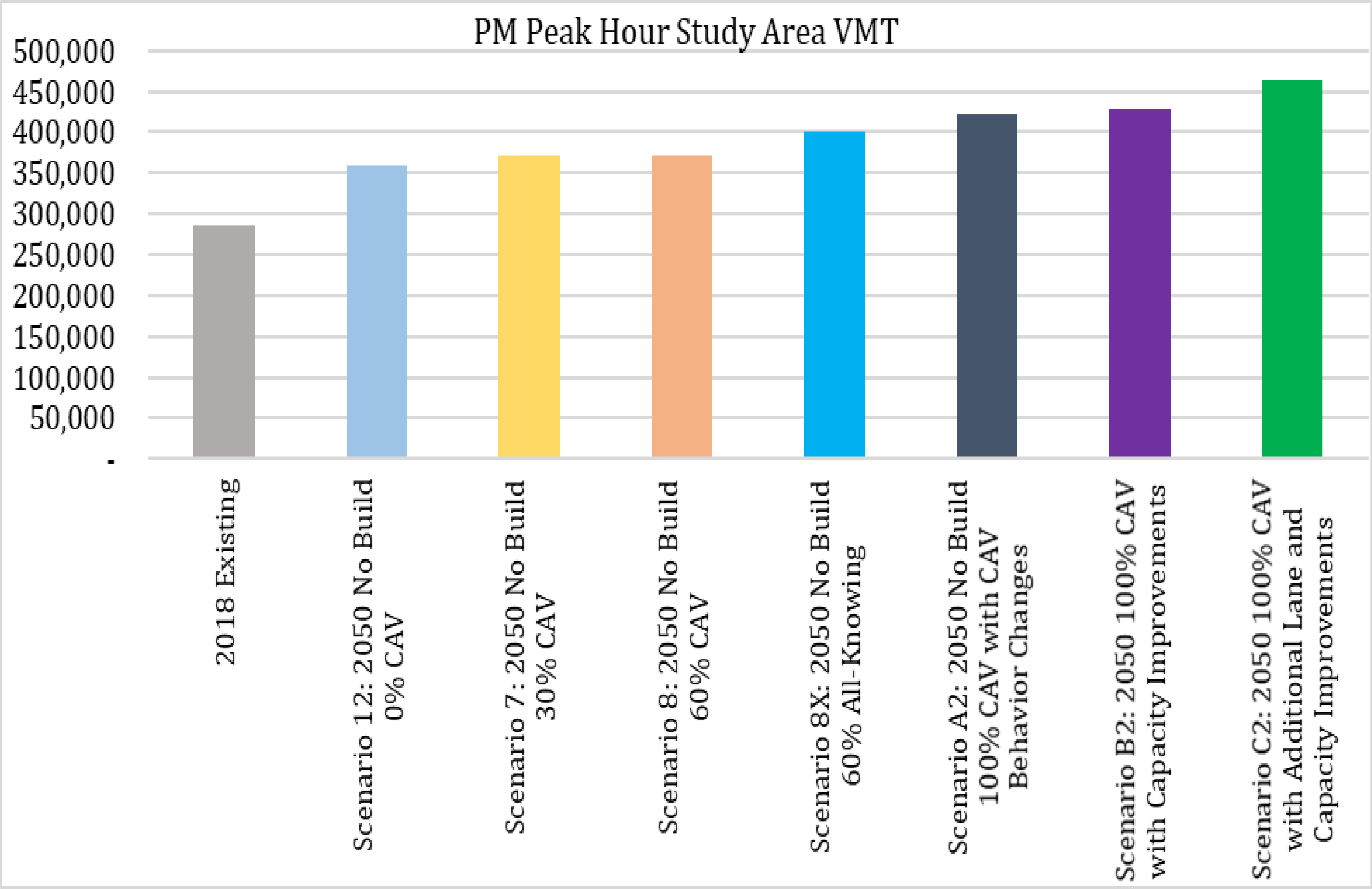
Focus Scenarios Description

#	Scenario Name	Year	TDM Scenario Demand Source	%HH with level 5 CAV	CAV Proportion of TNC fleet (%)	TNC CAV Price Discount (%)
No Build Scenarios						
Existing	2018 Existing No Build	2018	2018 No Build	0%	0%	0%
12	2050 No Build 0% CAV	2050	2050 No Build	0%	0%	0%
2050 Mid-Range Scenarios						
7	2050 30% CAV	2050	2050 30% CAV	30%	20%	50%
8	2050 60% CAV	2050	2050 60% CAV	60%	80%	50%
8X All-Knowing	2050 No Build 60% CAV All-Knowing	2050	2050 No Build	60%	NA	NA
A2	2050 No Build 100% CAV with CAV	2050	2050 No Build	100%	NA	NA
B2	2050 100% CAV with Capacity	2050	2050 100% CAV	100%	NA	NA
C2	2050 100% CAV with Additional Lane and	2050	2050 100% CAV + Lane	100%	NA	NA

