SANDAG ABM2+
Sensitivity Testing Report

September 2020

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Objectives

San Diego Association of Governments (SANDAG) modeling staff conducted a series of sensitivity tests to demonstrate the effects of various inputs on vehicle miles traveled (VMT), mode share, trip length, and transit boardings using Activity Based Model (ABM2+). This work was performed in response to the Final Sustainable Communities Strategy Program and Evaluation Guidelines issued by the California Air Resources Board (CARB) and to examine the responsiveness of ABM2+ to potential SANDAG 2021 Regional Plan strategies. Since draft ABM2+ software versions were used in this study, the performance metrics varied slightly. These metrics are for sensitivity testing analysis only and should not be interpreted as final ABM2+ performance metrics.

Description of Sensitivity Tests

In February 2020, to prepare for the ABM2+ technical advisory committee (TAC) peer review held in March 2020, the modeling staff conducted a series of sensitivity tests. Following CARB's sensitivity test guidelines, staff conducted land use, transit infrastructure and active transportation, local/regional pricing, new mobility, and exogenous variable sensitivity tests as described in Table 1. Some tests were adjusted either to conform to the ABM2+ structure or to set with testing values that are more in line with Regional Plan (RTP) strategies. Tests in the new mobility category, including autonomous vehicles (AV), transportation network companies (TNC), and micromobility (E-Scooter, E-Bike, etc.), were beyond CARB's recommendations. Most sensitivity tests were based on 2035 model runs using 2035 revenue constrained networks from the 2019 Federal RTP. The Population forecast was prepared by SANDAG Economic and Demographic Analysis (EDAM) staff in August 2019. The 2035 revenue constrained scenario was used as the baseline scenario to derive elasticity. Land use–related tests used the 2050 forecast to account for the full potential impact of population growth on VMT and mode share.

Table 1. Descriptions of ABM2+ Sensitivity Tests

CARB Category	Description	Test ID	Scenario	Year
Land Use	baseline	1	baseline	2050
	job/housing balance	2	new downtown	2050

	mix of land use	3	low VMT	2050
	street pattern via intersection density	4	10%	2050
		5	–10%	2050
	residential density	6	50%	2050
		7	–50%	2050
Transit and Active Transportation	2035 baseline without AV	8	2035 baseline without AV	2035
	transit headways (frequencies)	9	50%	2035
		10	–50%	2035
	self-owned E-Bike ownership	11		2035
		12		2035
		13		2035
Local/Regional Pricing	mileage-based fee via AOC	14	50%	2035
		15	–50%	2035
	transit fare	16	50%	2035
		17	free	2035
		18	–50%	2035
	managed lane/toll price	19	50%	2035
		20	–50%	2035
	parking costs	21	high	2035
		22	very high	2035
Exogenous Variables	free flow speed	23	reduce 5 mph on freeways	2035
		24	reduce 5 mph on all roads	2035
	household income	25	–1/3	2035
		26	1/3	2035
	regional employment	27	10%	2035
		28	–10%	2035
New Mobilities	2035 baseline with AV	29	2035 baseline with AV	2035
	TNC cost (all)	30	50%	2035
		31	–50%	2035
	pooled TNC cost	32	–50%	2035
		33	–75%	2035
	TNC wait time	34	–50%	2035
		35	50%	2035
	micromobility speed	36	30mph	2035
	micromobility focus	37	micromobility speed 20 mph, constant 0, cost and access time halved	2035
	access to micromobility	38	good	2035

		39	very good	2035
	micromobility cost	40	-50%	2035
		41	50%	2035
	AV household penetration rate	42	50%	2035
		43	0%	2035
	AV in-vehicle time coefficient	44	Reduce from 0.75 to 0.6	2035
		45	Increase from 0.75 to 0.9	2035
	AV operating cost scaler	46	Reduce from 0.7 to 0.5	2035
		47	Increase from 0.7 to 0.9	2035
	AV terminal time scaler	48	Reduce from 0.65 to 0.5	2035
		49	Increase from 0.65 to 0.8	2035
	TNC optimization	50	TNC optimization	2035
		51	TNC transit optimization	2035
	AV and TNC combos	52	20% household AV penetration rate and 30 min TNC benefits	2035
		53	20% household AV penetration rate and 7.5 min TNC benefits	2035
		54	50% household AV penetration rate and 15 min TNC benefits	2035
Telework	existing pattern	55	Existing telework rates	2035
	moderate growth pattern	56	Moderate telework rate growth	2035
	maximum growth pattern	57	Maximum telework rate growth	2035

Baseline Scenarios

Staff created three baseline scenarios to ensure consistency when comparing results from multiple scenarios in the same test group, including:

- 2050 baseline without AV
- 2035 baseline without AV
- 2035 baseline with AV (20% household AV penetration rate)

The 2050 baseline without AV was used for comparing scenarios in the land use test category. The 2035 baseline without AV, a business as usual scenario, was used for comparing 'conventional' tests, such as transit fare, transit service, and AOC tests. The 2035 baseline with AV was used for comparing all new mobility tests that assume a 20% household AV penetration rate. During the three-month testing period, there were a few minor software changes, which resulted in slightly different software versions. All comparisons in this report were checked to ensure the same software version was used for baseline and build tests in each test group.

Description of Test Input Changes

Land Use

Staff tested three 2050 population growth alternatives: business as usual – baseline, jobs close to housing, and low VMT.

- *Test 1 2050 Baseline without AV:* 2050 baseline using revenue constrained networks (Figures 10, 11, and 12 in Appendix B) and land use (Figures 3 and 6 in Appendix B) from the 2019 Federal RTP. The impact of AVs was not included.
- *Test 2 2050 Jobs close to housing:* This alternative represents a job/housing balance scenario with population growth concentrated in one of San Diego's job centers, Sorrento Valley.
- *Test 3 2050 Low VMT:* This alternative represents a scenario with population growth concentrated in urban cores with good transit, walk, and bike accessibilities. The construction of this Low VMT land use alternative is described in Figures 13, 14, and 15 in Appendix B.
- *Test 4 and 5 Intersection density:* In the MGRA input file, intersection densities were set to be 10 percent less or 10 percent more than the corresponding values in the 2050 baseline scenario. It should be noted that road networks were not changed, only the intersection density variable was modified. These tests fall into the controlled-variable test category per CARB's guidelines which define the controlled-variable land use tests as: these *are simply hypothesis testing which holds all other variables constant, neglecting the supply-demand interaction between inter-dependent variables in reality, to determine the change in model outputs (e.g., VMT, VHT, vehicle trips, mode share) with respect to the change in a single land use related variable (e.g., residential density, employment density, compact housing development).*
- *Tests 6 and 7 Residential density:* In the MGRA[1] input file, residential densities were set to be 50 percent less or 50 percent more than the corresponding values in the 2050 baseline scenario. It should be noted that households were not re-distributed, only the residential density variable was modified. These tests fall into CARB's controlled-variable test category.

Transit and Active Transportation

These tests evaluated transit and active transportation-related strategies through a more frequent transit service and the expansion of self-owned E-Bikes that operate at faster speeds than regular bikes.

- *Test 8 2035 Baseline without AVs:* This is a 2035 baseline scenario with revenue constrained networks (Figures 7, 8, and 9 in Appendix B) and land use (Figures 2 and 5 in Appendix B) from the 2019 Federal RTP. The impact of AVs was not included.
- *Tests 9 and 10 Transit Frequency:* For each scenario's transit route attribute table, the frequencies by route were set to be 50 percent less or 50 percent more than the corresponding values in the 2035 baseline.
- *Tests 11, 12 and 13 Self-Owned E-Bike Ownership:* For the three test scenarios, E-Bike ownership was increased to 35%, 65%, and 80%, respectively, to assess the impact of E-Bike ownership. Maximum bike distance thresholds were scaled up. Distance coefficients used to calculate bike logsums were scaled to make the bike speed changes necessary to represent the desired E-Bike

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[1] MGRA – Master Geographic Reference Areas are approximately 23,000 geographic areas in San Diego County created by overlaying unique combinations of jurisdictional, census and other geographies to create the basic building blocks for spatial analysis by SANDAG.

ownership percentages. Additionally, each of the three scenarios was run with and without an included E-Bike comfort benefit that represents the added utility that E-Bikes may offer over traditional bikes.

Local/Regional Pricing

These tests evaluated local/regional pricing-related strategies through mileage-based pricing (auto operating cost), reduction in transit fare cost, tolled roadways, and parking pricing.

- *Test 14 and 15 Mileage-base fees:* Fuel and maintenance costs were set to be 50 percent less or 50 percent more than the corresponding values in the 2035 baseline.
- *Tests 16, 17 and 18 Transit Fare:* For each scenario's transit route attribute table, the fares by route were set to be 50 percent less, free, or 50 percent more than the corresponding values in the 2035 baseline. The zone-based fare for commuter rail was updated in the same manner as the route-based fare assumption.
- *Test 19 and 20 Managed lane/Toll price:* The toll price of managed lanes/toll roads were set to be 50 percent less or 50 percent more than the corresponding values in the 2035 baseline.

Test 21 and 22 Parking cost scenarios: Staff constructed two test scenarios using the 2035 parking fee schedule provided by SANDAG planning staff. Each of the 6,556 MGRAs in mobility hubs is given hourly, daily, and monthly parking fees by mobility hub type as described in Table 2.

Table 2. Descriptions of ABM2+ Sensitivity Tests

Mobility Hub Type	# of MGRAs	Hourly	Daily	Monthly
1 – Urban Shed High	855	$6.5	$39	$571
2 – Tier 1 Employment Centers	391	$4.9	$29	$408
3 – Other Urban Shed Tracts	908	$4.9	$29	$408
4 – Costal	1,780	$3.3	$20	$245
5 – Child Shed	2,622	$1.6	$10	$131

Note: 2010 $ value

SANDAG Data Solutions (DS) staff provided 2035 parking space data for MGRAs in mobility hubs (5,689 out of 6,556 mobility hub MGRAs). Since the 2035 baseline parking data was prepared at an earlier time using slightly different data sources and methodologies, a small portion of the estimated MGRA parking spaces were lower than those in the 2035 baseline scenario. For any given MGRA, if parking space data was not provided or was lower than 2035 baseline parking spaces, then staff used the 2035 baseline parking space data.

There are four parking area types ("parkarea") in ABM:

1. Designates a parking constrained MGRA. Parking charges apply and are calculated as a weighted average of parking costs in MGRAs in parkarea 1 or 2 within walking distance (3/4 mile). The parking costs are weighted inversely by distance and by the number of spaces. Trips with destinations in a MGRA in parkarea 1 may choose to park in a different MGRA. A parking location choice model is applied to auto trips with destinations in parkarea 1.
2. This is a reserve area of parking for parkarea 1, e.g. a residential or commercial area immediately around downtown. Trips with destinations in parkarea 1 may choose to park in a

MGRA in parkarea 2, and parking charges may apply. In the base year, parkarea 2 MGRAs were constrained to be a quarter-mile buffer around downtown.

3. Only trips with destinations in the same MGRA may park here. Parking charges apply but are not calculated as a weighted average of walkable MGRAs.
4. Only trips with destinations in the same MGRA may park here. Parking charges do not apply (free parking)

High parking cost scenario: First, staff set parkarea to 1 for all 6,556 MGRAs in mobility hubs. Staff then updated the 2035 baseline parking costs using data from Table 2. All the updated costs were decreased by 50 percent. The parking cost in this scenario is higher than the 2035 baseline.

Very high parking cost scenario: First, staff set parkarea to 1 for all 6,556 MGRAs in mobility hubs. Staff then updated the 2035 baseline parking cost using data from Table 2. All the updated costs were increased by 50 percent over the values in Table 2. The parking cost in this scenario is much higher than the 2035 baseline.

Exogenous Variables

These tests evaluated exogenous factors through free flow speeds, household income, regional employment, and telework rates. CARB recommended that MPOs should conduct sensitivity tests on some of the most common exogenous variables in the travel demand model such as income distribution and auto operating cost. Auto operating cost tests are included in the pricing section.

- *Tests 23 and 24 Free flow speed:* Staff wrote Python scripts to create two modified networks with free flow speed reduced by 5mph on freeways and all roads, respectively.
- *Tests 25 and 26 Household income:* Household income was set to be one-third less or one-third more than the corresponding values in the 2035 baseline.
- *Tests 27 and 28 Regional total employment:* In the persons file, the number of full-time workers was set to be 10 percent less or 10 percent more than the corresponding values in the 2035 baseline. In the MGRA input file, employment at each MGRA was set to be 10 percent less or 10 percent more than the corresponding values in the 2035 baseline.
- *Test 55 Existing pattern:* Represents a business as usual scenario with permanent and occasional telework rates at 7% and 8%, respectively (same as the 2016/2017 household survey).
- *Test 56 Moderate growth pattern:* Represents a moderate telework growth scenario with permanent and occasional telework rates at 9% and 12%, respectively.
- *Test 57 Maximum growth pattern:* Represents a maximum telework growth scenario with permanent and occasional telework rates at 25% and 13%, respectively (same as the 2016/2017 household survey).

New mobility

These tests evaluated new mobility-related strategies through autonomous vehicles (AV), transportation network companies (TNC), and micromobility modes such as E-Scooters and shared E-Bikes. Since there are limited studies evaluating the impact of new mobility-related strategies, CARB's guidelines indicated that the current practice of the quantification of the GHG benefit is generally conducted through off-model analysis. ABM2+ was enhanced with explicit modeling of AV, TNC, and micromobilities. Staff were able to test new mobility scenarios beyond CARB's recommendations. Since some new mobility modes are included in multiple model components (e.g. resident model, airport model, visitor model, and cross border model), staff made changes to all model components whereas the new mobility modes apply.

- *Test 29 2035 baseline with AV:* 2035 baseline with AV using revenue constrained networks and land use from the 2019 Federal RTP. The impact of AV was included (the default AV penetration rate is 20 percent).
- *Tests 30 and 31 TNC cost:* Costs for single and pooled TNC modes was set to be 50 percent less or 50 percent more than the default values in the 2035 baseline.
- *Tests 32 and 33 Pooled TNC cost:* Costs for only the pooled TNC mode was set to be 50 or 75 percent less than the default values in the 2035 baseline.
- *Tests 34 and 35 TNC wait time:* Wait times for single and pooled TNC modes was set to be 50 percent less or 50 percent more than the corresponding default values in the 2035 baseline.
- *Test 36 Micromobility speed:* The micromobility mode speed was increased from 12 to 30 mph.
- *Test 37 Micromobility focus:* The micromobility mode speed was increased from 12 to 20 mph. The micromobility variable cost and fixed cost were set to $0.1/minute and $0.5, respectively (reduced by 50 percent compared with the default in the 2035 baseline). The micromobility constant was set to 0 (default is 60 in the 2035 baseline). Lastly, the micromobility access time was reduced by half in the MGRA-based input file from 5, 10, and 120 minutes to 2.5, 5, and 60 minutes for urban, suburban, rural MGRAs.
- *Test 38 and 39 Access to micromobility:* Access time to micromobility was specified in number of minutes by MGRA, to represent spatial differences in the availability of micromobility options such as E-Scooters. The baseline micromobility accessibility was estimated by SANDAG planning staff to be 5 minutes in the urban cores, 15 minutes in suburban areas within the City of San Diego, and unavailable elsewhere. For these sensitivity tests, the micromobility access time was set to 3, 5, and 15 minutes and 1, 3, and 5 minutes for urban, suburban, and rural MGRAs respectively.
- *Tests 40 and 41 Micromobility cost:* Costs for micromobility mode was set to be 50 percent less or 50 percent more than the default values in the 2035 baseline
- *Tests 42 and 43 Household AV penetration rate:* AV penetration rates were set to 50 percent and 100 percent (default is 20 percent in the 2035 baseline).
- *Test 44 and 45 AV in-vehicle time coefficient:* AV in-vehicle time coefficients were set to 0.6 and 0.9 (default is 0.75 in the 2035 baseline).
- *Tests 46 and 47 AV operating cost:* AV operating cost scalers were set to 0.5 and 0.9 (the default is 0.7 in the 2035 baseline).
- *Tests 48 and 49 AV terminal time:* AV terminal time scalers were set to 0.5 and 0.8 (the default is 0.65 in the 2035 baseline).
- *Test 50 TNC optimization:* The assumption was made that the TNC fleet is autonomous and much more widely available than current. The AV penetration rate was set to 0 percent. TNC wait time was set to be 50 percent less than the default values in the 2035 baseline. In mode choice UEC files, the alternative-specific constants (ASCs) of all TNC modes (TNC-Transit, single, and pooled-TNC) were increased by 30 minutes of equivalent in-vehicle time benefit, and Taxi alternative was turn off.

- *Test 51 TNC Transit optimization:* The AV penetration rate was set to 0 percent. The ASCs for TNC-Transit mode were increased by 30 minutes of equivalent in-vehicle time benefit.
- *Test 52 TNC benefits and 20 percent AV penetration rate:* The AV penetration rate was set to 20 percent. TNC wait time was set to be 50 percent less than the default values in the 2035 baseline. The ASCs for all TNC modes (TNC-Transit, single, and pooled) were increased by 30 minutes of equivalent in-vehicle time benefit, and the Taxi alternative was turned off.
- *Test 53 TNC benefits and 20 percent AV penetration:* The AV penetration rate was set to 20 percent. TNC wait time was set to be 50 percent less than the default values in the 2035 baseline. The ASCs for all TNC modes (TNC-Transit, single, and pooled) were increased by 7.5 minutes of equivalent in-vehicle time benefit, and the Taxi alternative was turned off.
- *Test 54 TNC benefits and 50 percent AV penetration:* The AV penetration rate was set to 50 percent. TNC wait time was set to be 50 percent less than the default values in the 2035 baseline. The ASCs for all TNC modes (TNC-Transit, single, and pooled) were increased by 15 minutes of equivalent in-vehicle time benefit, and the Taxi alternative was turned off.

Results and Findings

This section describes the sensitivity testing results and key findings. While some tests were simply hypothetical and were designed to mechanically examine the model's responsiveness to key variables, some other tests shed some insights of whether and how much the model responds to potential policy dials. The performance metrics analyzed include VMT, mode share, transit boardings, trip distance by mode, total trips, and in some cases test specific outputs such as toll road volumes. The analysis varied slightly, depending on the travel markets affected by the change of tested variables. While some analyses were based on metrics of all models including special market models like visitor, cross border, and truck models, some other analyses were for San Diego county resident models only.

Land Use

Land Use Tests (Tests 2 & 3)

Compared with the 2050 baseline, the low VMT land use alternative test had the following results:

- Total personal trips made by San Diego residents decreased by 1.2% (Figure 4)
- Average auto ownership decreased from 1.69 to 1.64 (Figure 2). Households without cars increased from 10.6% to 12.2% (Figure 3).
- VMT decreased by 3.7% (Figure 1)
- San Diego resident mode shares (Figure 5):
  - Drive alone (DA) decreased from 45.4% to 44.6%
  - Shared ride 2 (SR2) decreased from 23.6% to 23.3%
  - Shared ride 3 (SR3) decreased from 16.0% to 15.4%
  - Transit increased from 2.9% to 3.1%
  - Active modes (walk, bike, and micromobility) increased from 10.7% to 12.0%
- Transit boarding increased by nearly 5% (Figure 6)

- Average San Diego resident trip distance decreased from 6.1 miles to 5.9 miles; Trip distance of non-mandatory trips such as recreational, eating out, maintenance, shopping, and visiting all decreased. Work trip distance change was insignificant (Table 3).

Compared with the 2050 baseline, the jobs close to housing alternative test had the following results:

- VMT decreased by 2.0% (Figure 1)
- Average auto ownership decreased from 1.69 to 1.66 (Figure 2). Households without cars increased from 10.6% to 11.1% (Figure 3).
- Total personal trips made by San Diego residents decreased by 0.4% (Figure 4)
- San Diego resident mode shares (Figure 5):
    - DA decreased from 45.4% to 45.2%
    - SR2 decreased from 23.6% to 23.4%
    - SR3 decreased from 16.0% to 15.9%
    - Transit increased from 2.9% to 3.0%
    - Active modes (walk, bike, and micromobility) increased from 10.7% to 10.9%
- Transit boarding increased by 2.7% (Figure 6)
- Average San Diego resident trip distance decreased from 6.1 miles to 6.0 miles. Work trip distance decreased. Trip distance of non-mandatory trips such as recreational, eating out, maintenance, and shopping also decreased (Table 3).

These results confirm that ABM2+ is sensitive to land use alternatives. When households and population growth are concentrated in urban core areas, the model indicated lower VMT, lower auto mode shares, higher walk, bike, and transit mode shares, and shorter trip distances. Another interesting finding was that total person trips decreased, which may be caused by reduced auto ownership. It should be noted that the tested alternatives did not include employment growth.