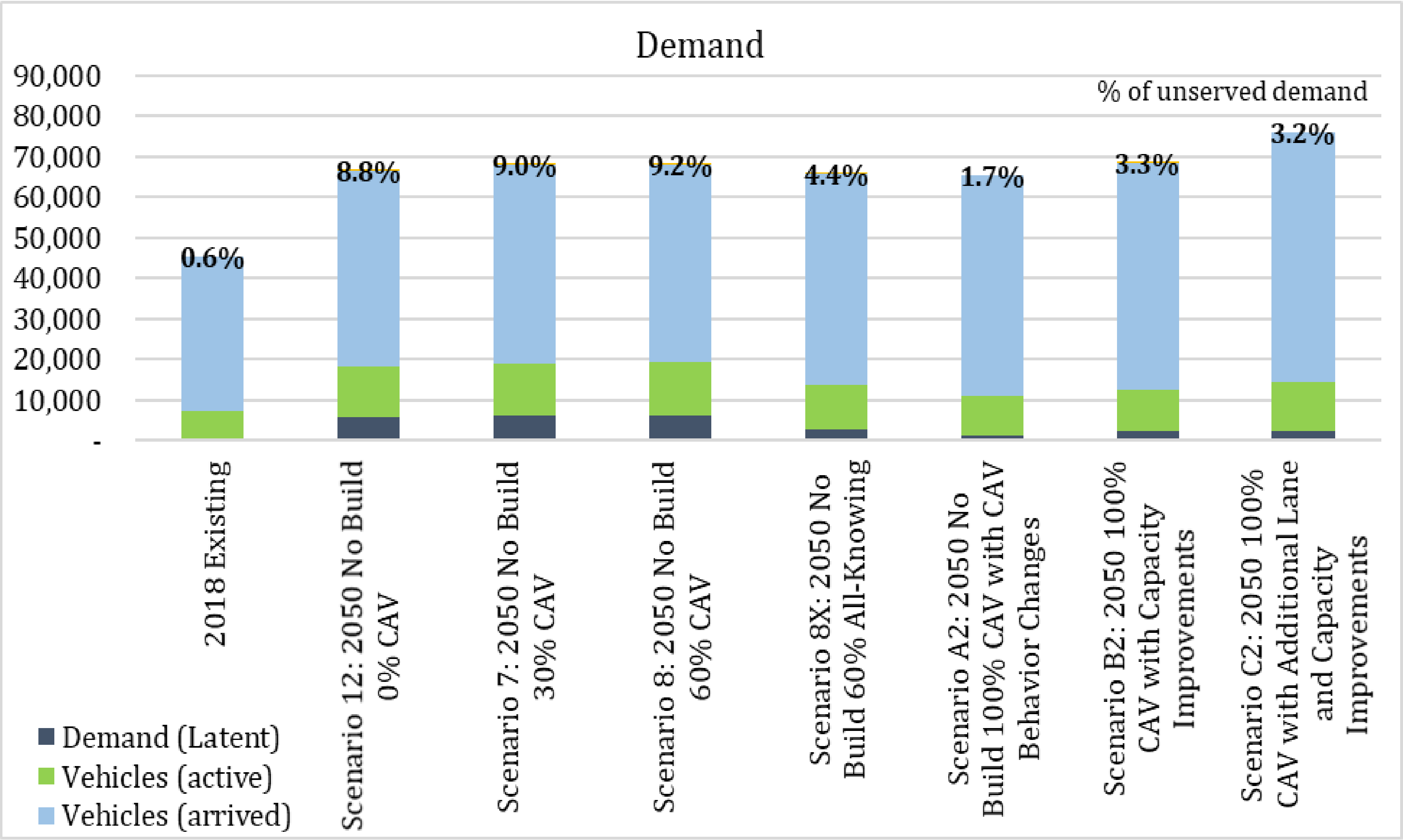
100% Penetration Simulation Fixes

- Lane by lane driver behavior assignment
- Increased gaps between leading vehicles
- Removed platoons at merge areas
- Removed platoons at dual-left turn storage at the US 33/Frantz Road intersection.
- This caused the creation of scenarios A1/A2, B1/B2 and C1/C2.

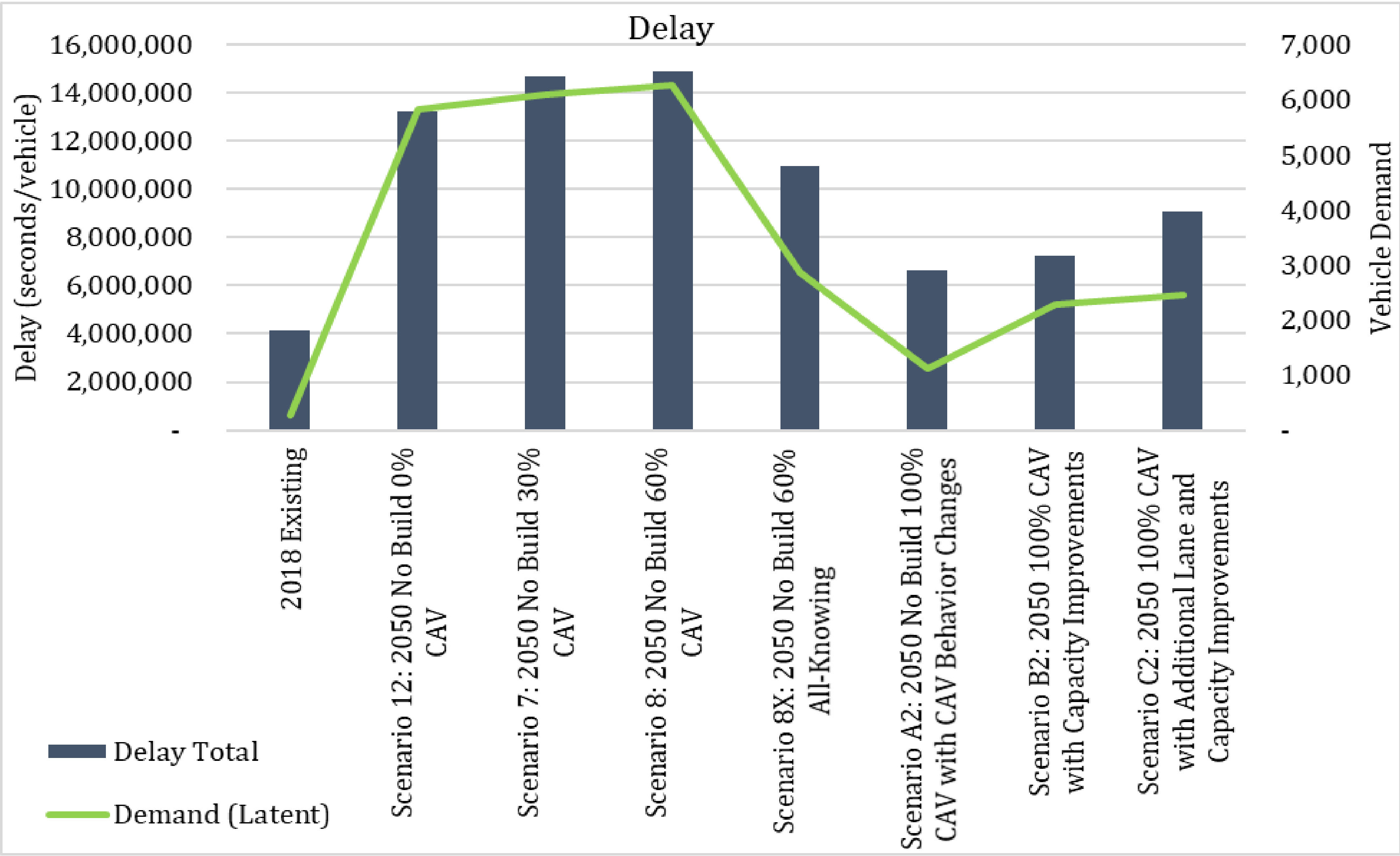
Systemwide Results for VMT



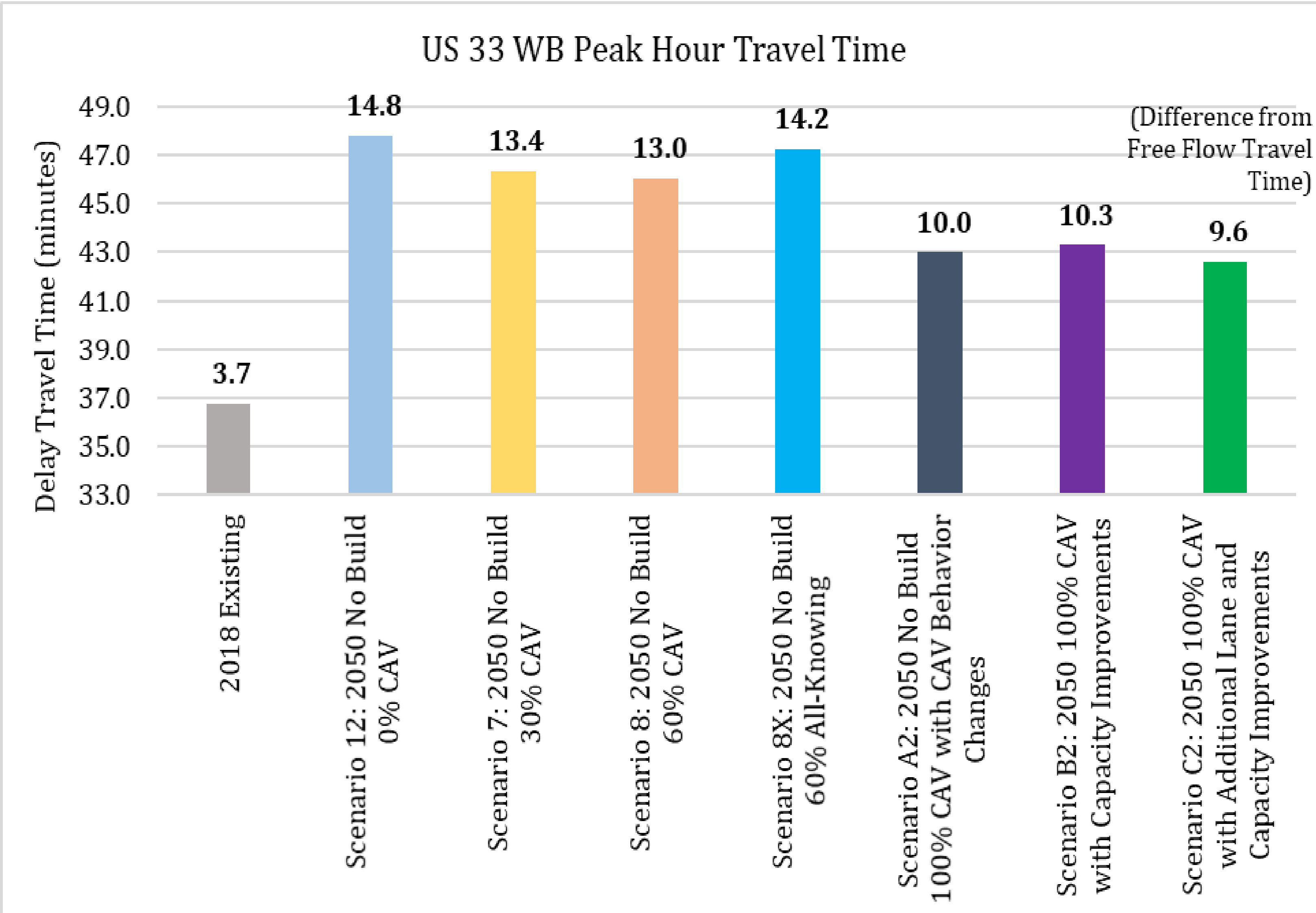
Systemwide Results for Demand (PM Peak Hour) (Active + Arrived + Latent)