Figure 1. VMT Change: Land Use Alternatives vs 2050 Baseline (tests 2 and 3)

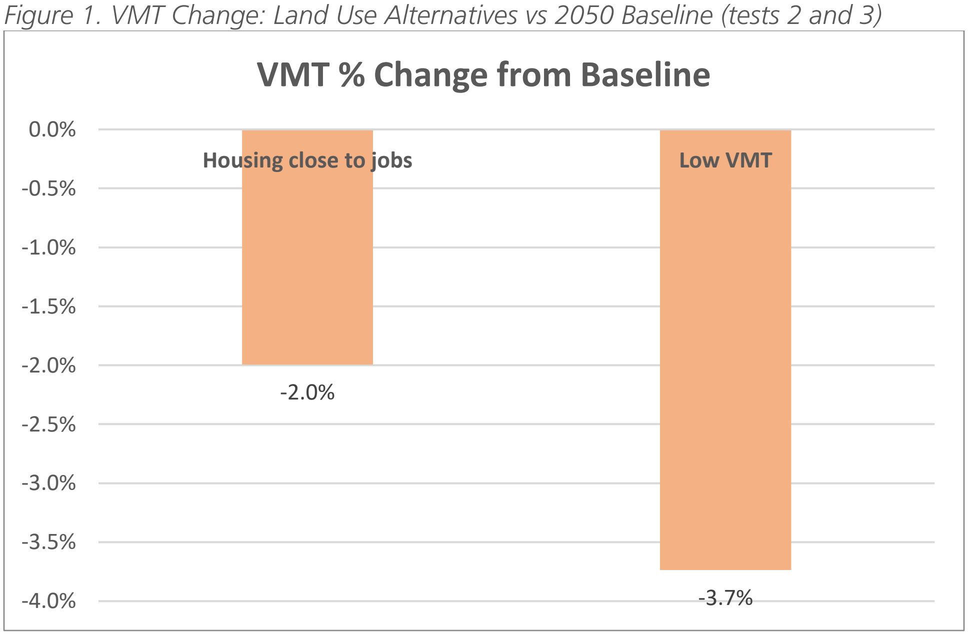


Figure 2. Average Auto Ownership: Land Use Alternatives vs 2050 Baseline (tests 2 and 3)

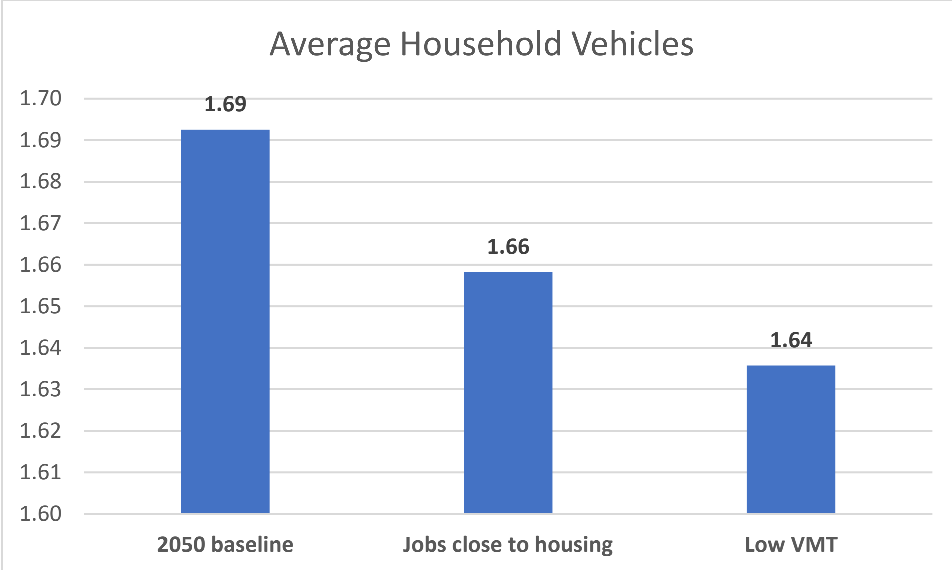


Figure 3. Average Auto Ownership by Number of Vehs: Land Use Alternatives vs 2050 Baseline (tests 2 and 3)

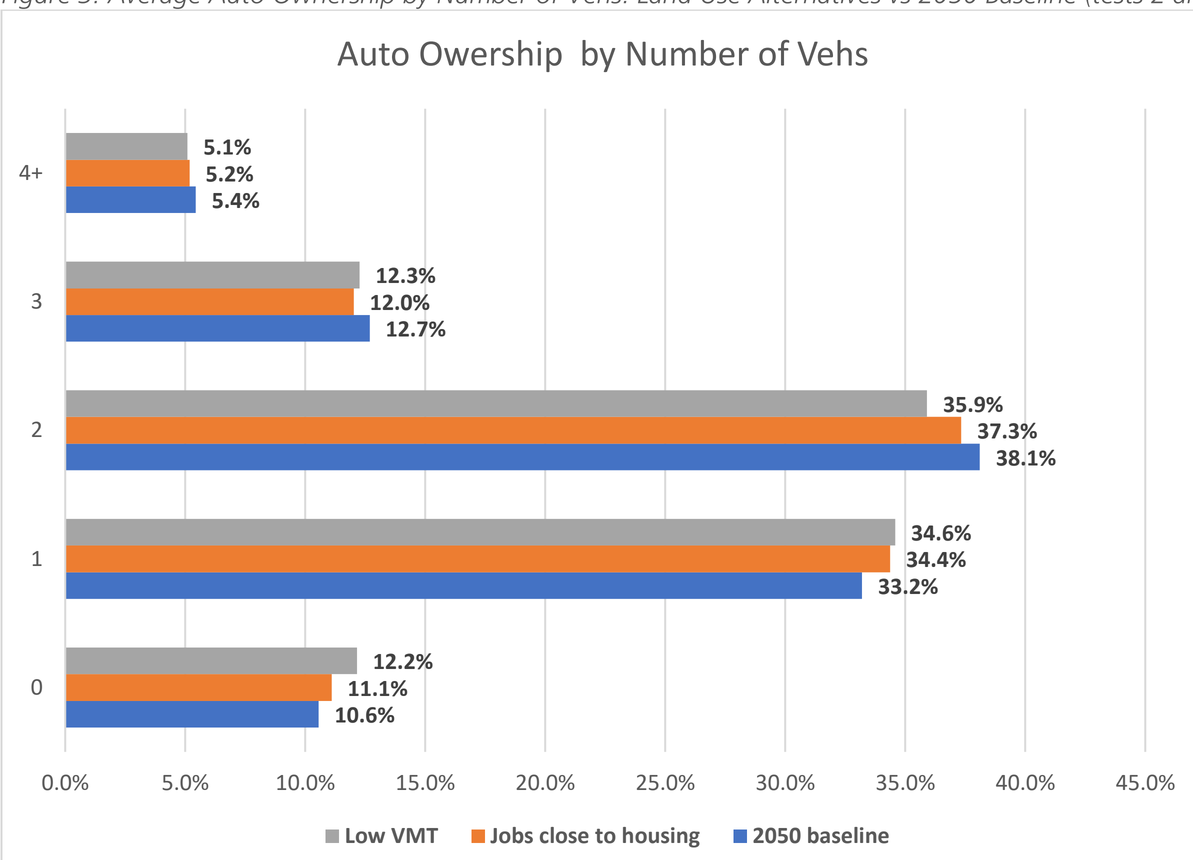


Figure 4. Total Person Trips: Land Use Alternatives vs 2050 Baseline (tests 2 and 3)

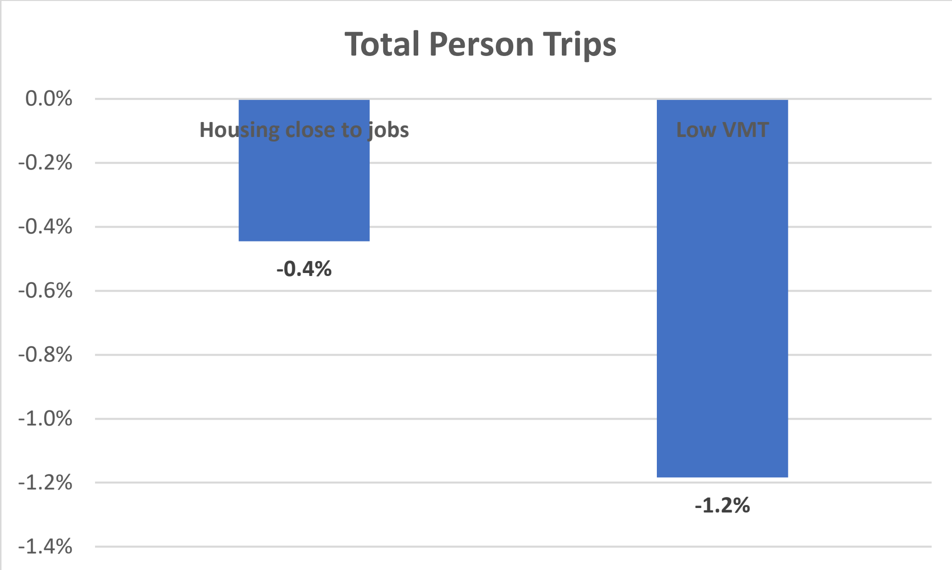


Figure 5. Mode Share of Person Trips: Land Use Alternatives vs 2050 Baseline (tests 2 and 3)

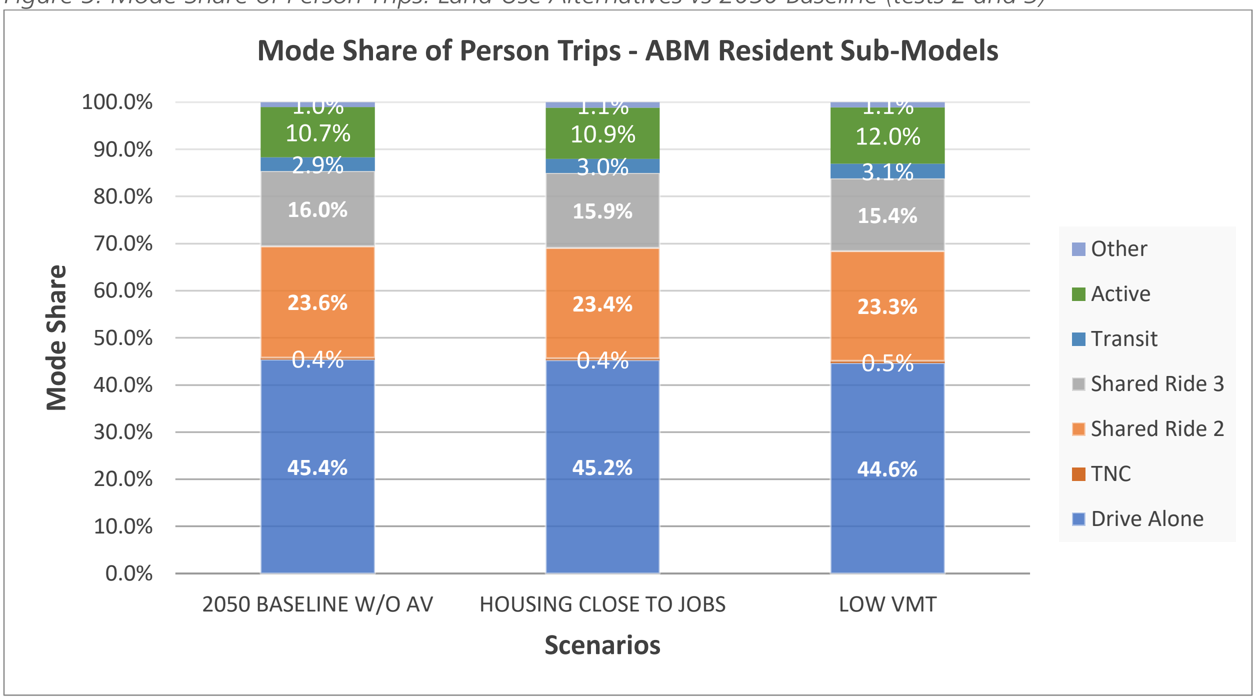


Figure 6. Transit Boarding Change from Baseline: Land Use Alternatives vs 2050 Baseline (tests 2 and 3)

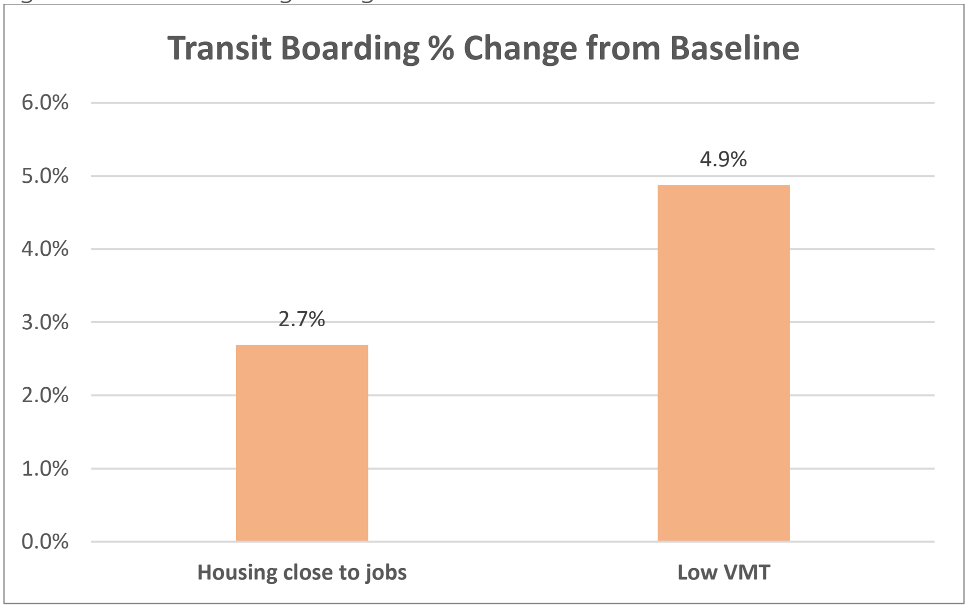


Table 3. Person Trip Distance by Purpose: Land Use Alternatives vs 2050 Baseline (tests 2 and 3)

Alternative	Rec.	Dining	Escort	Home	Maint.	School	Shop	Univ	Visit	Work	Total
2050 baseline w/o AV	4.9	5.3	5.2	6.0	5.1	4.6	4.2	8.2	5.8	10.3	6.1
Housing close to jobs	4.7	5.2	5.1	5.9	4.9	4.6	4.2	8.1	5.8	10.2	6.0
Low VMT	4.6	5.1	4.9	5.7	4.9	4.3	4.0	8.2	5.6	10.3	5.9

Residential Density & Intersection Density Tests (Tests 4-7)

Compared with the 2050 baseline, the 50% higher residential density test had the following results:

- VMT decreased by 1.1% (Figure 7)
- San Diego resident mode shares (Figure 8):
  - DA decreased from 45.4% to 44.8%
  - SR3 decreased from 16.0% to 15.7%
  - Transit increased from 2.9% to 3.3%
  - Active modes (walk, bike, and micromobility) increased from 10.7% to 11.1%
- Transit boarding increased by over 10% (Figure 9)

Compared with the 2050 baseline, the 50% lower residential density test had the following results:

- VMT increased by 0.9 % (Figure 7)
- San Diego resident mode shares (Figure 8):
  - DA increased from 45.4% to 46.0%
  - Transit decreased from 2.9% to 2.6%
  - Active mode (walk, bike, and micromobility) decreased from 10.7% to 10.2%

- Transit boarding decreased by nearly 10% (Figure 9)

These results confirm that the ABM2+ is sensitive to residential density. When residential density increased, the model indicated lower VMT, lower auto mode shares, and higher walk, bike, and transit mode shares. When residential density decreased, the opposite effects were observed. It should be noted that these are simply hypothesis tests which hold all other variables constant, neglecting the supply-demand interaction between inter-dependent variables. In the SANDAG model, residential densities are calculated from the synthetic population and MGRA acreage. Since the synthetic population was not altered, the test results should not be interpreted as the effects of +-50% population changes.

Compared with the 2050 baseline, the 10% higher intersection density test had the following results:

- Insignificant VMT change (Figure 7)
- Active mode (walk, bike, and micromobility) increased slightly from 10.7% to 10.8% (Figure 8)
- Transit boarding increased slightly by 1.0% (Figure 9)

Compared with the 2050 baseline, the 10% lower intersection density test had the following results:

- Insignificant VMT change (Figure 7)
- Active mode (walk, bike, and micromobility) decreased slightly from 10.7% to 10.4% (Figure 8)
- Insignificant Transit boarding change (Figure 9)

Although ABM2+ responds to intersection density changes in the expected direction, the impact of +-10% intersection density changes were limited. When intersection density increased, the model indicated slightly higher walk, bike, and transit mode shares. When intersection density decreased, the opposite effects were observed. It should be noted that these are simply hypothesis tests which holds all other variables constant, neglecting the supply-demand interaction between inter-dependent variables. In the SANDAG model, walk and bike times are calculated between each MGRA using an all-streets network. In this test, only the intersection density variable at the MGRA level was changed; the actual network was not altered from the baseline scenario. Therefore, the non-motorized times and distances in the model were unchanged from the baseline scenario; the test results should not be interpreted as the effects of +-10% road network build in the region.

Figure 7. VMT Change: Residential Density & Intersection Density Tests (Tests 4-7)

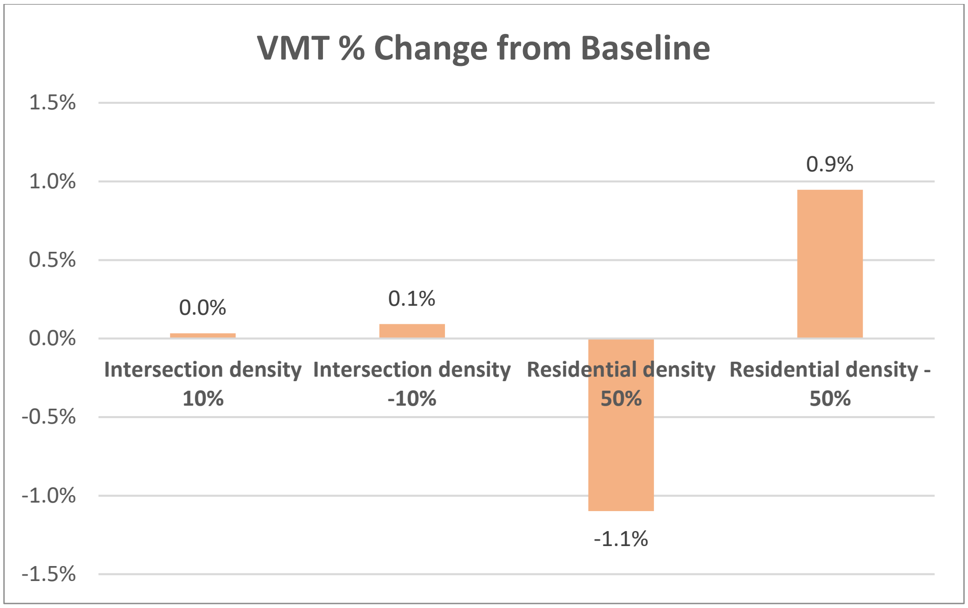

VMT % Change from Baseline
1.5%
1.0%
0.5%
0.0%
-0.5%
-1.0%
-1.5%
0.0%
0.1%
-1.1%
0.9%
Intersection density 10%
Intersection density -10%
Residential density 50%
Residential density -50%

Figure 8. Mode Share of Person Trips: Residential Density & Intersection Density Tests (Tests 4-7)

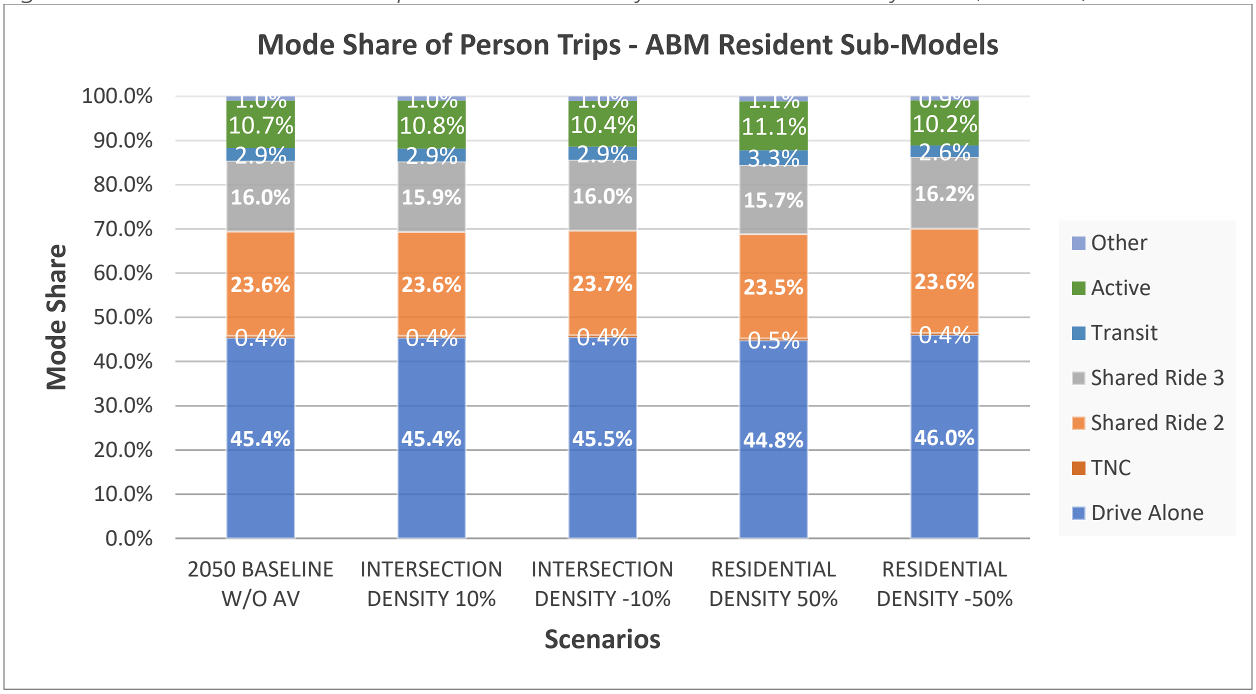
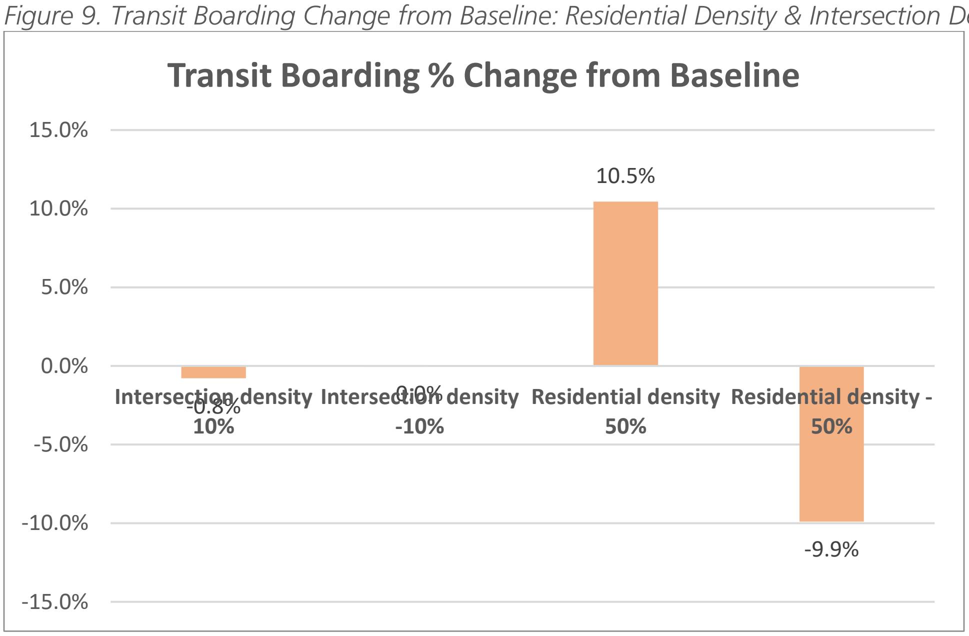


Figure 9. Transit Boarding Change from Baseline: Residential Density & Intersection Density Tests (Tests 4-7)



Transit and Active Transportation

Transit Headway Tests (Tests 9 & 10)

Compared with the 2035 baseline, the 50% more frequent transit services test had the following results:

- VMT increased by 0.3% (Figure 10)

- Mode share for all models (Figure 11):
    - DA decreased from 45.3% to 45.1%
    - Transit increased from 2.7% to 3.1%
- Transit boarding increased by over 16% (Figure 12), suggesting that a 1 percent increase in transit frequency will lead to a ridership increase of 0.32% (elasticity of 0.32).

Compared with the 2035 baseline, the 50% less frequent transit services test had the following results:

- Insignificant VMT change (Figure 13)
- Mode share changes of all models (Figure 11):
    - DA increased from 45.3% to 45.5%
    - Transit decreased from 2.7% to 2.5%
- Transit boarding decreased by over 11% (Figure 12), suggesting that a 1 percent decrease in transit frequency will lead to a ridership decrease of 0.22% (elasticity of 0.22).

The results confirm that ABM2+ is sensitive to transit frequency. When transit services frequency improved, the model indicated higher transit mode share, lower drive alone mode share, and higher transit boardings. When transit services frequency was decreased, the opposite effects were observed. It should be noted that transit boardings changed the most on routes whose headways were changed the most; in other words, reducing headway from 60 minutes to 30 minutes has a much larger effect than changing the headway from 10 minutes to 5 minutes. Another interesting finding was that VMT increased slightly when transit services improved. This may be caused by the additional bus VMT generated by the more frequent services (Table 4).

Figure 10. VMT Change: Transit Headway Tests (Tests 9 & 10)

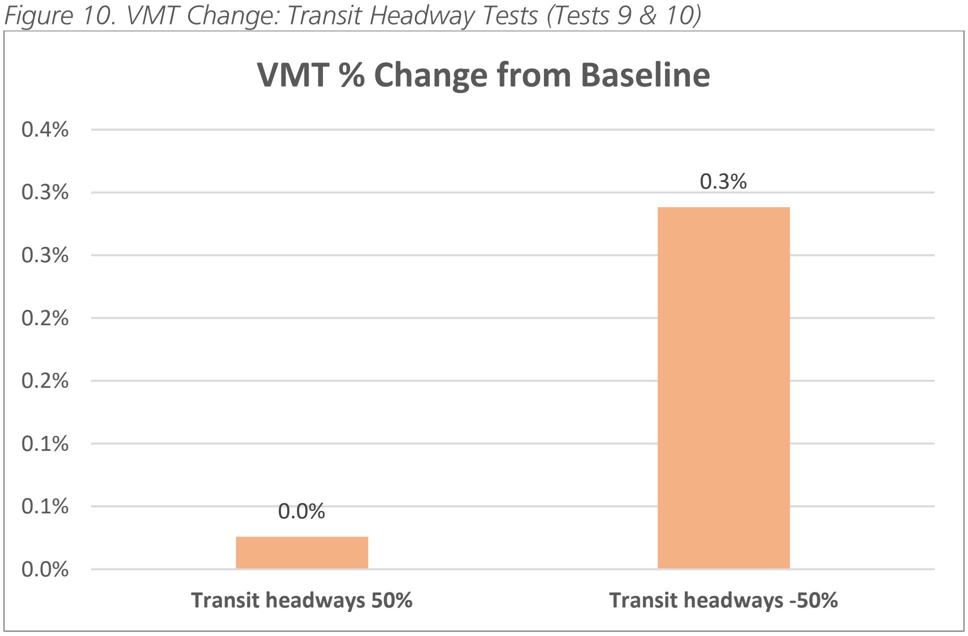


Figure 11. Mode Share of Person Trips: Transit Headway Tests (Tests 9 & 10)

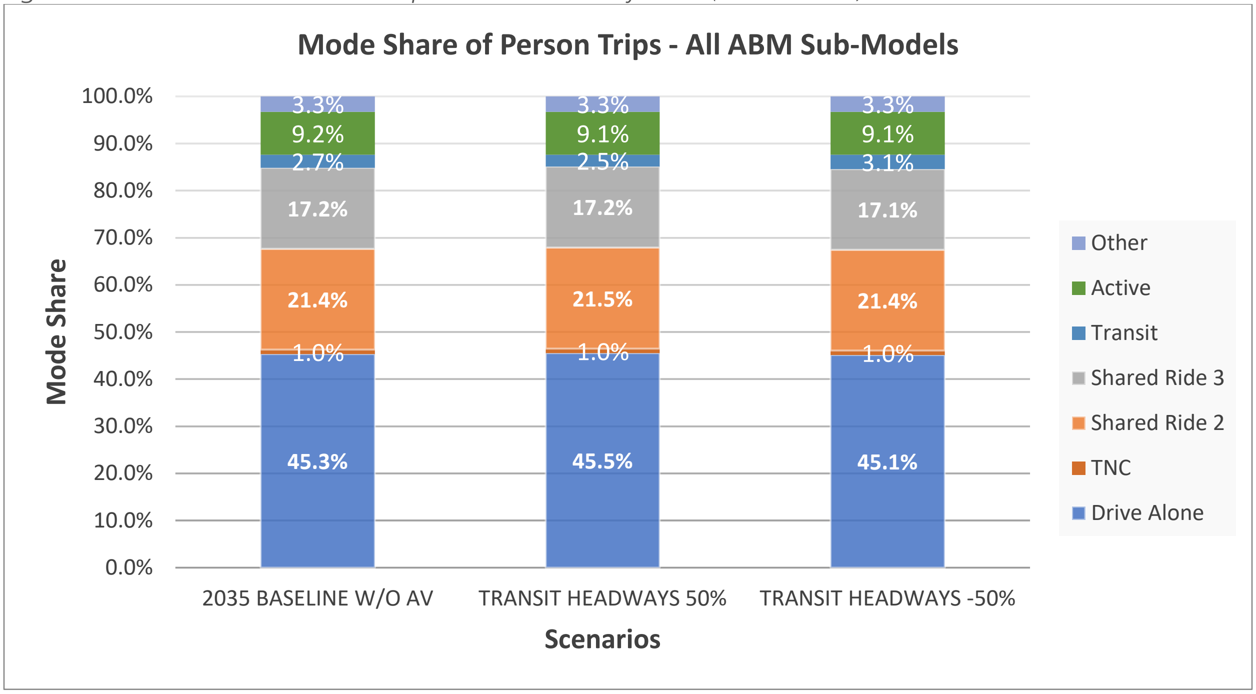


Figure 12. Transit Boarding Change from Baseline: Transit Headway Tests (Tests 9 & 10)

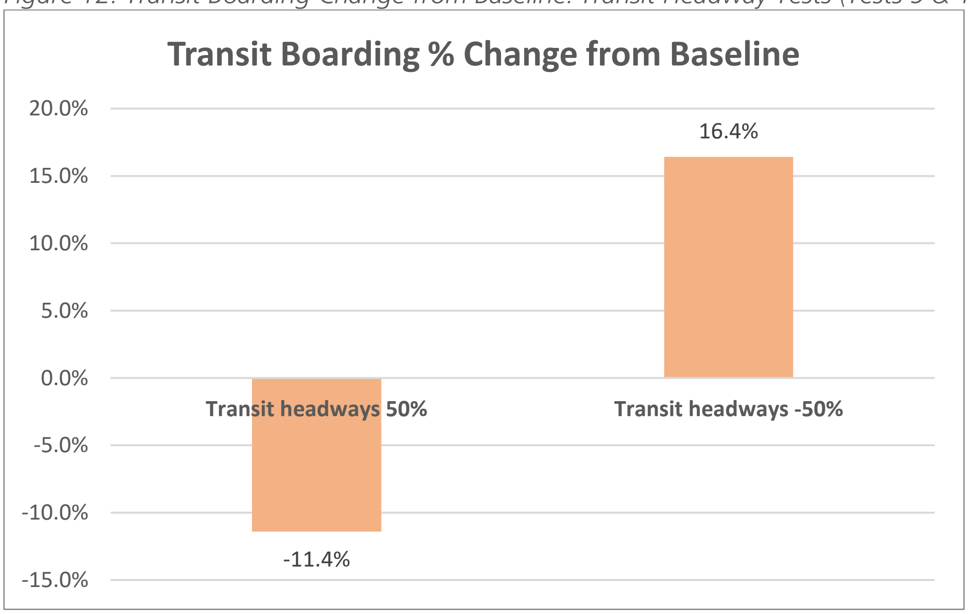


Figure 13. VMT Change from Baseline (Bus Excluded): Transit Headway Tests (Tests 9 & 10)

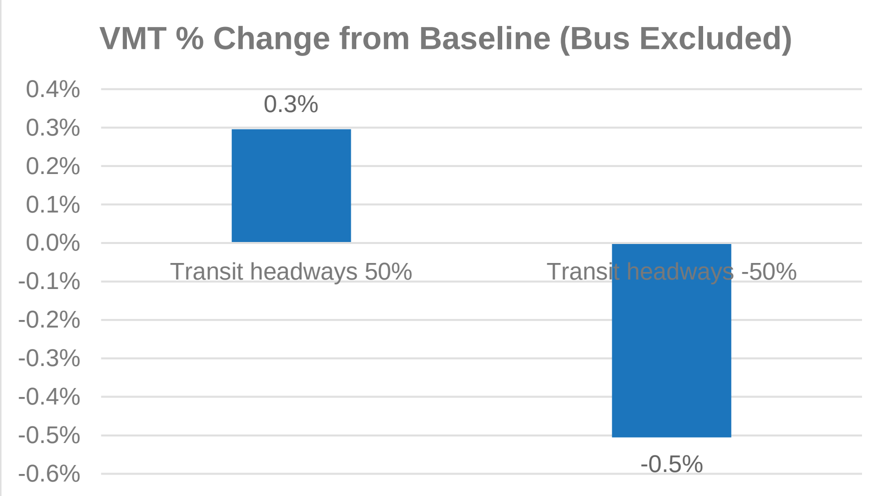


Table 4. VMT by Mode: Transit Headway Tests (Tests 9 & 10)

description	Auto	Truck	Bus	Total	VMT % Change	Total (Bus Excluded)	VMT % Change
2035 baseline w/o AV	90,028,010	4,911,338	762,403	95,701,751	-	94,939,348	
Transit headways 50%	90,306,080	4,914,248	506,083	95,726,411	0.0%	95,220,328	0.3%
Transit headways -50%	89,563,664	4,895,720	1,518,248	95,977,632	0.3%	94,459,384	-0.5%

Self-Owned E-Bike Ownership Tests (Tests 11-13)

To assess the impact of an increase in E-Bike ownership throughout the region, staff created three scenarios with 35%, 65%, and 80% E-Bike ownership shares. These scenarios were created under the presumption that the average bike speed for a scenario with no E-Bike ownership is 10 mph and 15 mph for one with 100% E-Bike ownership. Based upon this, a scenario with 50% E-Bike ownership would have an average bike speed of 12.5 mph. Therefore, by prorating the baseline 10 mph average bike speed of the three scenarios to 11.75 mph, 13.25 mph, and 14 mph, respectively, the desired ownership percentages were applied.

The differences between E-Bikes and traditional bikes are not limited to speed, however. There are aspects of E-Bikes that make them more desirable, such as comfort or ease of use. As this added benefit can bring more utility to individuals, staff included an E-Bike comfort benefit variable in the mode choice calculations. Assuming the benefit of a 100% E-Bike scenario is 20 minutes, the equivalent benefits are 7 minutes, 13 minutes, and 16 minutes for the 35%, 65%, and 80% E-Bike ownership scenarios, respectively.

For this test, the three scenarios were run with and without the E-Bike comfort benefit. This allows for the assessment of the impact of E-Bike ownership and the added comfort benefit separately.

Compared with the 2035 baseline, the test which increased E-Bike ownership to 35% had the following results:

No E-Bike comfort benefit:

- VMT decreased by 0.24% (Figure 14)
- Transit boardings decreased by 0.9% (Figure 15)
- Mode shares of all models (Figure 16):
    - Drive Alone decreased from 40.2% to 40.1%
    - Bike increased from 1.16% to 1.46%
- Average bike distance increased from 3.03 miles to 3.72 miles (Table 5)

With E-Bike comfort benefit:

- VMT decreased by 0.34% (Figure 14)
- Transit boardings decreased by 1.4% (Figure 15)
- Mode shares of all models (Figure 16):
    - Drive Alone decreased from 40.2% to 40.0%
    - Bike increased from 1.16% to 1.64%
    - Walk decreased from 10.9% to 10.8%
- Average bike distance increased from 3.03 miles to 3.69 miles (Table 5)

Compared with the 2035 baseline, the test which increased E-Bike ownership to 65% had the following results:

No E-Bike comfort benefit:

- VMT decreased by 0.35% (Figure 14)
- Transit boardings decreased by 1.5% (Figure 15)
- Mode shares of all models (Figure 16):
    - DA decreased from 40.2% to 40.0%
    - Bike increased from 1.16% to 1.61%
    - Walk decreased from 10.9% to 10.8%
- Average bike distance increased from 3.03 miles to 3.98 miles (Table 5)

With E-Bike comfort benefit:

- VMT decreased by 0.59% (Figure 14)
- Transit boardings decreased by 1.9% (Figure 15)
- Mode shares of all models (Figure 16):
    - DA decreased from 40.2% to 39.9%
    - Bike increased from 1.16% to 1.96%

    - Walk decreased from 10.9% to 10.8%
- Average bike distance increased from 3.03 miles to 3.96 miles (Table 5)

Compared with the 2035 baseline, the test which increased E-Bike ownership to 80% had the following results:

No E-Bike comfort benefit:

- VMT decreased by 0.38% (Figure 14)
- Transit boardings decreased by 1.7% (Figure 15)
- Mode shares of all models (Figure 16):
    - DA decreased from 40.2% to 40.0%
    - Bike increased from 1.16% to 1.69%
    - Walk decreased from 10.9% to 10.8%
- Average bike distance increased from 3.03 miles to 4.15 miles (Table 5)

With E-Bike comfort benefit:

- VMT decreased by 0.68% (Figure 14)
- Transit boardings decreased by 2.6% (Figure 15)
- Mode shares of all models (Figure 16):
    - DA decreased from 40.2% to 39.8%
    - Bike increased from 1.16% to 2.16%
    - Walk decreased from 10.9% to 10.7%
    - Transit decreased from 4.1% to 4.0%
- Average bike distance increased from 3.03 miles to 4.08 miles (Table 5)

The results confirm that ABM2+ is sensitive to E-Bike ownership. When E-Bike ownership increased, the model indicated lower VMT, lower drive alone mode share, lower walk mode share, and higher bike mode share. Additionally, as E-Bike ownership increased, the average bike distance also increased. The results also suggest that ABM2+ is sensitive to the added E-Bike comfort benefit. When the E-Bike comfort benefit was included, the model indicated even lower VMT, lower transit boardings, lower drive alone mode share, lower walk mode share, and higher bike mode share. However, there is a reduction in the average bike distance when compared to the scenarios without the E-Bike benefit.

Figure 14. VMT Change from Baseline: Self-Owned E-Bike Ownership Tests (Tests 11-13)

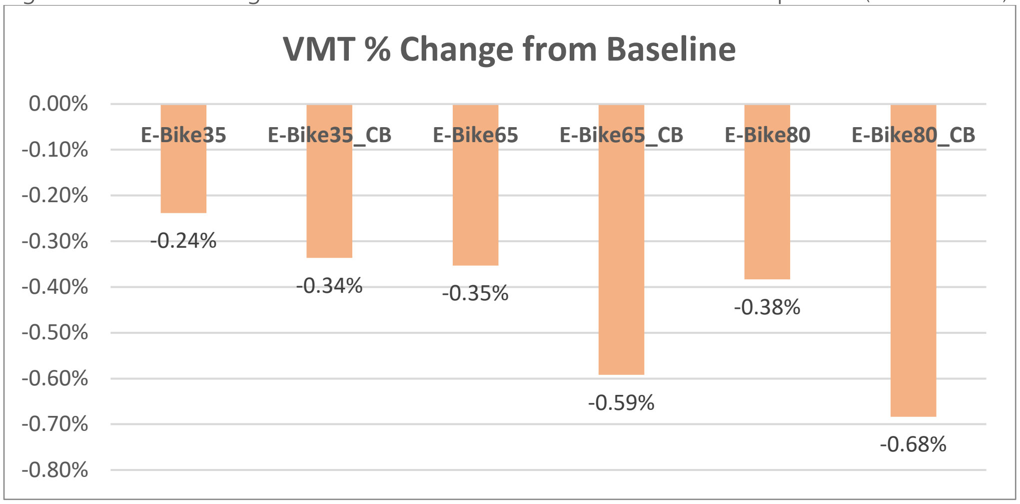


Figure 15. Transit Boarding Change from Baseline: Self-Owned E-Bike Ownership Tests (Tests 11-13)

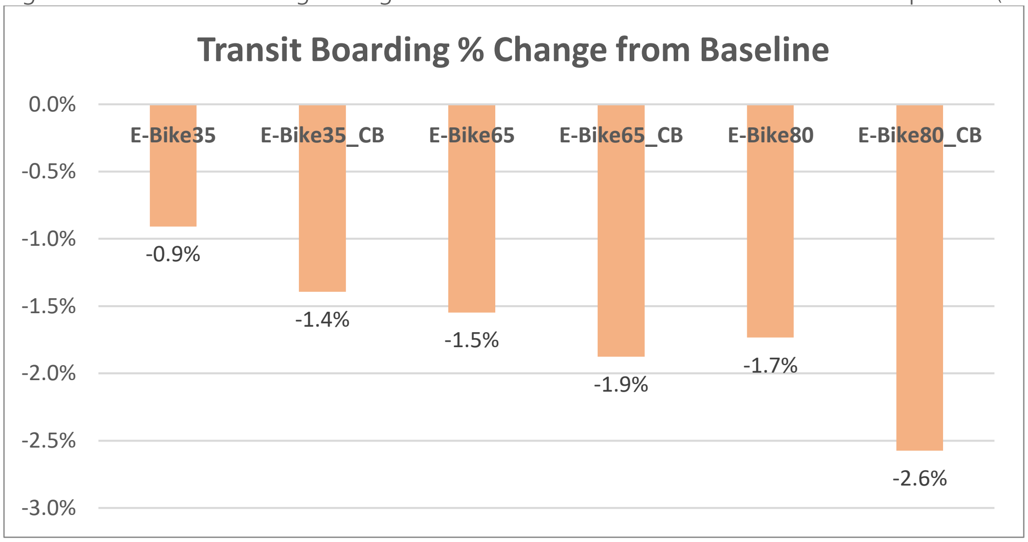


Figure 16. Mode Share of Person Trips: Self-Owned E-Bike Ownership Tests (Tests 11-13)