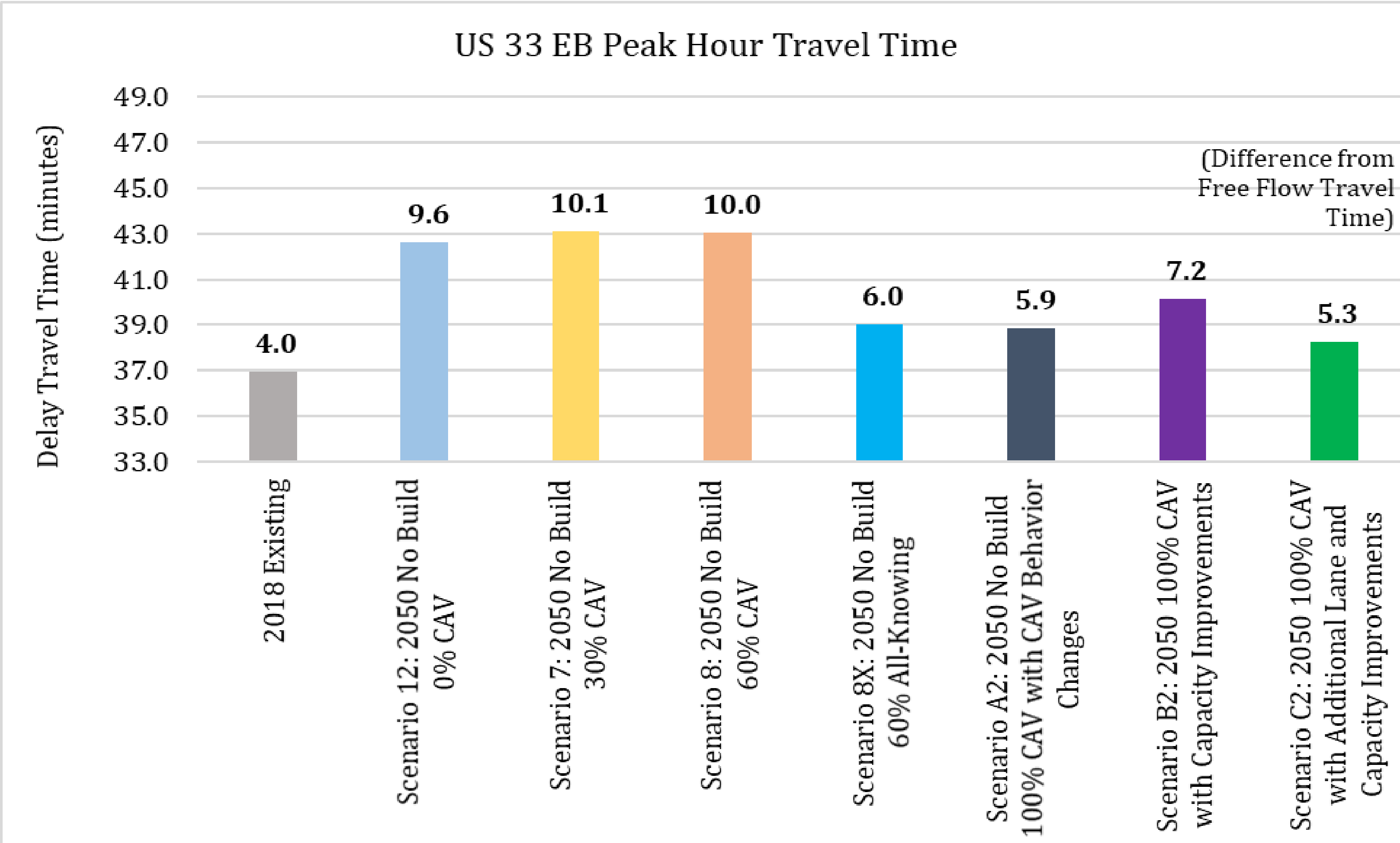
Systemwide Results for Delay Total



Travel Time US-33: Entire Corridor WB



Travel Time US-33: Entire Corridor EB (35.3 mi)