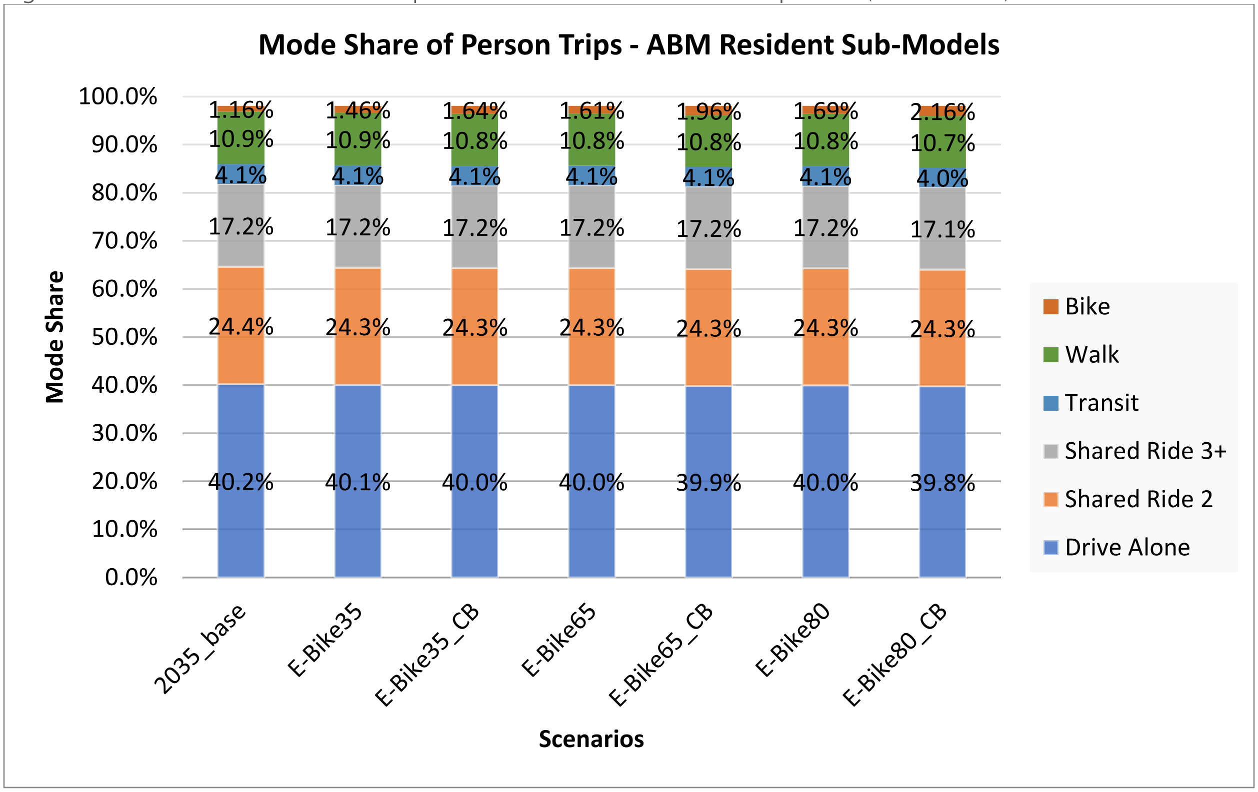


Table 5. Trip Length by Mode: Self-Owned E-Bike Ownership Tests (Tests 11-13)

description	DA	SR2	SR3+	Non-Pooled TNC	Pooled TNC	Walk	Bike	Micro-Mobility	Micro-Transit	Transit	Total
2035_BASE	7.4	5.8	5.9	3.8	6.5	0.8	3.03	0.9	1.1	9.7	6.0
E-Bike35	7.4	5.8	5.9	3.8	6.5	0.8	3.72	0.9	1.1	9.7	6.0
E-Bike35_CB	7.4	5.8	5.9	3.8	6.5	0.8	3.69	0.9	1.1	9.7	6.0
E-Bike65	7.4	5.8	5.9	3.8	6.5	0.8	3.98	0.9	1.0	9.7	6.0
E-Bike65_CB	7.4	5.8	5.9	3.8	6.5	0.8	3.96	0.9	1.1	9.7	6.0
E-Bike80	7.4	5.8	5.9	3.8	6.5	0.8	4.15	0.9	1.1	9.7	6.0
E-Bike80_CB	7.4	5.8	5.9	3.8	6.5	0.8	4.08	0.9	1.1	9.7	6.0

Local/Regional Pricing

Auto Operating Cost (AOC) Tests (Tests 14 & 15)

Compared with the 2035 baseline, the 50% AOC increase test had the following results:

- VMT decreased by 5% (Figure 17), suggesting that a 1 percent increase in AOC will lead to a VMT decrease of 0.1% (elasticity of -0.1).
- Mode shares for all models (Figure 18):
    - DA decreased from 45.3% to 44.9%
    - SR2 decreased from 21.4% to 21.3%
    - SR3 decreased from 17.2% to 16.8%

  - Transit mode share increased from 2.7% to 3.1%
  - Active modes (walk, bike, and micromobility) increased from 9.2% to 9.5%
- Transit boarding increased by nearly 14% (Figure 19)
- Average trip distance decreased from 7.2 miles to 7.0 miles; DA, SR2, and SR3 trip distances all decreased; Transit trip distance increased (Table 6).
- Total person trips for San Diego residents and all travelers decreased by 1.5% and 1.7%, respectively (Figure 20).

Compared with the 2035 baseline, the 50% AOC decrease test had the following results:

- VMT increased by 3.8% (Figure 17), suggesting that a 1 percent decrease in AOC will lead to a VMT increase of 0.08% (elasticity of -0.08).
- Mode share changes for all models (Figure 18):
  - DA increased from 45.3% to 45.7%
  - SR2 increased from 21.4% to 21.6%
  - SR3 increased from 17.2% to 17.6%
  - Transit mode share decreased from 2.6% to 2.3%
  - Active mode (walk, bike, and micromobility) decreased from 9.2% to 8.8%
- Transit boarding decreased by nearly 14% (Figure 19).
- Average trip distance increased from 7.2 miles to 7.5 miles; DA, SR2, and SR3 trip distances all increased; Transit trip distance decreased (Table 6).
- Total personal trips for San Diego residents and all travelers increased by 1.8% and 2.0% respectively (Figure 20).

The results confirm that auto operating cost is a key variable that affects VMT and mode share. When AOC increased, the model indicated lower auto mode share, higher transit, walk, bike, and micromobility mode shares, and shorter trip distance. The AOC increase, essentially making driving less affordable, lowered overall travel demand by 1.7%. The combined effect of mode share shifts toward non-auto modes, reduced travel demand, and shorter trip distance resulted in significant VMT decrease. When AOC decreased, the opposite effects were observed.

Figure 17. VMT Change from Baseline: Auto Operating Cost (AOC) Tests (Tests 14 & 15)

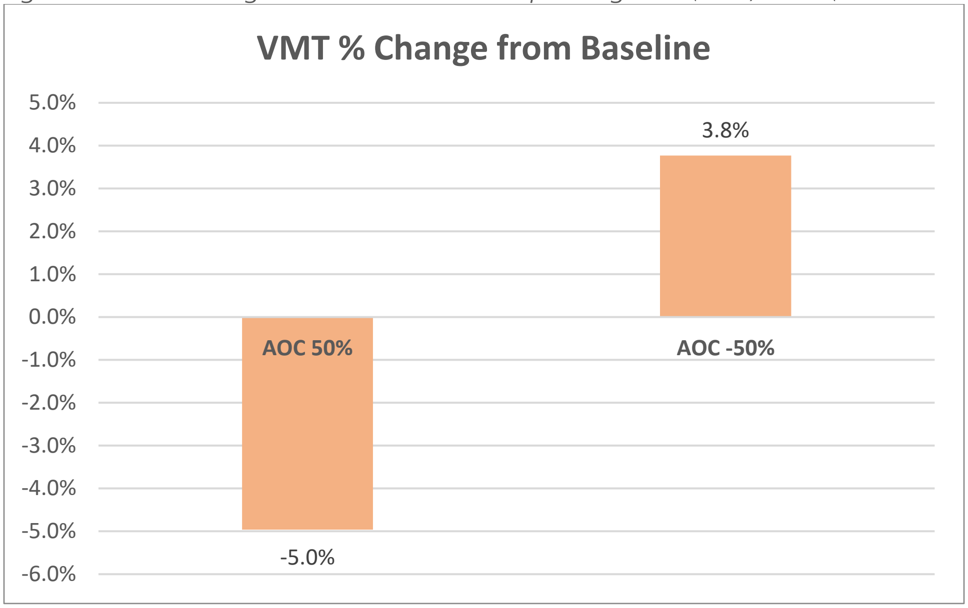


Figure 18. Mode Share of Person Trips: Auto Operating Cost (AOC) Tests (Tests 14 & 15)

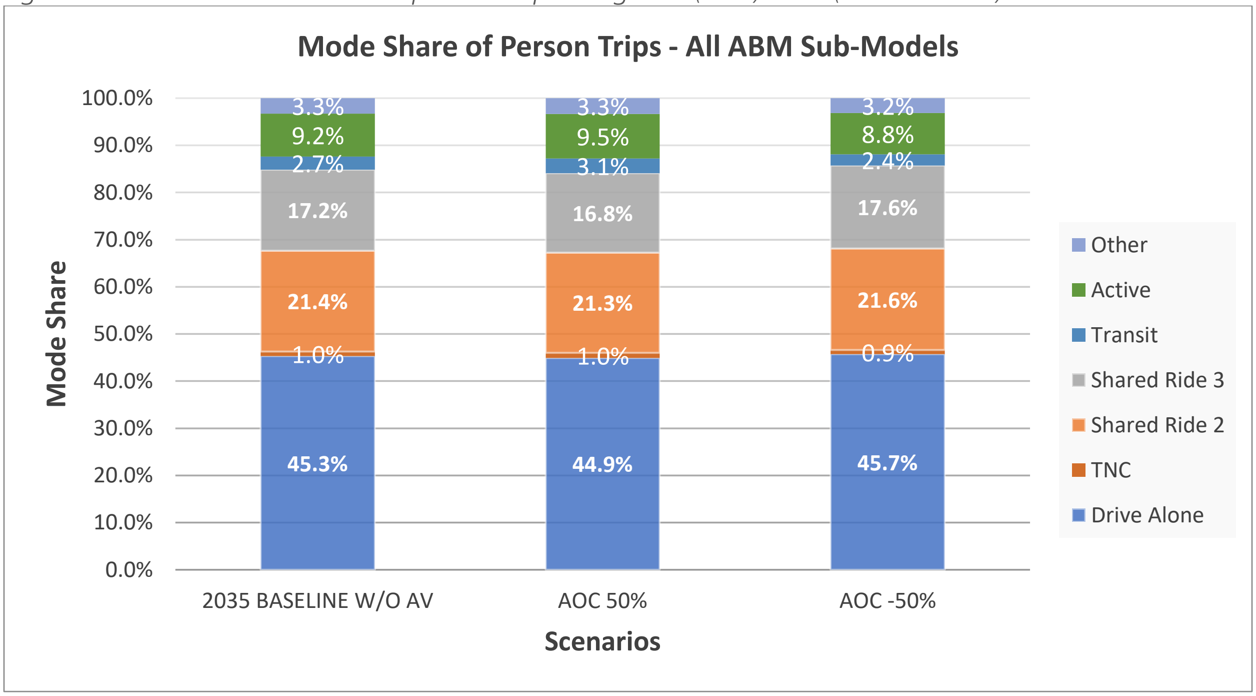


Figure 19. Transit Boarding Change from Baseline: Auto Operating Cost (AOC) Tests (Tests 14 & 15)

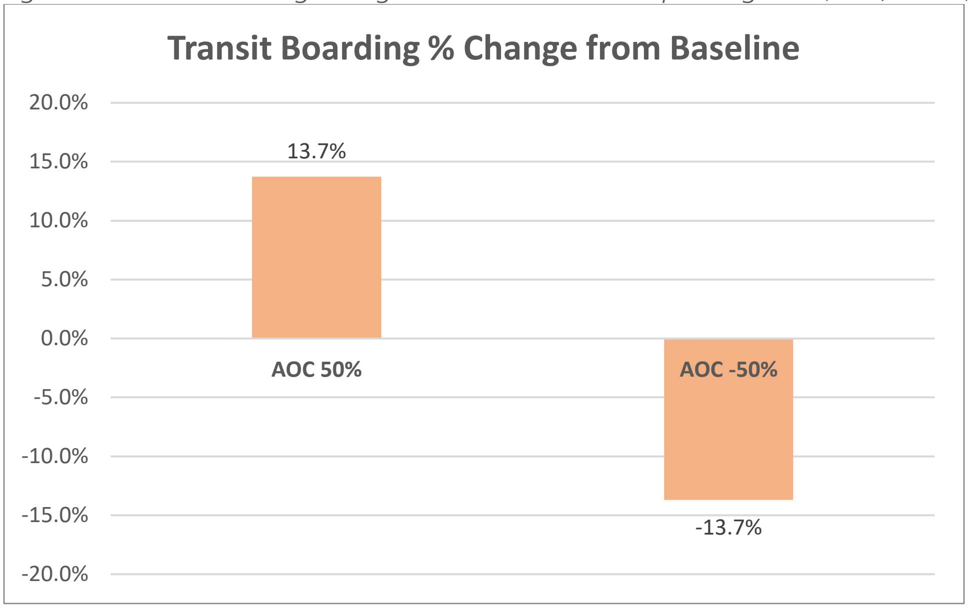


Figure 20. Total Person Trips Change from Baseline: *Auto Operating Cost (AOC) Tests (Tests 14 & 15)*

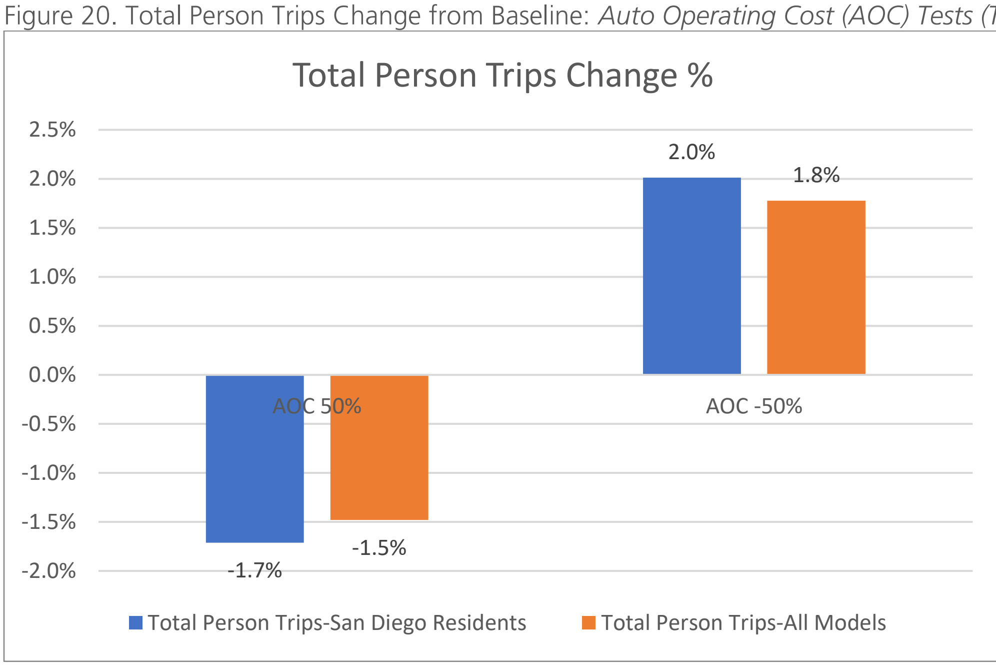


Table 6. Person Trip Distance by Mode: Auto Operating Cost (AOC) Tests (Tests 14 & 15)

description	DA	SR2	SR3	TNC	Pooled TNC	Walk	Bike	Transit	Total
2035 baseline w/o AV	7.9	7.2	7.8	7.6	4.8	0.8	3.2	9.2	7.2
AOC 50%	7.7	7.0	7.4	7.8	5.0	0.8	3.3	9.7	7.0
AOC -50%	8.2	7.5	8.4	7.5	4.6	0.8	3.0	8.8	7.5

Transit Fare Tests (Tests 16-18)

Compared with the 2035 baseline, the free transit fare test had the following results:

- VMT decreased by 1.1% (Figure 21)
- Mode shares for all models (Figure 22):
    - DA decreased from 45.3% to 44.6%
    - SR3 decreased from 17.2% to 16.9%
    - Transit increased from 2.7% to 4.0%
    - Active modes (walk, bike, and micromobility) decreased slightly from 9.2% to 9.0%
- Transit boarding increased by nearly 50% (Figure 23), suggesting that a 1 percent decrease in transit fare will lead to a transit ridership increase of 0.5% (elasticity of -0.5).

Compared with the 2035 baseline, the 50% fare decrease test had the following results:

- VMT decreased by 0.5% (Figure 21)
- Mode shares of all models (Figure 22):
    - DA decreased from 45.3% to 45.0%
    - Transit increased from 2.7% to 3.3%
    - Active modes (walk, bike, and micromobility) decreased slightly from 9.2% to 9.1%
- Transit boarding increased by over 20% (Figure 23), suggesting that a 1 percent decrease in transit fare will lead to transit ridership increase of 0.4% (elasticity of -0.4).

Compared with the 2035 baseline, the 50% fare increase test had the following results:

- VMT increased by 0.4% (Figure 21)
- Mode share changes (Figure 22):
    - DA increased from 45.3% to 45.6%
    - Transit decreased from 2.7% to 2.3%
- Transit boarding decreased by 17% (Figure 23), suggesting that a 1 percent increase in transit fare will lead to a transit ridership decrease of 0.38% (elasticity of -0.38).

The results confirm that ABM2+ is sensitive to transit fares. When transit fares decreased, the model indicated lower VMT, higher transit mode share, and lower drive alone mode share. The slightly lower walk, bike, and micromobility mode shares suggest that there is competition between transit mode and walk, bike, and micromobility modes. When transit fares increased, the opposite effects were observed.

Figure 21. Total Person Trips Change from Baseline: *Transit Fare Tests (Tests 16-18)*

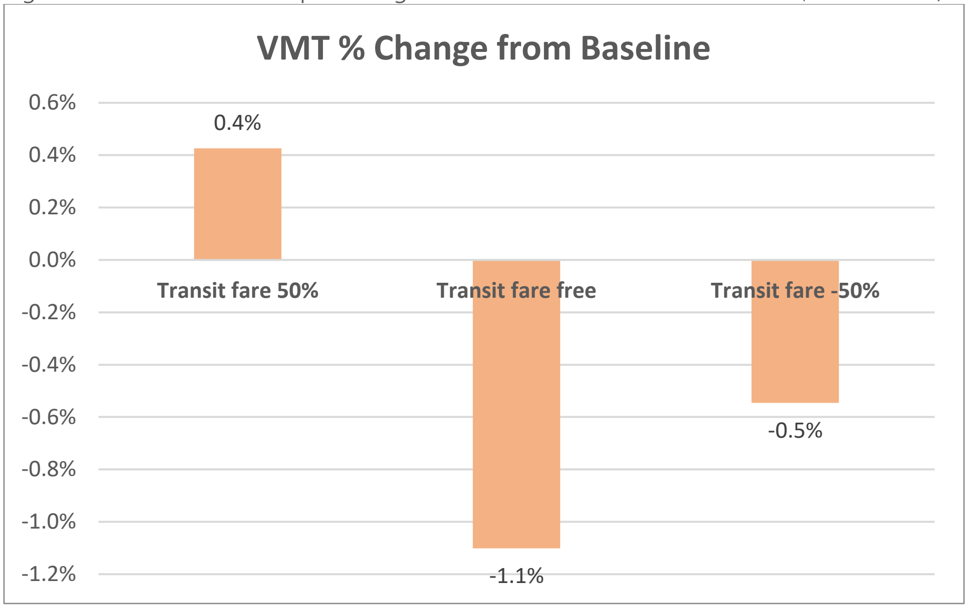


Figure 22. Mode Share of Person Trips: *Transit Fare Tests (Tests 16-18)*

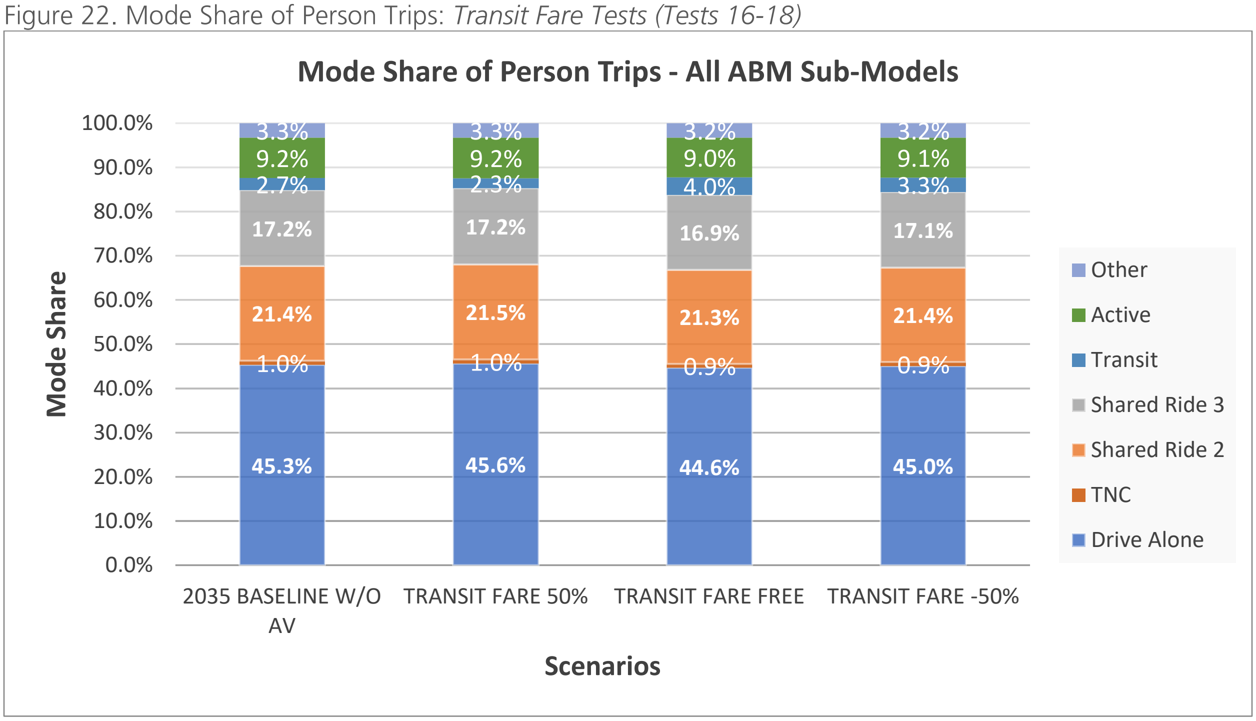
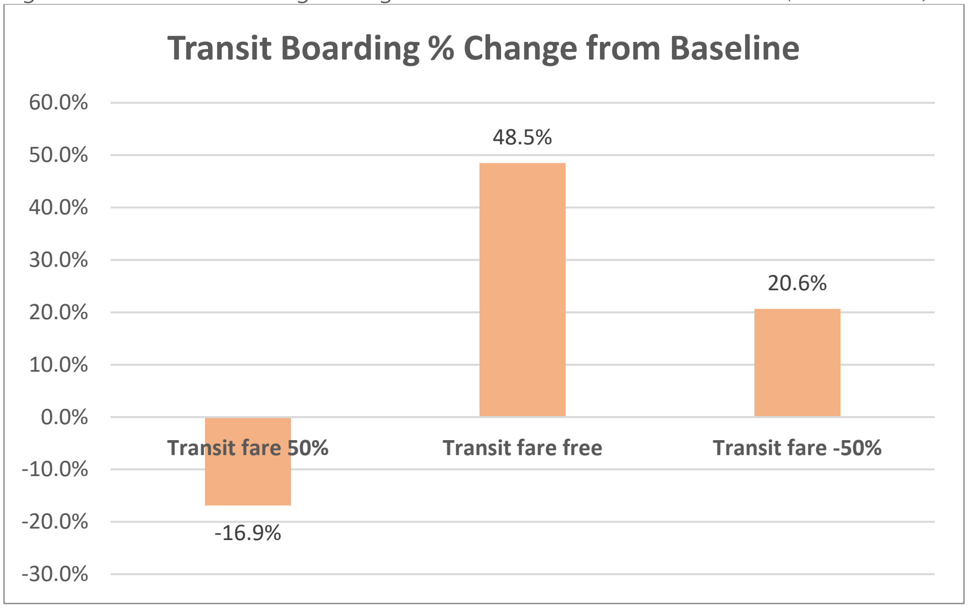


Figure 23. Transit Boarding Change from Baseline: *Transit Fare Tests (Tests 16-18)*



Managed Lane/Toll Price Tests (Tests 19 & 20)

Compared with the 2035 baseline, the 50% toll increase test had the following results:

- VMT decreased slightly by 0.1% (Figure 24)
- Percent of VMT on toll roads decreased from 3.2% to 2.6% (Figure 27)
- Insignificant mode share changes (Figure 25)
- Toll road volumes decreased significantly by 20% (Figure 26).

Compared with the 2035 baseline, the 50% toll decrease test had the following results:

- VMT increased by 0.2% (Figure 24)
- Percent of VMT on toll roads increased from 3.2% to 4.1% (Figure 27)
- Insignificant mode share changes (Figure 25)
- Toll road volumes increased by 33% (Figure 26)

The results confirm that ABM2+ is sensitive to managed lane/toll pricing. When toll price increased, both traffic volumes and VMT on toll roads decreased significantly. However, the model only indicated slightly lower VMT primarily because toll roads are only a very small portion of San Diego's transportation system. Also note that on I-15, only single-occupant vehicles are tolled; therefore changing the toll cost only affects the price for SOV usage of the facility, and when SOV usage decreases, there is additional capacity for high-occupancy vehicles which may take advantage of the increased available capacity. When managed lane/toll price decreased, the opposite effects were observed.

Figure 24. VMT Change from Baseline: Managed Lane/Toll Price Tests (Tests 19 & 20)

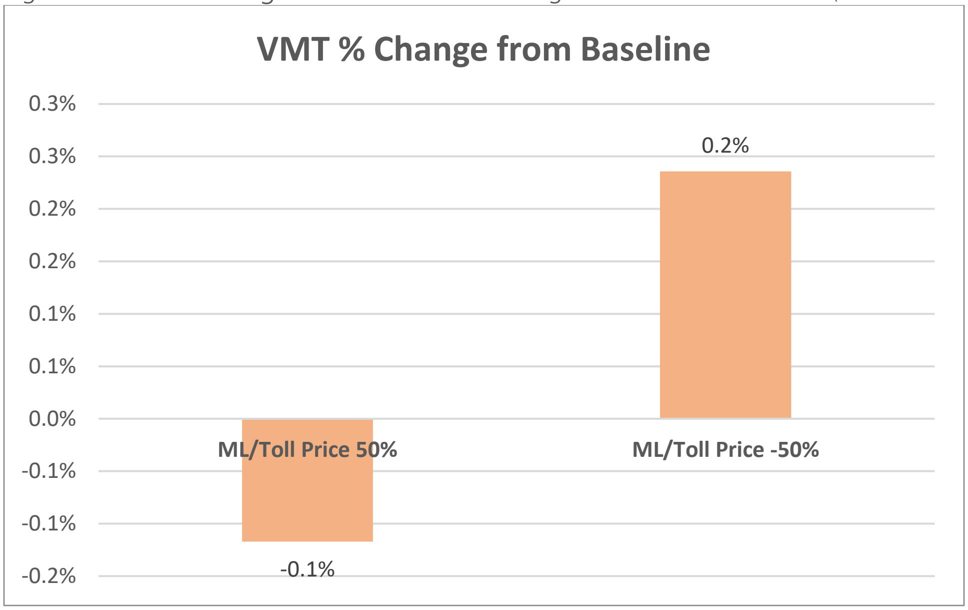


Figure 25. Mode Share of Person Trips: Managed Lane/Toll Price Tests (Tests 19 & 20)

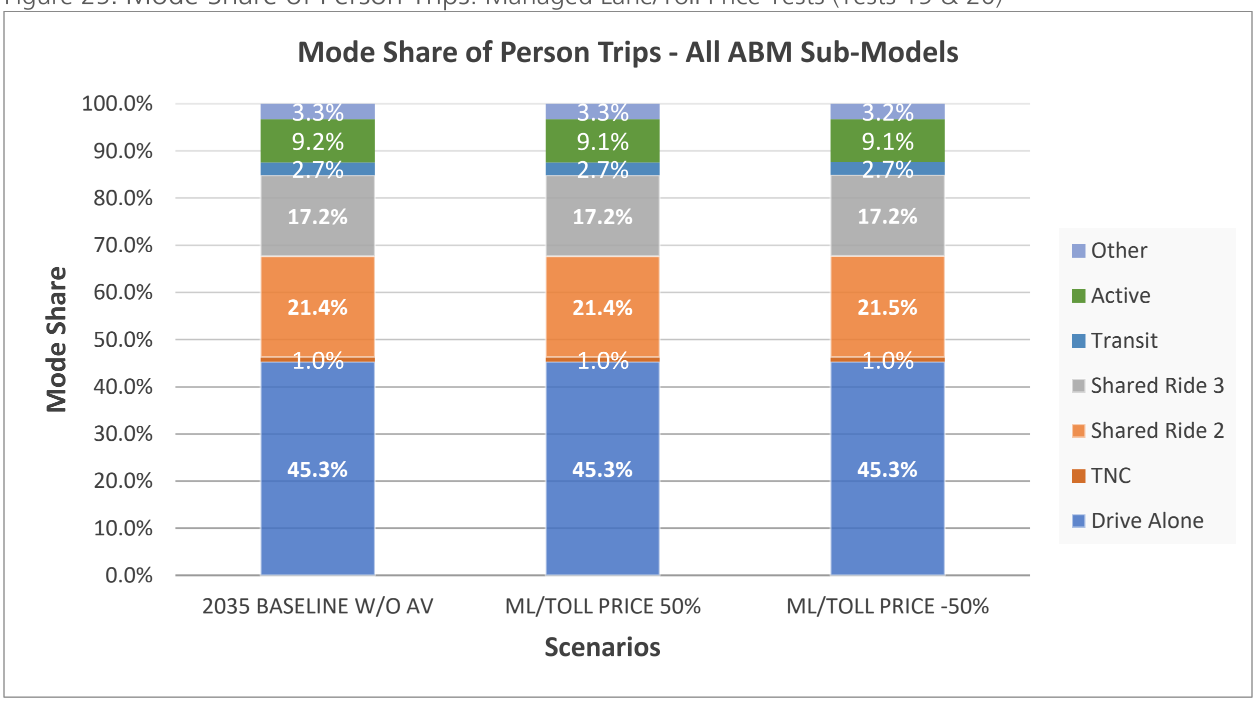


Figure 26. Toll Road Volumes Change from Baseline: Managed Lane/Toll Price Tests (Tests 19 & 20)

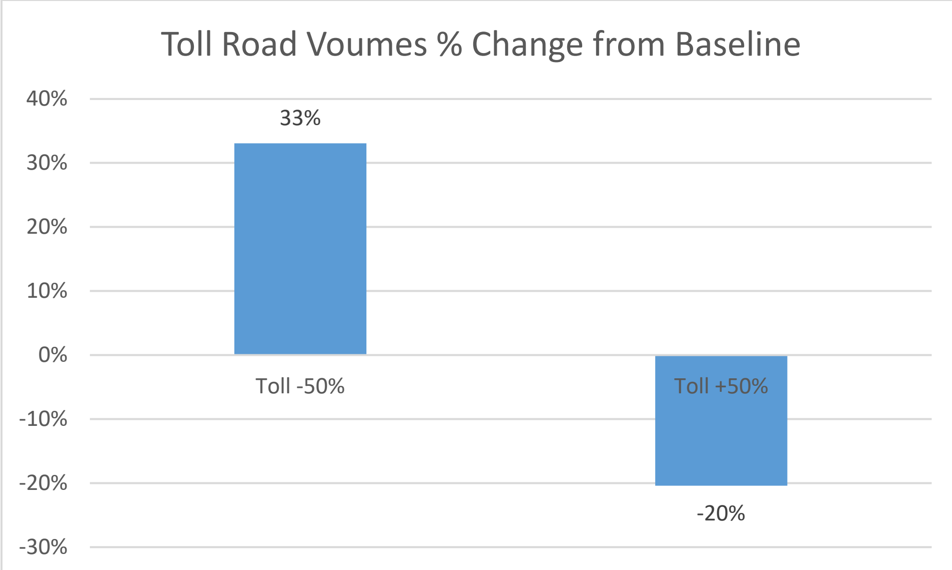
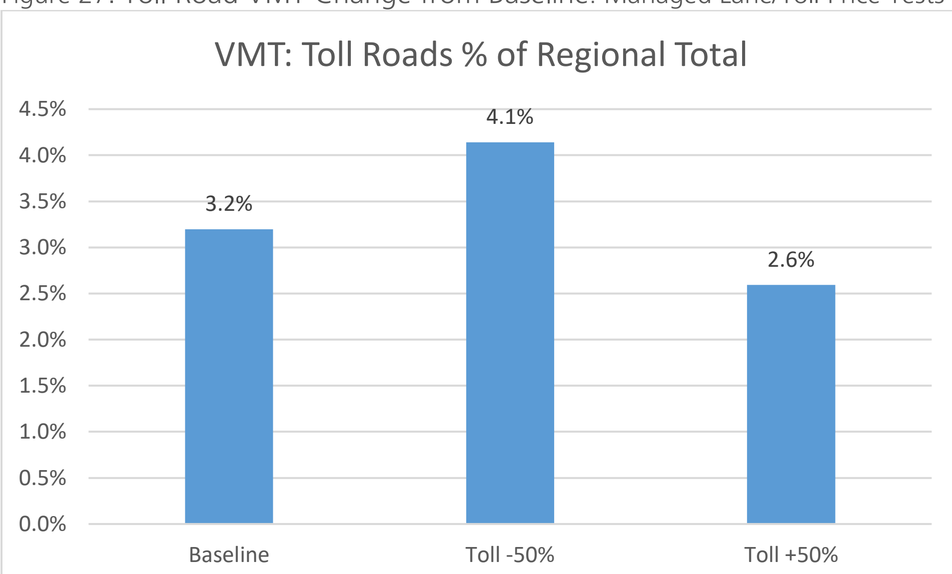


Figure 27. Toll Road VMT Change from Baseline: Managed Lane/Toll Price Tests (Tests 19 & 20)



Parking Cost Tests (Tests 21 & 22)

In comparison with the baseline, the high parking cost test had the following results:

- VMT decreased by 1.4% (Figure 28)
- Mode shares for all models (Figure 29):
    - DA decreased from 45.3% to 44.1%
    - SR3 increased from 17.2% to 17.4%

    - Transit increased from 2.7% to 3.2%
    - Active modes (walk, bike, and micromobility) increased from 9.2% to 9.5%
- Transit boarding increased by over 17% (Figure 30)
- Although the overall trip distance change was insignificant, DA trip distance increased slightly from 7.9 miles to 8.0 miles (Table 7).
- Total person and vehicle trips decreased by 0.2% and 0.4%, respectively (Figure 31).

In comparison with the baseline, a very high parking cost had the following results:

- VMT decreased by 2.8% (Figure 28);
- Mode share changes (Figure 29):
    - DA decreased from 45.3% to 42.7%
    - SR3 increased from 17.2% to 17.8%
    - Transit mode share increased from 2.7% to 3.6%
    - Active modes (walk, bike, and micromobility) increased from 9.2% to 10.1%
- Transit boarding increased by nearly 30% (Figure 30)
- Although the overall trip distance change was insignificant, DA trip distance increased from 7.9 miles to 8.1 miles (Table 7).
- Total person and vehicle trips decreased by 0.5% and 1.2%, respectively (Figure 31).

The results confirm that parking cost is a key variable that affects VMT and mode shares. When parking price increased, the model indicated lower VMT, lower DA mode share, higher transit mode share, and higher walk, bike, and micromobility mode shares. The slightly increased drive alone distance indicated that drivers park further away from destinations to avoid high parking fees.

Figure 28. VMT Change from Baseline: Parking Cost Tests (Tests 21 & 22)

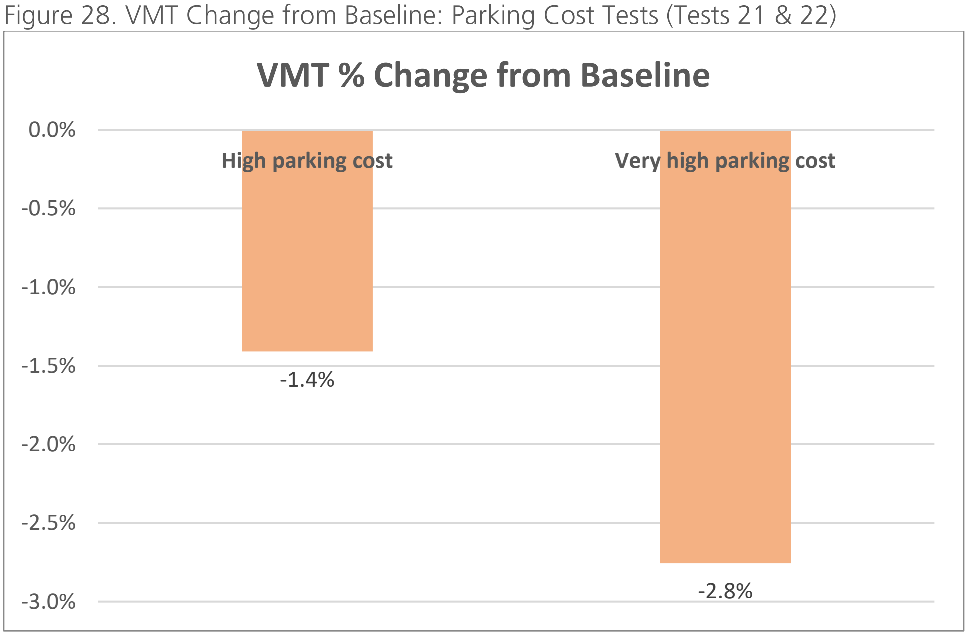


Figure 29. Mode Share of Person Trips: Parking Cost Tests (Tests 21 & 22)

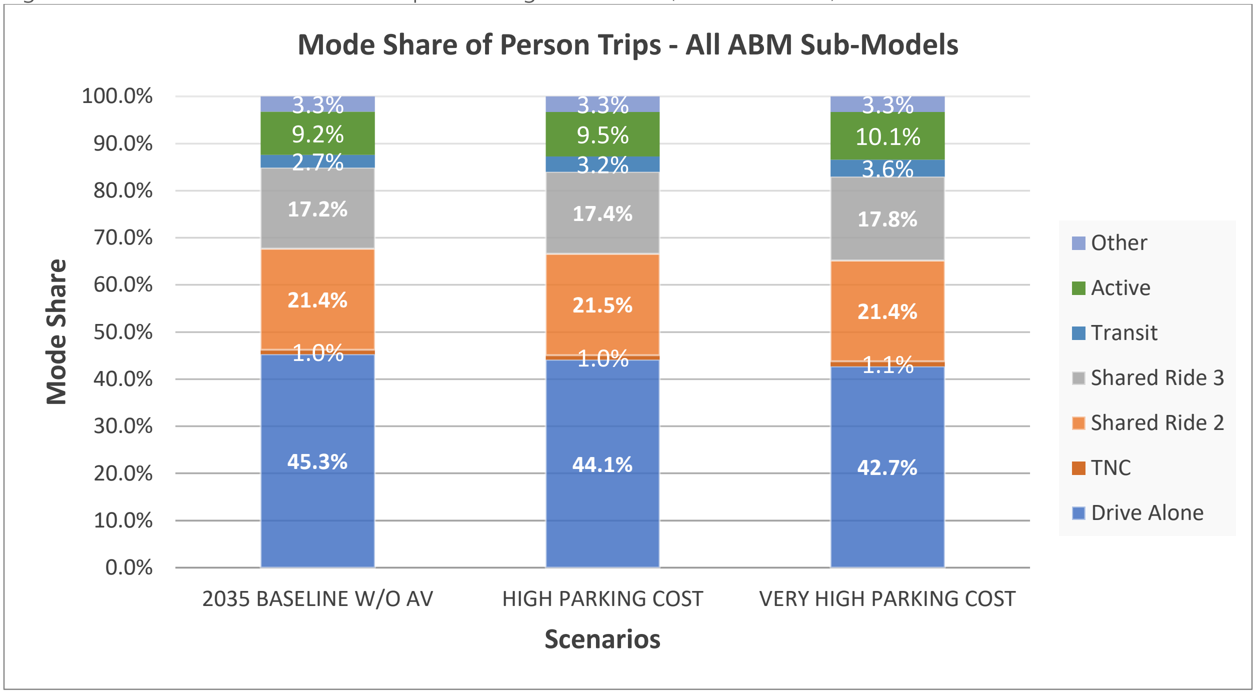


Figure 30. Transit Boarding Change from Baseline: Parking Cost Tests (Tests 21 & 22)

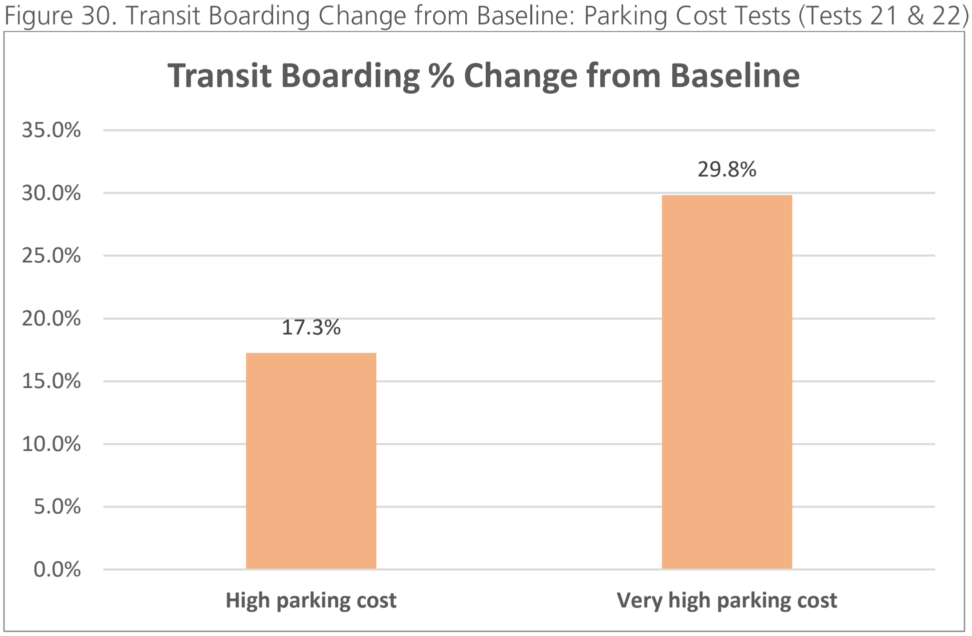


Figure 31. Total Person Trips and Trips Change from Baseline: Parking Cost Tests (Tests 21 & 22)

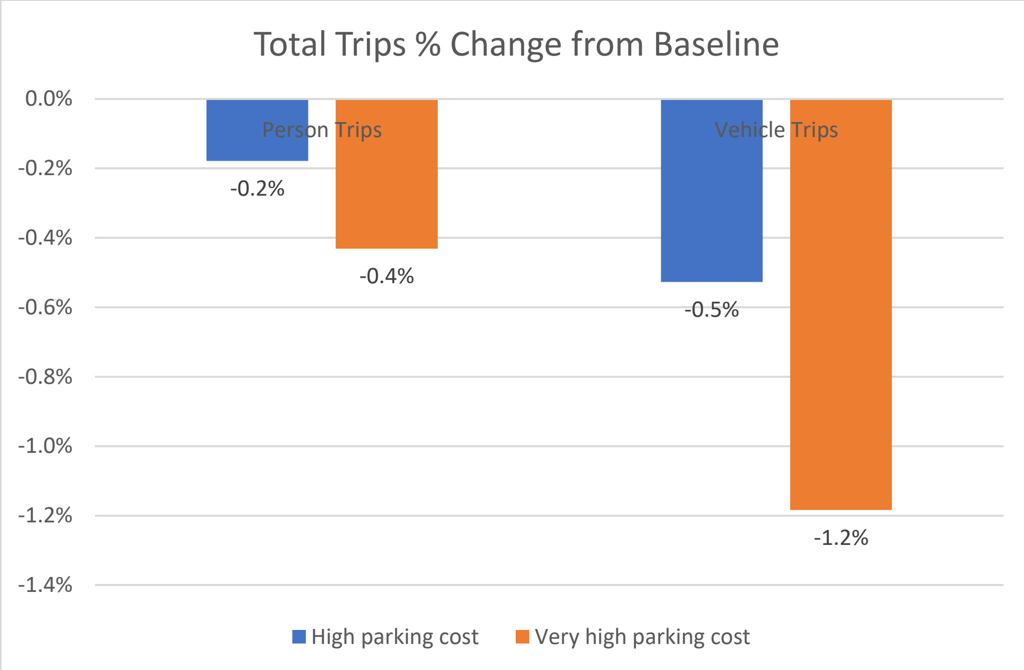


Table 7. Person Trip Distance by Mode: Parking Cost Tests (Tests 21 & 22)

description	DA	SR2	SR3	TNC	Pooled TNC	Walk	Bike	Transit	Total
2035 baseline w/o AV	7.9	7.2	7.8	7.6	4.8	0.8	3.2	9.2	7.2
High parking cost	8.0	7.2	7.8	7.5	4.7	0.8	3.2	9.2	7.2
Very high parking cost	8.1	7.3	7.8	7.3	4.7	0.8	3.2	9.2	7.2

Exogenous Variables

Free Flow Speed Tests (Tests 23 & 24)

Compared with the 2035 baseline, the 5mph free flow speed decrease on freeways test had the following results:

- VMT decreased by nearly 0.5% (Figure 32)
- Insignificant mode share changes (Figure 33)
- Average trip distance decreased slightly from 7.3 miles to 7.2 miles. DA, SR3, and truck trip distances all decreased (Table 8).