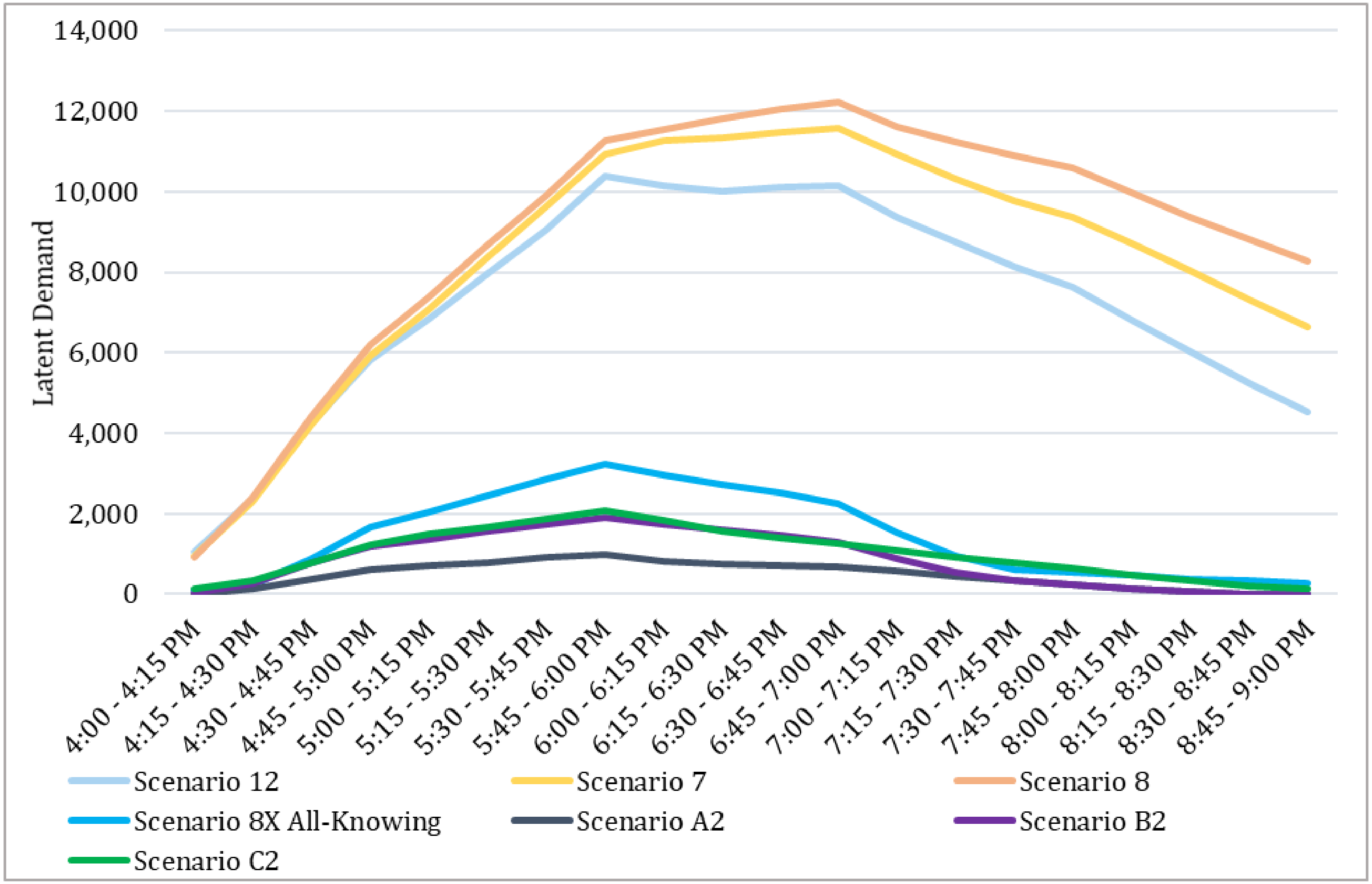


Post Peak Hour Performance