Compared with the 2035 baseline, the 5mph free flow speed decrease on all roadways test had the following results:

- VMT decreased by 1.3% (Figure 32)
- Insignificant mode share changes (Figure 33)
- Average trip distance decreased slightly from 7.3 miles to 7.2 miles. DA, SR3, and truck trip distances all decreased (Table 8).

The results lead to the conclusion that reducing free flow speed results in lower VMT. Although mode share changes were insignificant, average trip distance decreased, indicating that the lowered free flow speed discouraged longer trips.

Figure 32. VMT Change from Baseline: Free Flow Speed Tests (Tests 23 & 24)

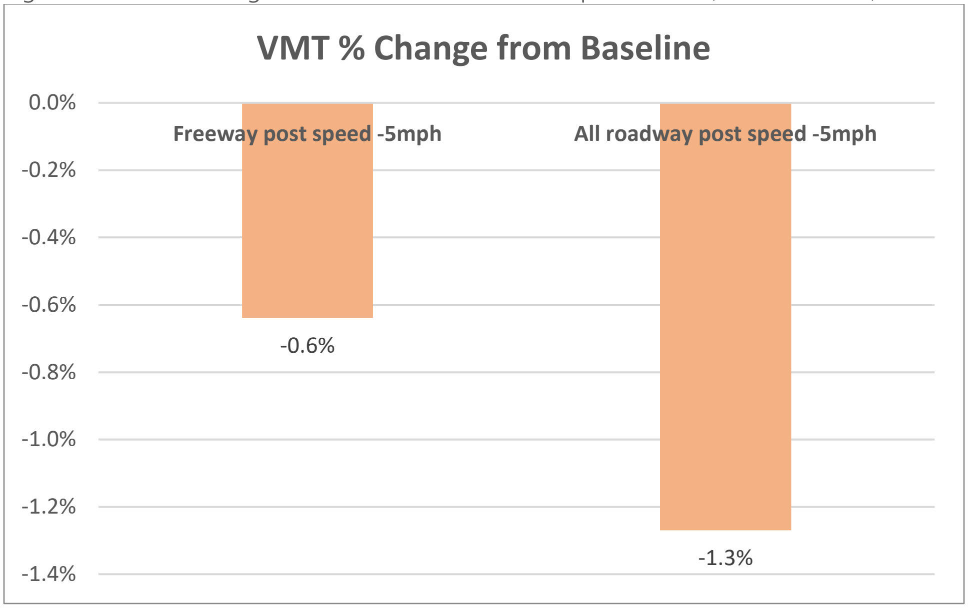


Figure 33. Mode Share of Person Trips: Free Flow Speed Tests (Tests 23 & 24)

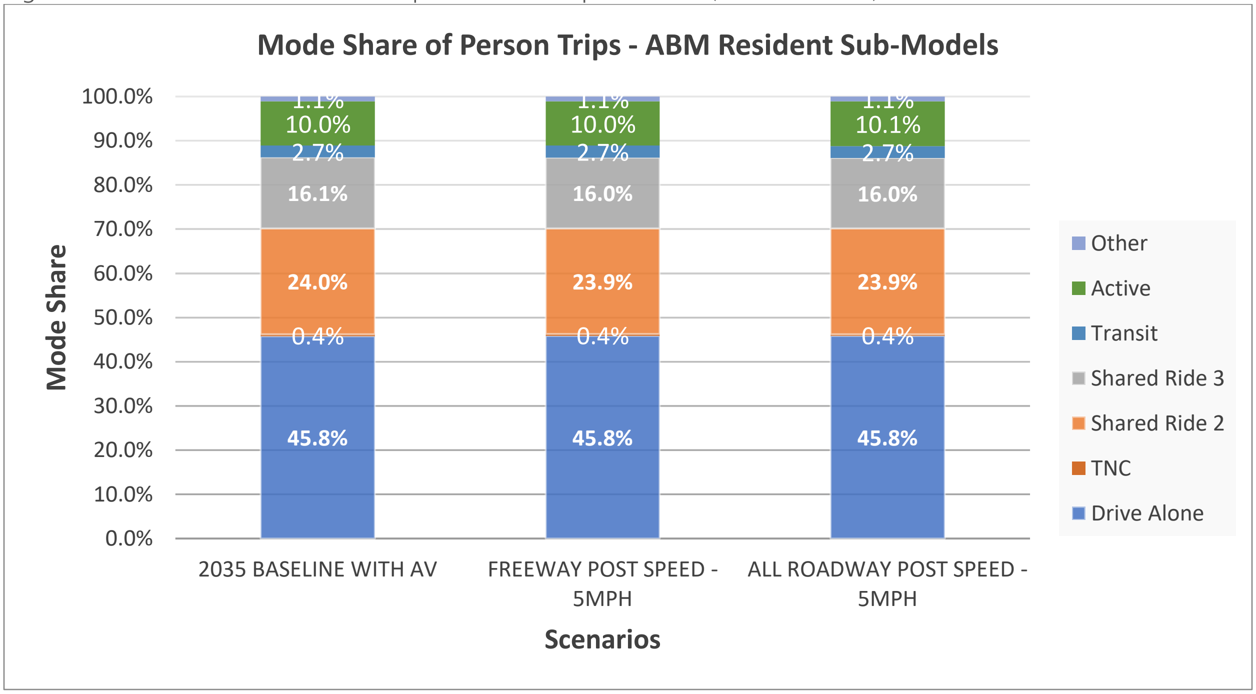


Figure 34. Transit Boarding Change from Baseline: Free Flow Speed Tests (Tests 23 & 24)

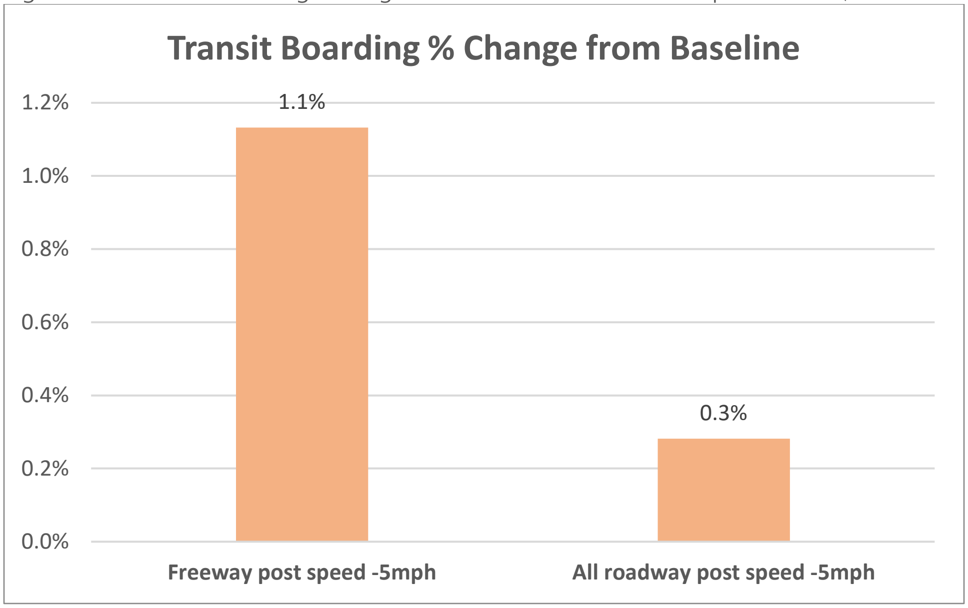


Table 8. Person Trip Distance by Mode: Free Flow Speed Tests (Tests 23 & 24)

description	DA	SR2	SR3	TNC	Pooled TNC	Walk	Bike	Transit	Total
2035 baseline with AV	8.0	7.2	8.3	7.7	6.0	0.8	3.3	9.1	7.3
Freeway post speed -5mph	7.9	7.2	8.2	7.7	6.1	0.8	3.3	9.2	7.2
All roadway post speed -5mph	7.9	7.2	8.2	7.7	6.1	0.8	3.4	9.2	7.2

Household Income Tests (Tests 25 & 26)

In comparison with the 2035 baseline, a test with household income lowered by a third had the following results:

- VMT decreased by 3.3% (Figure 35)
- San Diego resident mode shares (Figure 36):
    - DA decreased from 45.8% to 45.5%
    - SR3 decreased from 16.6% to 16.4%
    - Transit increased from 2.6% to 2.8%
    - Active mode (walk, bike, and micromobility) increased from 9.9% to 10.2%
- Transit boarding increased by 5.5% (Figure 37)
- Trip distance of DA, SR2, and SR3 all decreased; TNC and Taxi trip distance also decreased (Table 8).
- Total person trips of San Diego residents decreased by 2.6% (Figure 38)

In comparison with the 2035 baseline, a test with household income increased by a third had the following results:

- VMT increased by 2% (Figure 35)
- Mode share changes (Figure 36):
    - DA increased from 45.8% to 45.9%
    - SR3 increased from 16.6% to 16.8%
    - Transit decreased from 2.6% to 2.4%
    - Active mode (walk, bike, and micromobility) decreased slightly from 9.9% to 9.8%
- Transit boarding decreased by 3.5% (Figure 37)
- Trip distance of DA, SR2, and SR3 all increased; TNC and Taxi trip distance also increased (Table 8).
- Total person trips of San Diego residents increased by 1.6% (Figure 38)

The results suggest that ABM2+ is sensitive to household income. When household income increased, the model indicated higher VMT, higher auto mode share, lower transit, walk, bike, and micromobility mode shares. The results confirm that a population with higher income would generate more travel demand. With higher income, the distance of auto modes, TNC, and taxi all increased, indicating a higher income encouraged driving or using mobility as a service. When household income decreased, the opposite effects were observed. It should be noted that these are simply hypothesis tests which hold all other variables constant, neglecting the supply-demand interaction between inter-dependent variables. The test results should not be interpreted as the effects of +-1/3 household income changes in San Diego.

Figure 35. VMT Change from Baseline: Household Income Tests (Tests 25 & 26)

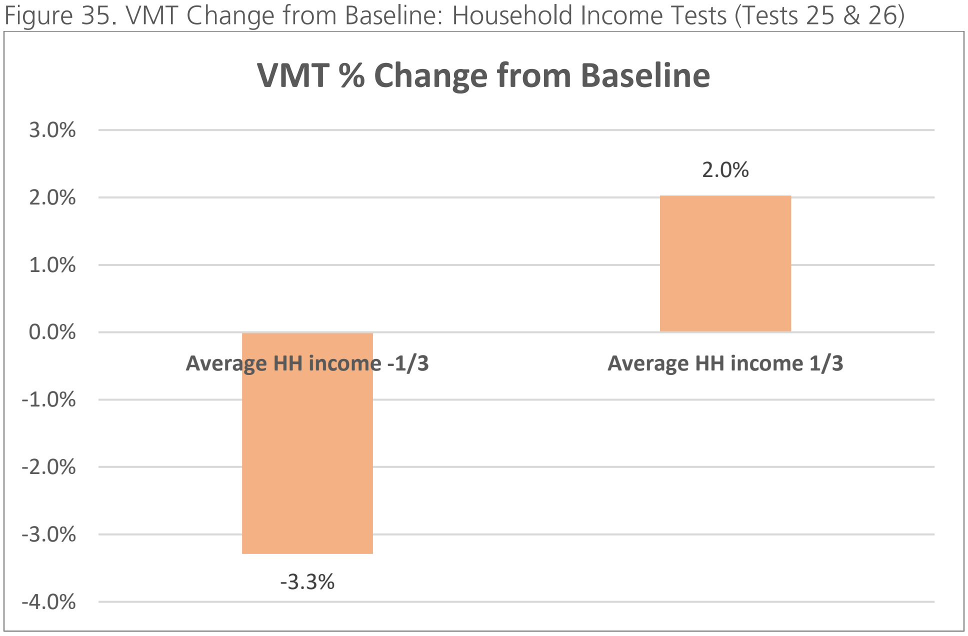


Figure 36. Mode Share of Person Trips: Household Income Tests (Tests 25 & 26)

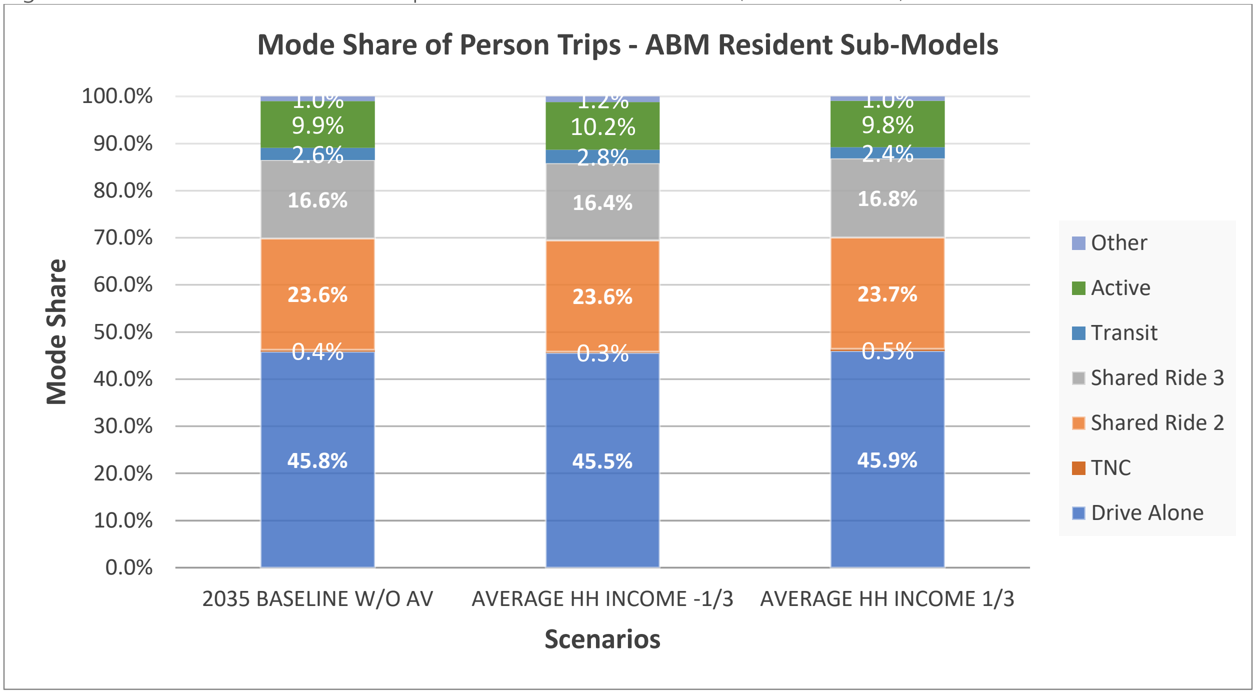


Figure 37. Transit Boarding Change from Baseline: Household Income Tests (Tests 25 & 26)

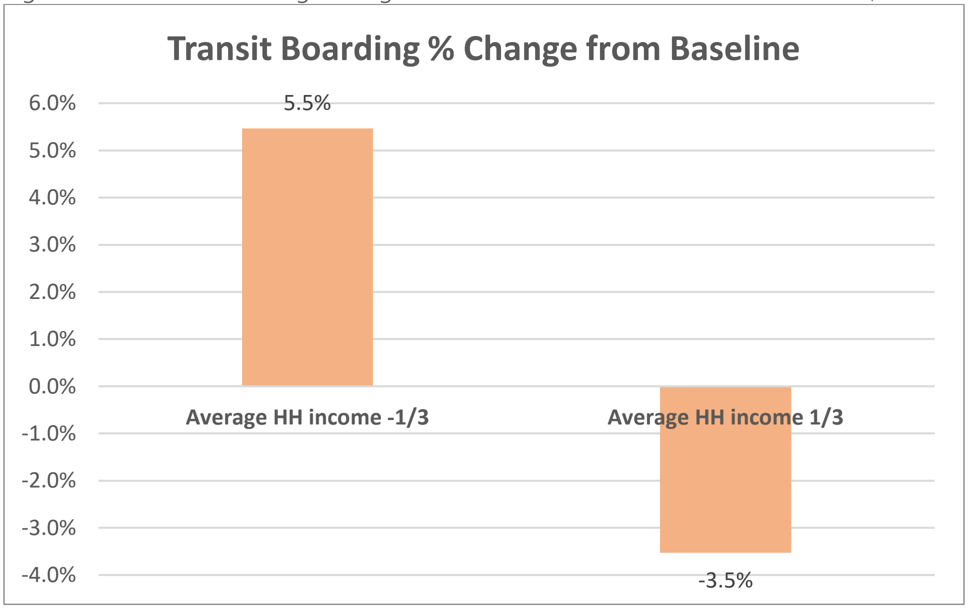


Figure 38. Total Person Trips Change from Baseline: Household Income Tests (Tests 25 & 26)

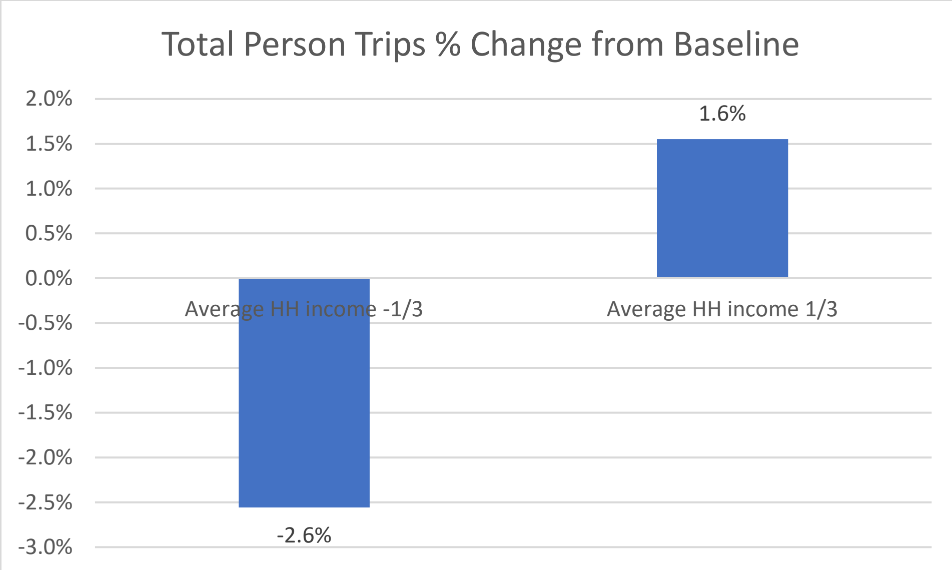


Table 8. Person Trip Distance by Mode: Household Income Tests (Tests 25 & 26)

description	DA	SR2	SR3	TNC	Pooled TNC	Walk	Bike	Transit	Taxi	Total
2035 baseline w/o AV	7.5	5.7	5.9	3.3	3.6	0.8	3.2	8.9	0.9	6.1
Average HH income -1/3	7.4	5.6	5.8	3.1	3.4	0.8	3.3	9.0	0.8	6.1
Average HH income 1/3	7.6	5.8	6.0	3.5	3.7	0.8	3.1	8.9	1.0	6.2

Regional Employment Tests (Tests 27 & 28)

In comparison with the 2035 baseline, a test with 10% larger regional employment had the following results:

- VMT increased by over 4% (Figure 39)
- San Diego resident mode shares (Figure 41):
  - DA increased from 45.8% to 47.9%
  - SR2 decreased from 23.6% to 22.5%
  - SR3 decreased from 16.6% to 15.7%
  - Transit increased from 2.6% to 2.7%
  - Active mode (walk, bike, and micromobility) decreased slightly from 9.9% to 9.8%
- Transit boarding increased by over 5% (Figure 40)

- Average trip distance of San Diego residents increased from 6.1 miles to 6.3 miles; While work trip length decreased from 10.3 miles to 10.1 miles, non-mandatory trip distance in general increased (Table 9).
- Total person trips of San Diego residents increased by 1.6% (Figure 42).

In comparison with the 2035 baseline, a test with 10% smaller reginal employment had the following results:

- VMT decreased by over 6% (Figure 39)
- Mode share changes (Figure 41):
    - DA decreased from 45.8% to 42.7%
    - SR2 increased from 23.6% to 25.0%
    - SR3 increased from 16.6% to 18.4%
    - Active mode (walk, bike, and micromobility) decreased slightly from 9.9% to 9.8%
- Transit boarding decreased by nearly 2% (Figure 40).
- Average trip distance of San Diego residents decreased from 6.1 miles to 5.9 miles; While work trip length increased from 10.3 miles to 10.5 miles, non-mandatory trip distance in general decreased (Table 9).
- Total person trips of San Diego residents decreased by 0.5% (Figure 42).

The experiments suggest that ABM2+ is sensitive to regional employment. When regional employment increased, the model indicated higher VMT, high travel demand, higher DA mode share, lower shared ride auto mode shares, and lower walk, bike, and micromobility mode shares. Although overall trip distance increased, work trip distance decreased, indicating the abundance of jobs allow workers to choose jobs closer to home. When regional employment decreased, the opposite effects were observed. It should be noted that these are simply hypothesis tests which hold all other variables constant, neglecting the supply-demand interaction between inter-dependent variables. The test results should not be interpreted as the effects of +-10% regional employment changes in San Diego.