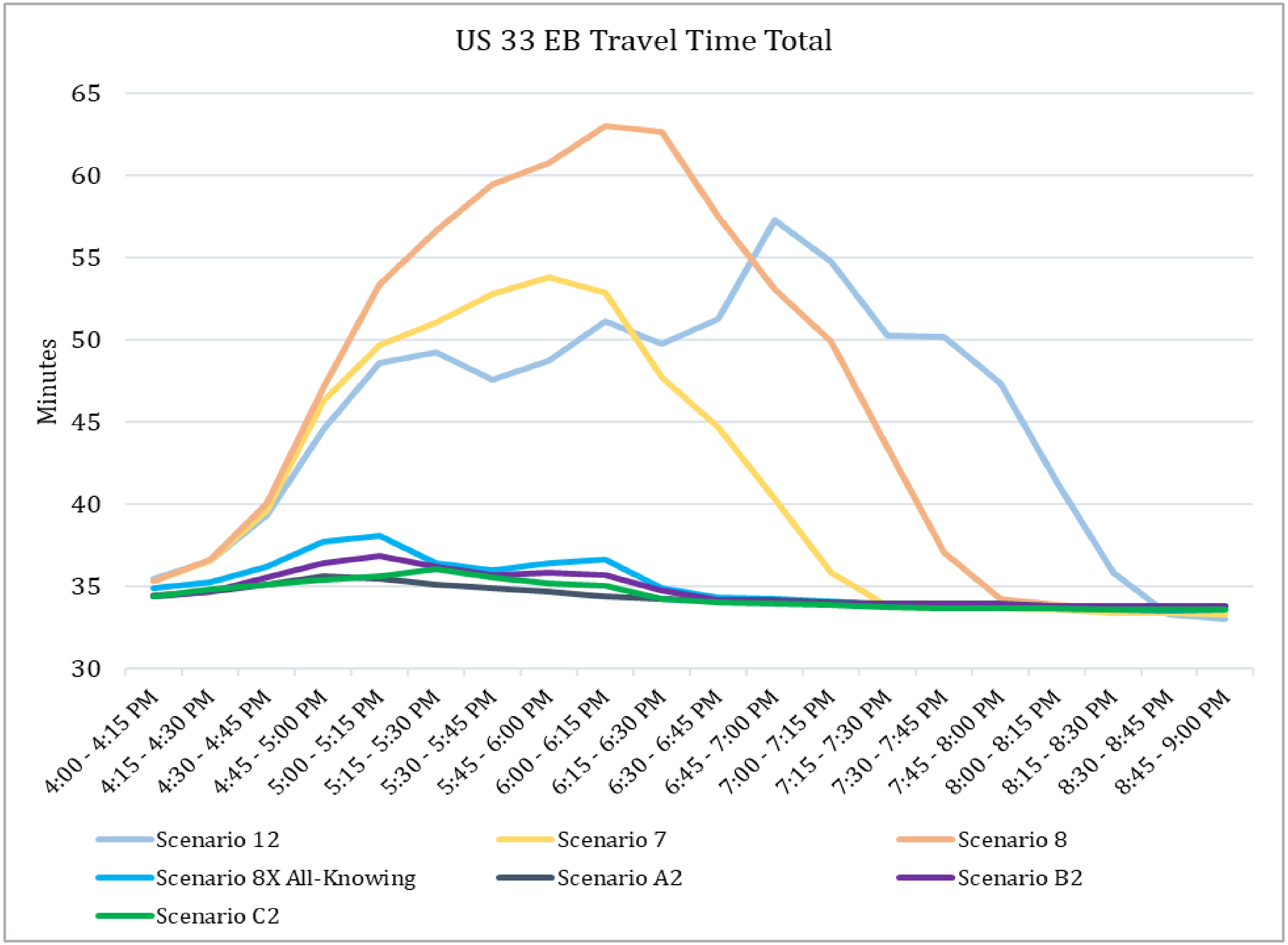
US-33 Throughput: East and West of Avery Road

Scenario	West of Avery		East of Avery	
	WB	% Difference from Scenario 12	WB	% Difference from Scenario 12
Scenario 12: 2050 No Build 0% CAV	4,719	-	6,584	-
Scenario 7: 2050 30% CAV	4,754	0.8%	6,783	3.0%
Scenario 8: 2050 60% CAV	4,665	-1.1%	6,725	2.1%
Scenario 8X All-Knowing: 2050 No Build 60% CAV All-Knowing	5,467	15.9%	7,622	15.8%
Scenario A2: 2050 No Build 100% CAV with CAV Behavior Changes Behavior	6,080	28.9%	8,187	24.3%
Scenario B2: 2050 100% CAV with Capacity Improvements	5,992	27.0%	8,211	24.7%
Scenario C2: 2050 100% CAV with Additional Lane and Capacity Improvements	7,058	49.6%	8,722	32.5%

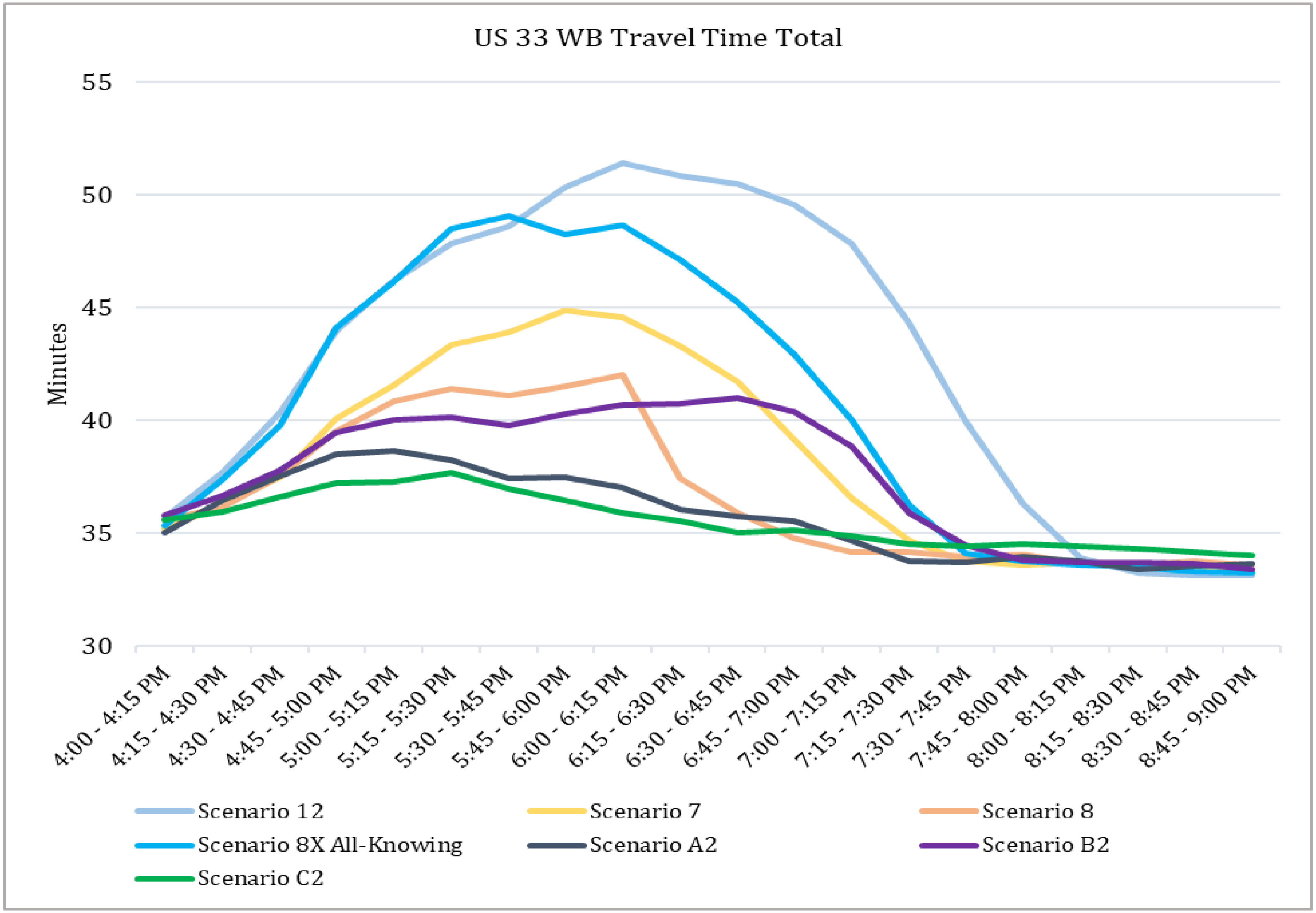
Systemwide Results: Latent Demand Results with Additional After-Peak Hours



US 33 EB Results: Travel Time Results with Additional After-Peak Hours



US 33 WB Results: Travel Time Results with Additional After-Peak Hours



Key Findings and Recommendations

Key CAV Findings

- TDM results show that 1% increase in CAV increase total trips by 0.1%
- 60% penetration (8X)
  - Improved throughput of ~15% on the most congested section of the US 33 corridor
  - Reduced travel time of 4 minutes in the EB direction and 1.5 minutes in the WB direction during the peak hour
  - Returns to normal travel time conditions 2 hours earlier in the EB direction and 45 minutes earlier in the WB direction
  - CAVs (without induced traffic) does not s help improve conditions in the peak (WB) but does during the post peak hours
- 100% penetration
  - Distinct operational and capacity improvements
  - A2 shows that capacity gains offset traffic growth except for induced traffic
  - Scenario B serves induced traffic w/ exception of urbanized area east of I-270
  - Scenario C with extra lane worked well except on I-270 ramps, simulation has trouble routing on ramps with splits. It was necessary to adjust configurations and timings at the 33/Frantz intersection.

US 33 Inspired Follow-up Studies

- Dedicated CAV lanes
- Vehicle-to-Infrastructure communication impacts
- Additional analysis of arterials
- Improve capability of adding TNCs to mix
- Additional analysis of merging operations and platooning; CDM Smith will perform research for North Texas Toll Authority on this topic
- Consider SE impacts; sensitivity analysis for today's SE conditions
- Develop new performance measures (e.g., additional trips adding mobility gains)

Potential Travel Demand Model Considerations

- West end of study area is an external station giving “edge of study” problems.
- Very low rate in TNC adoption, due to base year data limitations.
- As one travels from west to east, increases in induced demand.
- As demand increases, 0-occupancy demand increases almost linearly. More investigation might be needed.
- More granular analysis of ABM outputs might give understanding of:
  - Non-HBW trip purposes
  - VMT increases
  - Car ownership
  - O-occupancy trips
  - Increase in traffic due to reduction of driving ability restrictions?

Connected Vehicle Considerations

- Isolation of V2I capabilities
  - Platooning vs. V2I speed harmonization
  - AV traffic signal recognition vs. V2I SPaT data
  - Improved adaptive signal performance with V2I data
  - Green light glide path on signalized corridors
  - AV merging vs. cooperative V2V merging

Questions