Figure 39. VMT Change from Baseline: Regional Employment Tests (Tests 27 & 28)

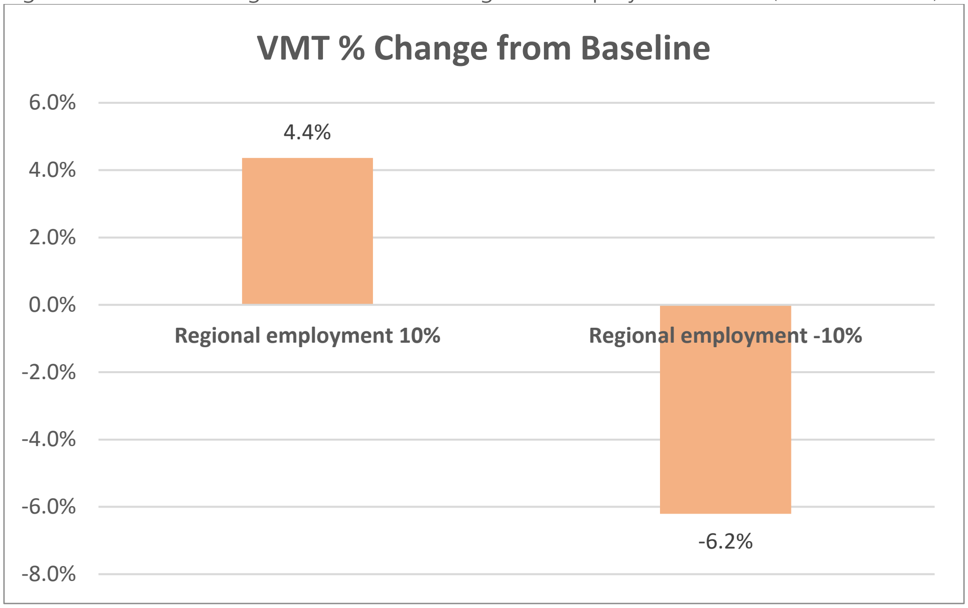


Figure 40. Transit Boarding Change from Baseline: Regional Employment Tests (Tests 27 & 28)

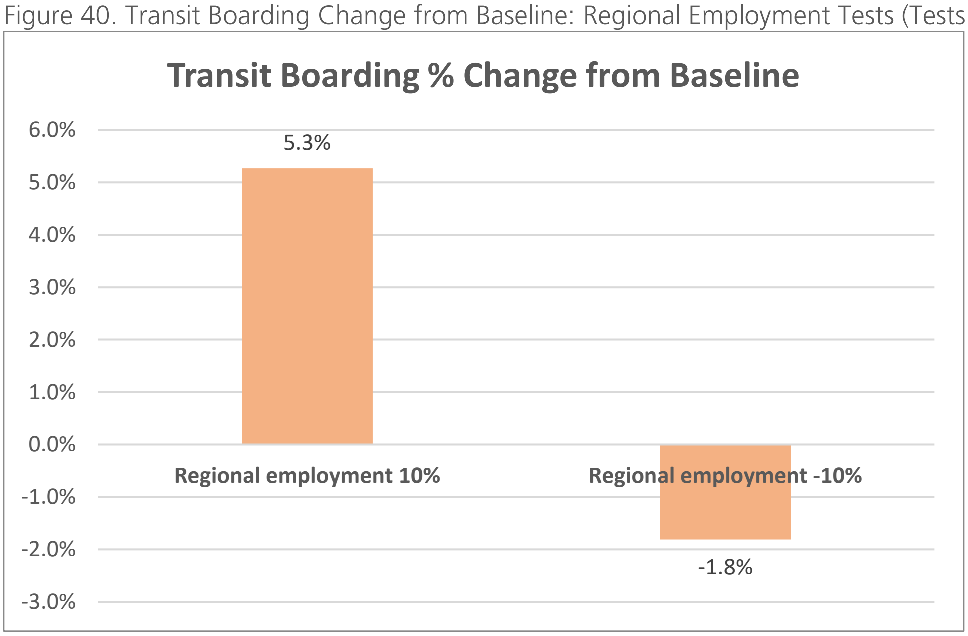


Figure 41. Mode Share of Person Trips: Regional Employment Tests (Tests 27 & 28)

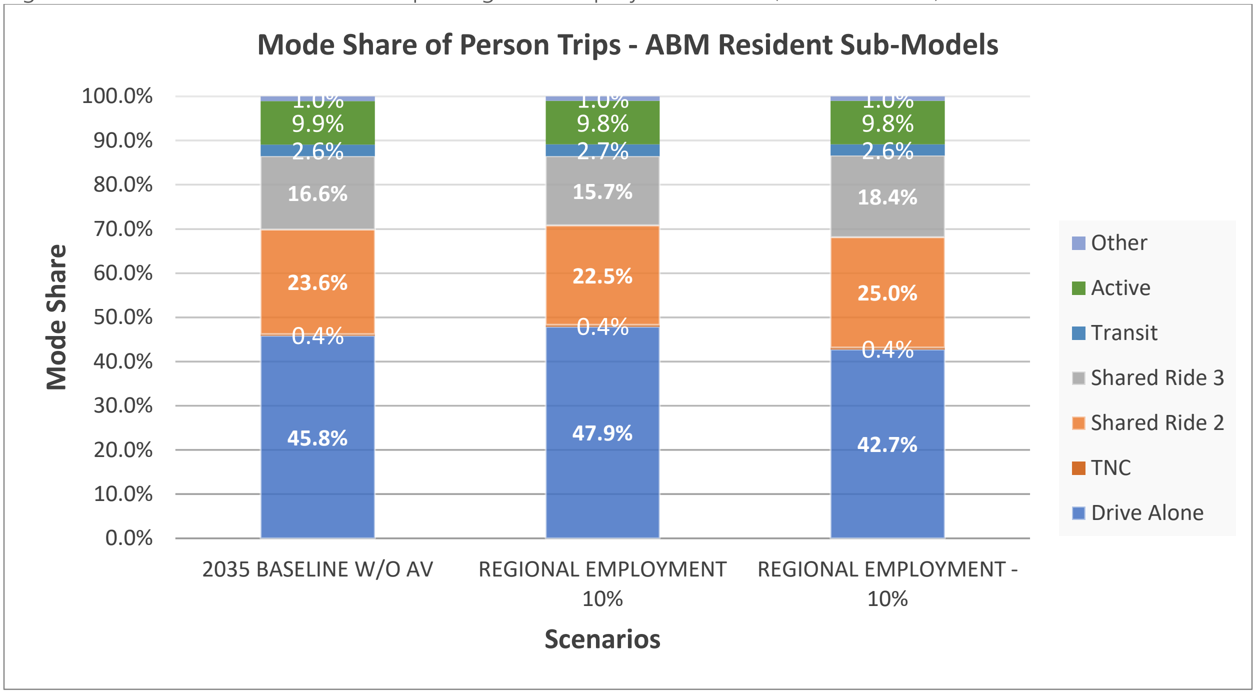


Figure 42. Total Person Trips Change from Baseline: Regional Employment Tests (Tests 27 & 28)

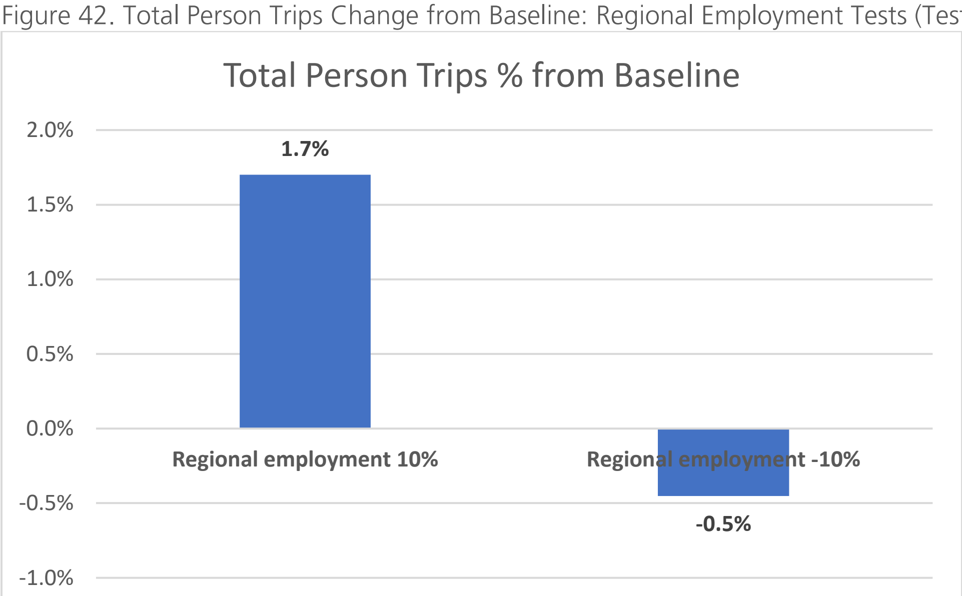


Table 9. Person Trip Distance by Purpose: Household Income Tests (Tests 27 & 28)

description	Rec.	Dining	Escort	Maint.	School	Shop	Univ.	Visit	Work	Total
2035 baseline w/o AV	5.0	5.3	5.2	5.2	4.6	4.3	8.2	6.0	10.3	6.1
Regional employment 10%	5.0	5.4	5.3	5.2	4.6	4.3	8.3	6.0	10.1	6.3
Regional employment - 10%	4.9	5.2	5.0	5.2	4.6	4.2	8.3	5.8	10.5	5.9

New mobility

TNC Cost Tests (Tests 30 & 31)

In comparison with the 2035 baseline, a test with 50% higher TNC cost had the following results:

- Insignificant VMT change (Figure 43)
- Mode shares for all models (Figure 44):
  - DA increased from 45.3% to 45.4%
  - TNC decreased significantly from 0.8% to 0.4%
  - Insignificant transit mode share change.
- Transit boarding increased by over 1% (Figure 46)
- Total TNC trips decreased by 35%, suggesting that a 1 percent increase in TNC cost will lead to a TNC trip decrease of 0.7% (elasticity of -0.7) (Figure 47).
- Deadhead TNC VMT (no passengers) increased slightly from 41.9% to 42.3% and pooled TNC VMT decreased from 11.6% to 11.0% (Figure 46).
- Although average trip distance change was insignificant, regular TNC trip distance increased from 7.7 miles to 9.1 miles, pooled TNC trip distance increased from 6.0 miles to 6.2 miles (Table 10).

In comparison with the 2035 baseline, a test with 50% lower TNC cost had the following results:

- VMT increased by 0.4% (Figure 43)
- Mode shares for all models (Figure 44):
  - DA decreased from 45.3% to 45.2%
  - SR3 decreased from 16.7% to 16.1%
  - Transit decreased from 2.7% to 2.6%
  - TNC increased from 0.8% to 1.8%
- Transit boarding decreased by 2% (Figure 46)
- Total TNC trips increased by 97%, suggesting that a 1 percent decrease in TNC cost will lead to a TNC trip increase of 2.0% (elasticity of -2.0) (Figure 47).
- Deadhead TNC trips (no passenger) decreased from 41.9% to 41% and pooled TNC increased from 11.6% to 13.1% (Figure 46).
- Although average trip distance change was insignificant, regular TNC trip distance decreased from 7.7 miles to 7.6 miles, pooled TNC trip distance increased from 6.0 miles to 6.6 miles (Table 10).

The results suggest that the TNC cost increase did not have a significant impact on VMT and mode shares, except for the significant TNC mode share decrease. The TNC cost increase caused a significant TNC trip distance increase from 7.7 miles to 9.1 miles. Deadhead TNC VMT did not change much, but pooled TNC VMT decreased.

When TNC cost decreased, VMT increased, TNC mode share increased significantly, and transit mode share decreased. This suggests a competition between TNC and transit. As TNC became more affordable, mode shares shifted from transit to TNC and caused more VMT. As TNC cost decreased, among the three auto modes (DA, SR2, and SR3), only SR3 mode share increased significantly, which needs more investigation. Deadhead TNC VMT decreased slightly, but pooled TNC VMT increased.

Figure 43. VMT Change from Baseline: TNC Cost Tests (Tests 30 & 31)

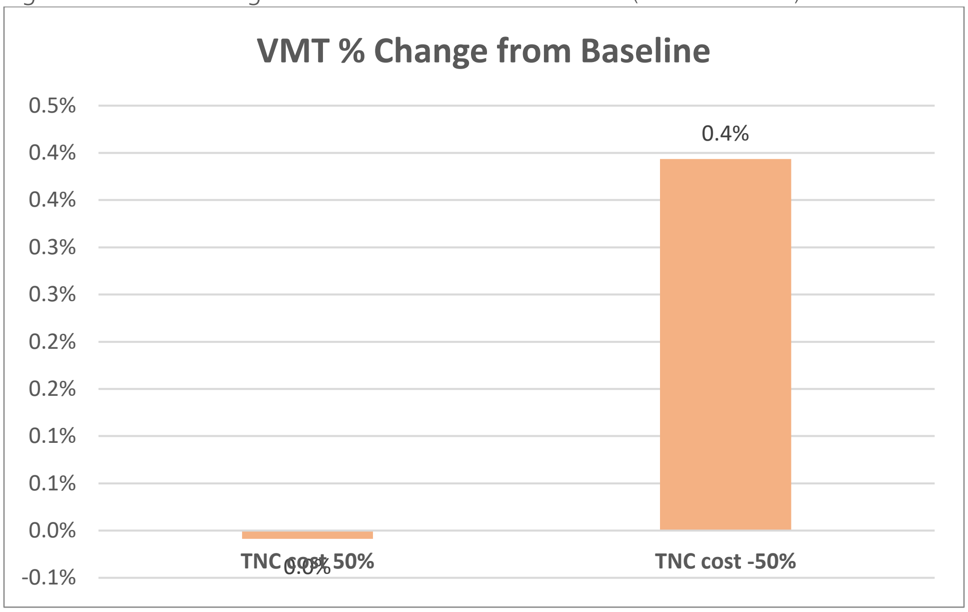


Figure 44. Mode Share of Person Trips: TNC Cost Tests (Tests 30 & 31)

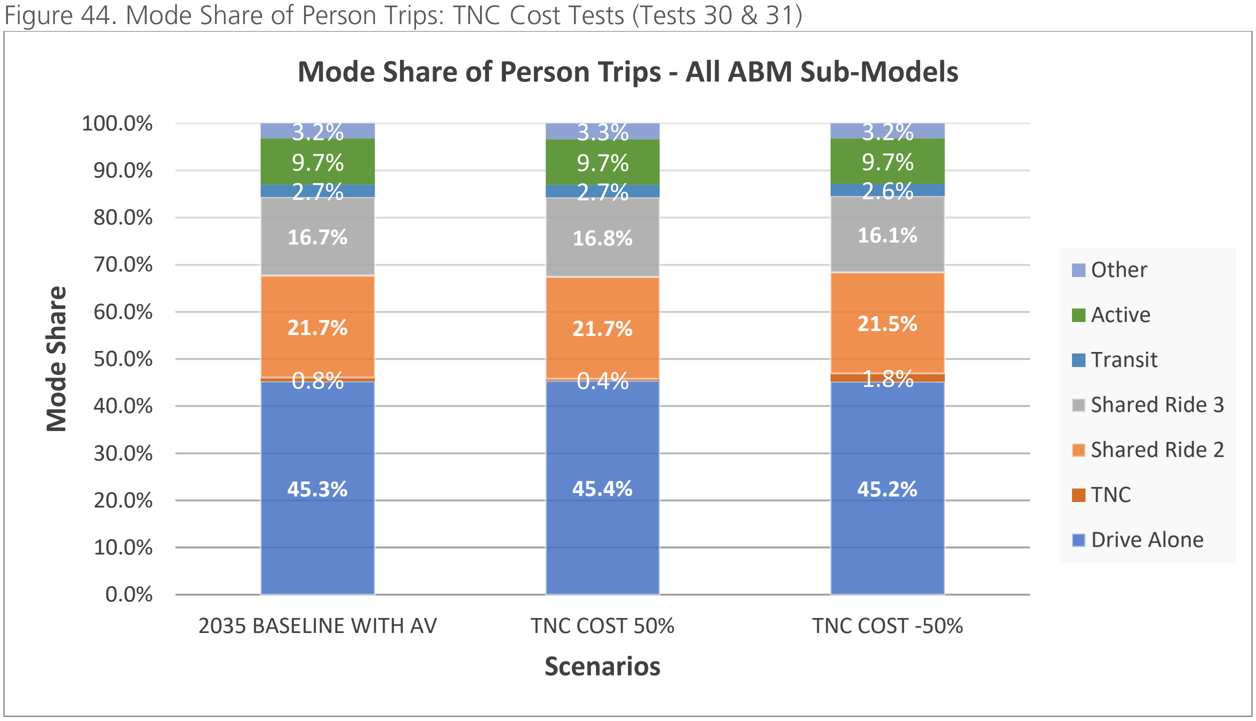


Figure 45. Transit Boarding Change from Baseline: TNC Cost Tests (Tests 30 & 31)

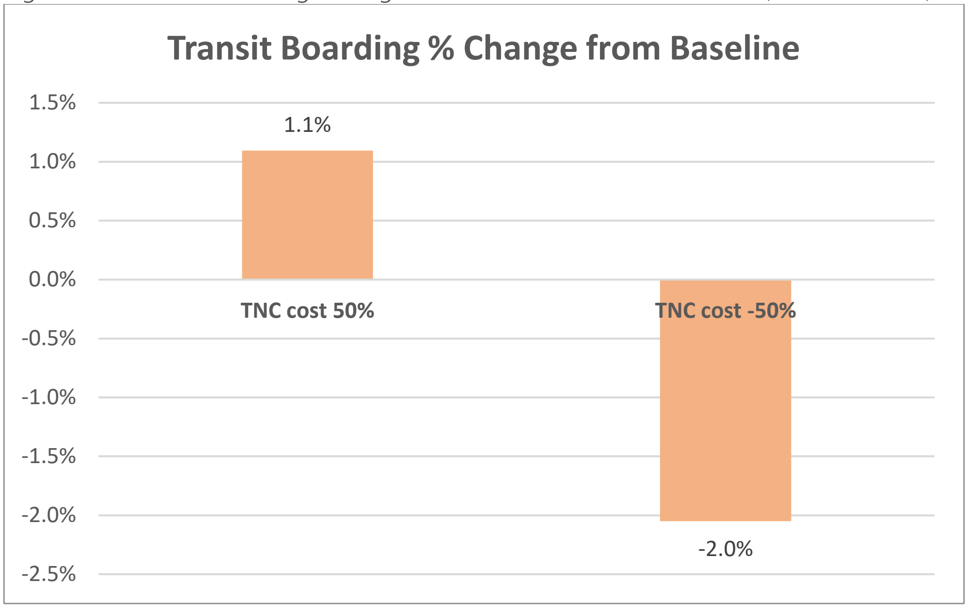


Figure 46. Share of TNC Trips by Number of Passengers: TNC Cost Tests (Tests 30 & 31)

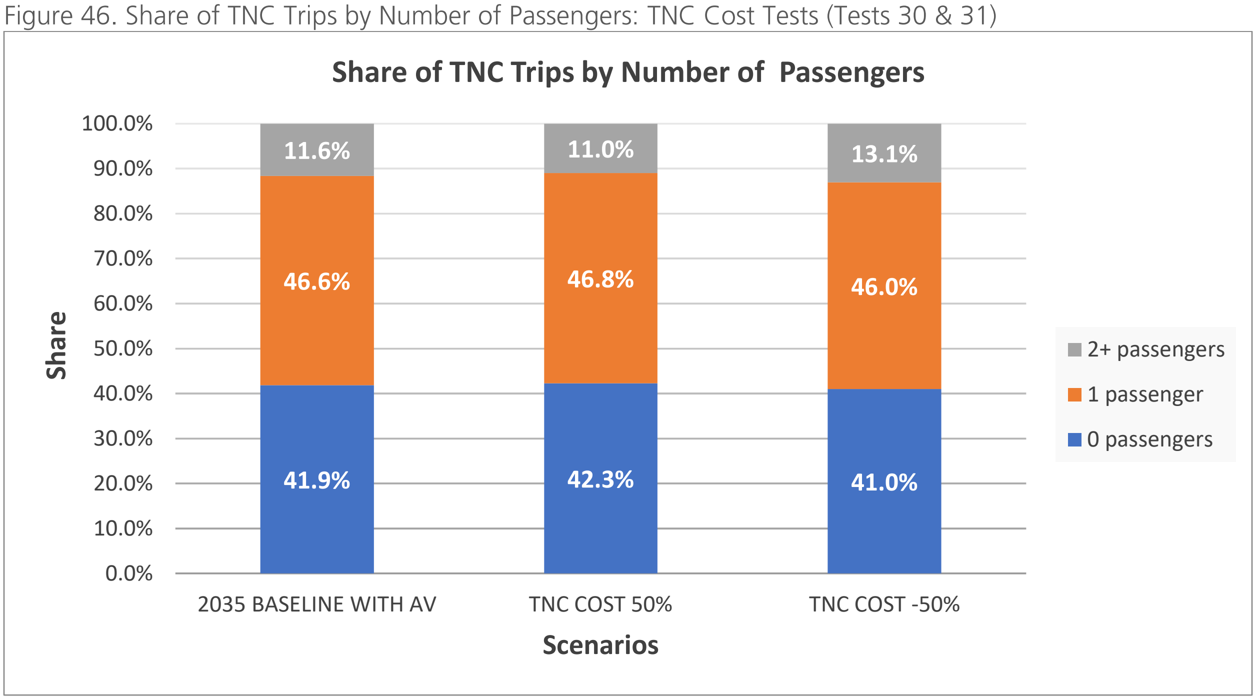


Figure 47. TNC Trips Change from Baseline: TNC Cost Tests (Tests 30 & 31)

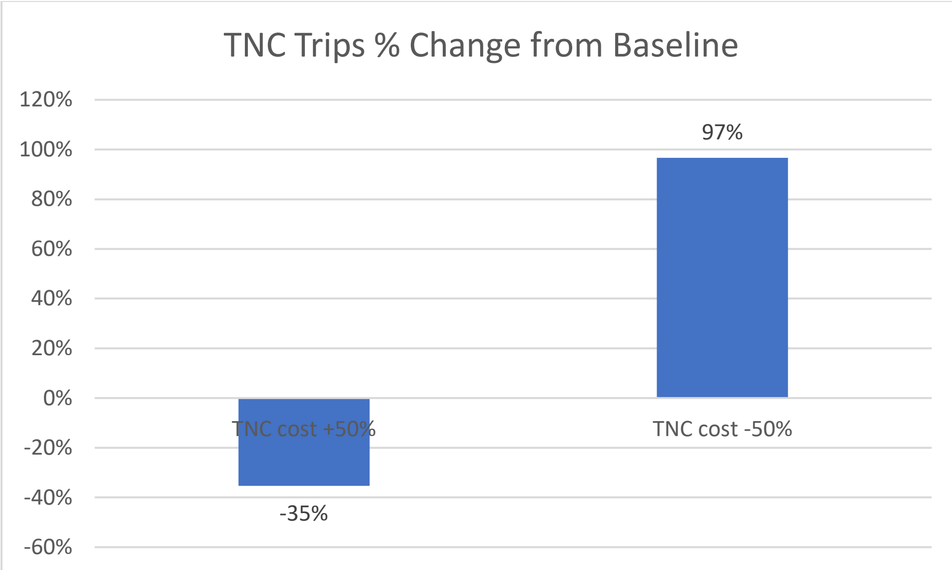


Table 10. Person Trip Distance by Mode: Household Income Tests (Tests 30 & 31)

description	DA	SR2	SR3	TNC	Pooled TNC	Walk	Bike	Transit	Total
2035 baseline with AV	8.0	7.2	8.3	7.7	6.0	0.8	3.3	9.1	7.3
TNC cost 50%	7.9	7.2	8.3	9.1	6.2	0.8	3.3	9.1	7.3
TNC cost -50%	8.0	7.2	8.2	7.6	6.6	0.8	3.3	9.2	7.3

Pooled TNC Cost Tests (Tests 32 & 33)

In comparison with the 2035 baseline, a test with 50% lower pooled TNC cost had the following results:

- Insignificant VMT change (Figure 48)
- VMT generated by TNC increased by 1.0% (Figure 49)
- Among all TNC VMT, pooled TNC VMT decreased from 9.6% to 9.3% and deadhead TNC VMT decreased from 31.7% to 31.1% (Figure 51).
- Mode shares for all models (Figure 50):
    - DA decreased from 45.4% to 45.3%
    - Transit decreased from 2.7% to 2.6%.
    - Pooled TNC increased from 0.1% to 0.2%, a 100% increase, suggesting that a 1 percent decrease in pooled TNC cost will lead to a pooled TNC trip increase of 2% (elasticity of -2.0).
- Transit boarding decreased by nearly 1% (Figure 52)
- Although average trip distance change was insignificant, pooled TNC trip distance increased from 8.7 miles to 9.4 miles (Table 11).

In comparison with the 2035 baseline, a test with 75% lower pooled TNC cost had the following results:

- VMT increased by 0.1% (Figure 48)
- TNC VMT increased by 2.6% (Figure 49)
- Among all TNC VMT, pooled TNC VMT increased from 9.6% to 12.8% and deadhead TNC VMT decreased from 31.7% to 29.1% (Figure 51).
- Mode share changes (Figure 50):
    - DA decreased from 45.4% to 45.1%
    - Transit decreased from 2.7% to 2.6%.
    - Pooled TNC increased from 0.1% to 0.4%, a 300% increase, suggesting that a 1 percent decrease in pooled TNC cost will lead to pooled TNC trip increase of 4% (elasticity of -4.0).
- Transit boarding decreased by nearly 2% (Figure 52)
- Although the average trip distance change was insignificant, pooled TNC trip distance increased from 8.7 miles to 10.7 miles (Table 11).

The results suggest pooled TNC cost reductions had significant impact on pooled TNC trips, but limited impact on overall VMT. When pooled TNC costs decreased, pooled TNC mode share was higher, and both drive alone and transit mode shares were lower, indicating that TNC competes with both drive alone and transit modes. Pooled TNC trip distance increased and regular TNC trip distance decreased. This suggests two findings. First, travelers tend to take longer pooled TNC trips as the cost becomes more affordable. Second, more affordable pooled TNC shifted longer regular TNC trips to pooled TNC trips. In the 50% cost reduction test, pooled TNC VMT was slighter lower than baseline, which is counter intuitive and needs further investigation.

Figure 48. VMT Change from Baseline: Pooled TNC Cost Tests (Tests 32 & 33)

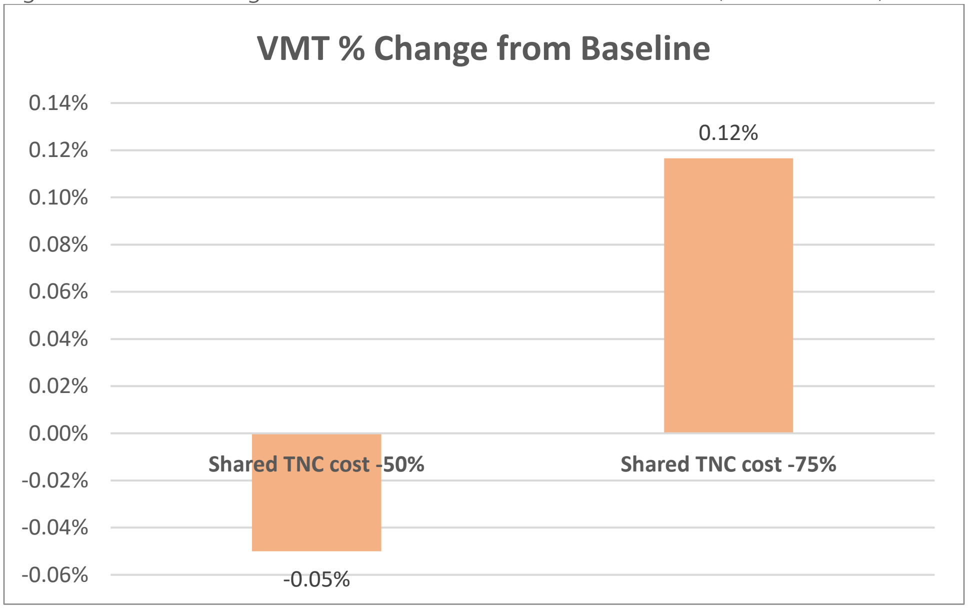


Figure 49. TNC VMT Change from Baseline: Pooled TNC Cost Tests (Tests 32 & 33)

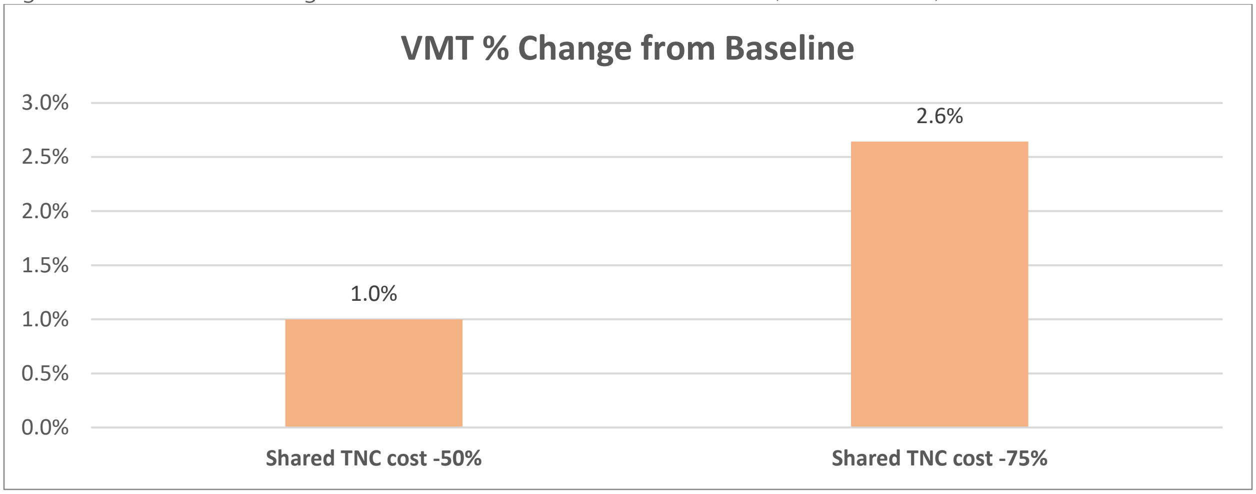


Figure 50. Mode Share of Person Trips: Pooled TNC Cost Tests (Tests 32 & 33)

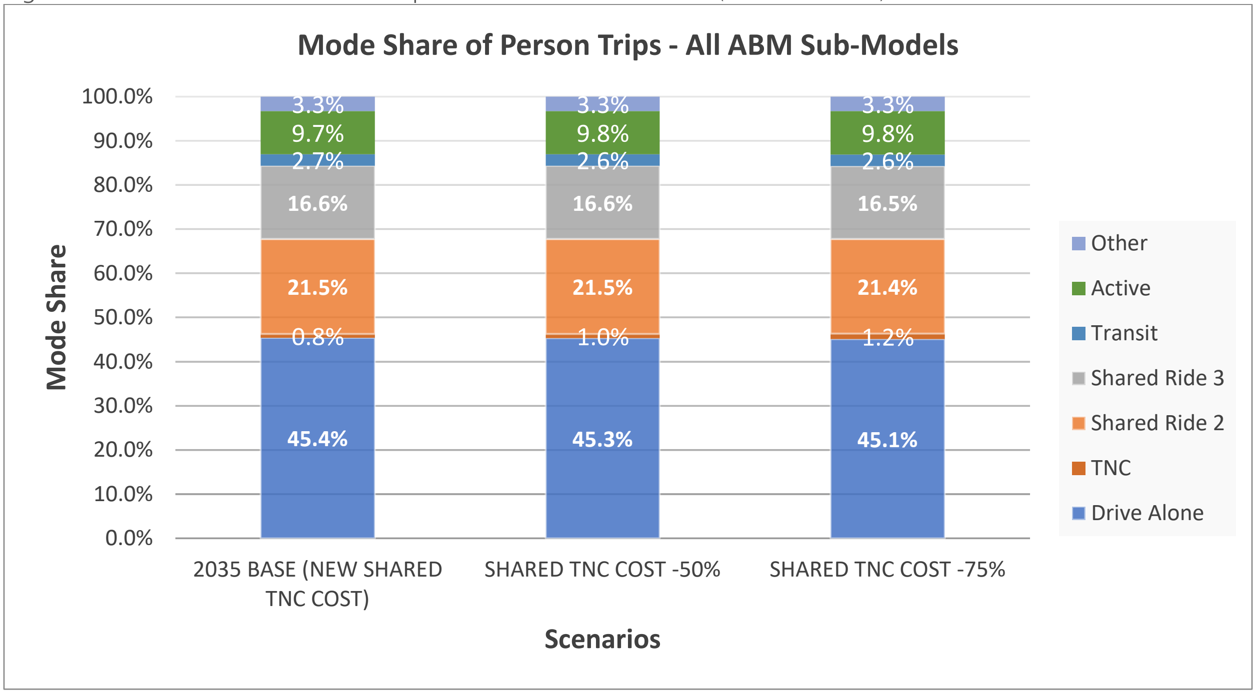


Figure 51. Share of TNC VMT by Occupancy: Pooled TNC Cost Tests (Tests 32 & 33)

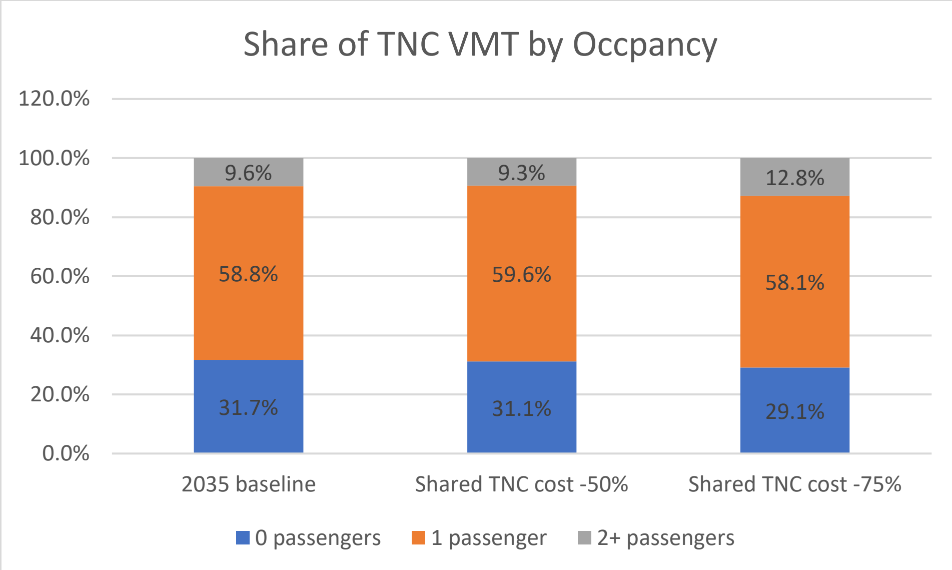


Figure 52. Transit Boarding Change from Baseline: Pooled TNC Cost Tests (Tests 32 & 33)

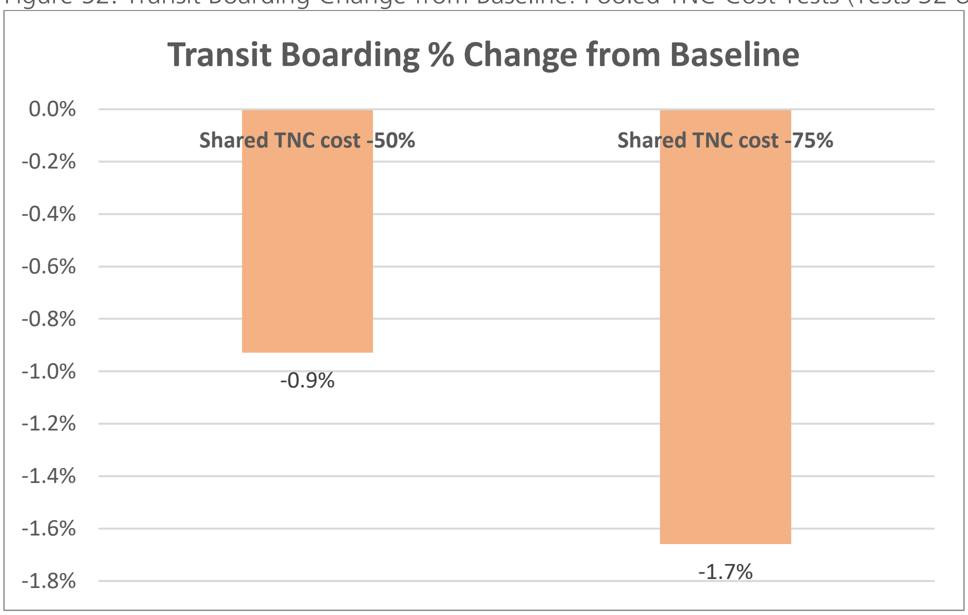


Table 11. Person Trip Distance by Mode: Pooled TNC Cost Tests (Tests 32 & 33)

description	DA	SR2	SR3	TNC	Pooled TNC	Walk	Bike	Transit	Total
2035 base (new Shared TNC cost)	7.9	7.2	8.3	7.7	8.7	0.8	3.3	9.1	7.2
Shared TNC cost - 50%	7.9	7.2	8.3	7.4	9.4	0.8	3.3	9.1	7.2
Shared TNC cost - 75%	7.9	7.2	8.3	7.1	10.7	0.8	3.3	9.1	7.2

TNC Wait Time Tests (Tests 34 & 35)

Compared with the 2035 baseline, a 50% TNC wait time decrease test had the following results:

- Mode share changes were insignificant, except TNC mode share which increased from 0.8% to 0.9% (Figure 53).
- Total TNC trips increased by 13%, suggesting that a 1 percent decrease in TNC wait time will lead to a TNC trip increase of 0.26% (elasticity of -0.26) (Figure 54).
- Share of TNC VMT increased from 0.85% to 0.95% (Figure 55)

Compared with the 2035 baseline, a 50% TNC wait time increase test had the following results:

- Mode share changes were insignificant except TNC mode share which decreased from 0.8% to 0.7% (Figure 53).
- Total TNC trips decreased by 9%, suggesting that a 1 percent increase in TNC wait time will lead to a TNC trip decrease of 0.18% (elasticity of -0.18) (Figure 54).
- Share of TNC VMT decreased from 0.85% to 0.79% (Figure 55)

The results suggest TNC wait time had significant impact on TNC trips but limited impact on regional VMT because of the very small TNC mode share. When TNC wait time decreased, both TNC trips and TNC VMT increased. When TNC wait time increased, the opposite effects were observed.

Figure 53. Transit Boarding Change from Baseline: TNC Wait Time Tests (Tests 34 & 35)

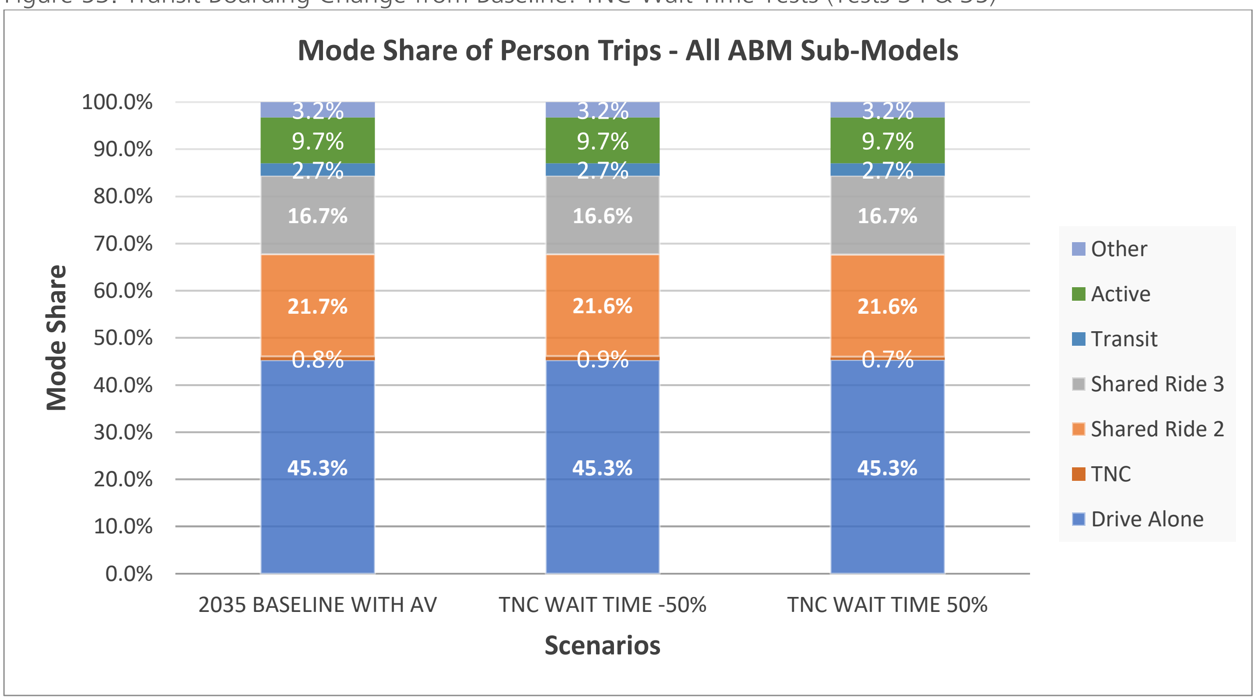


Figure 54. TNC Trips Change from Baseline: TNC Wait Time Tests (Tests 34 & 35)

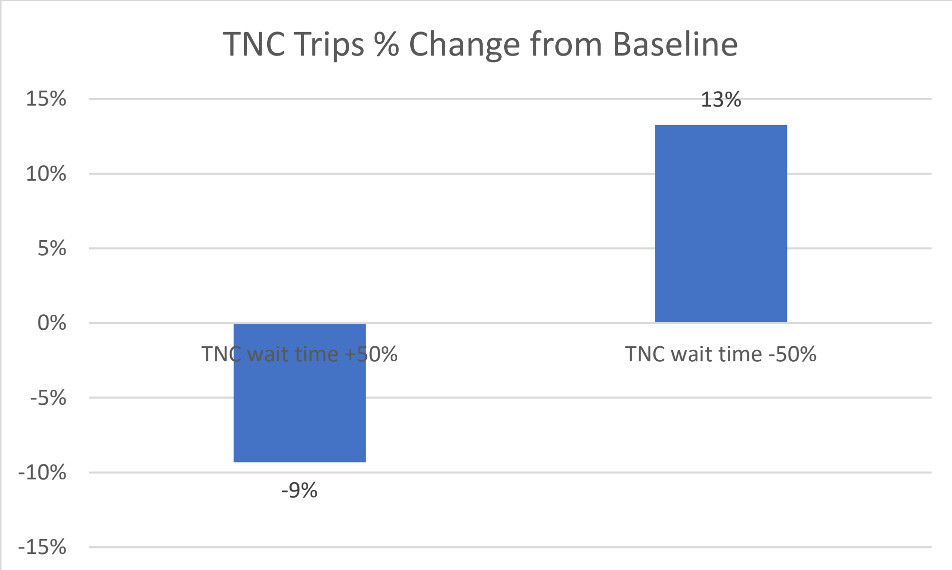
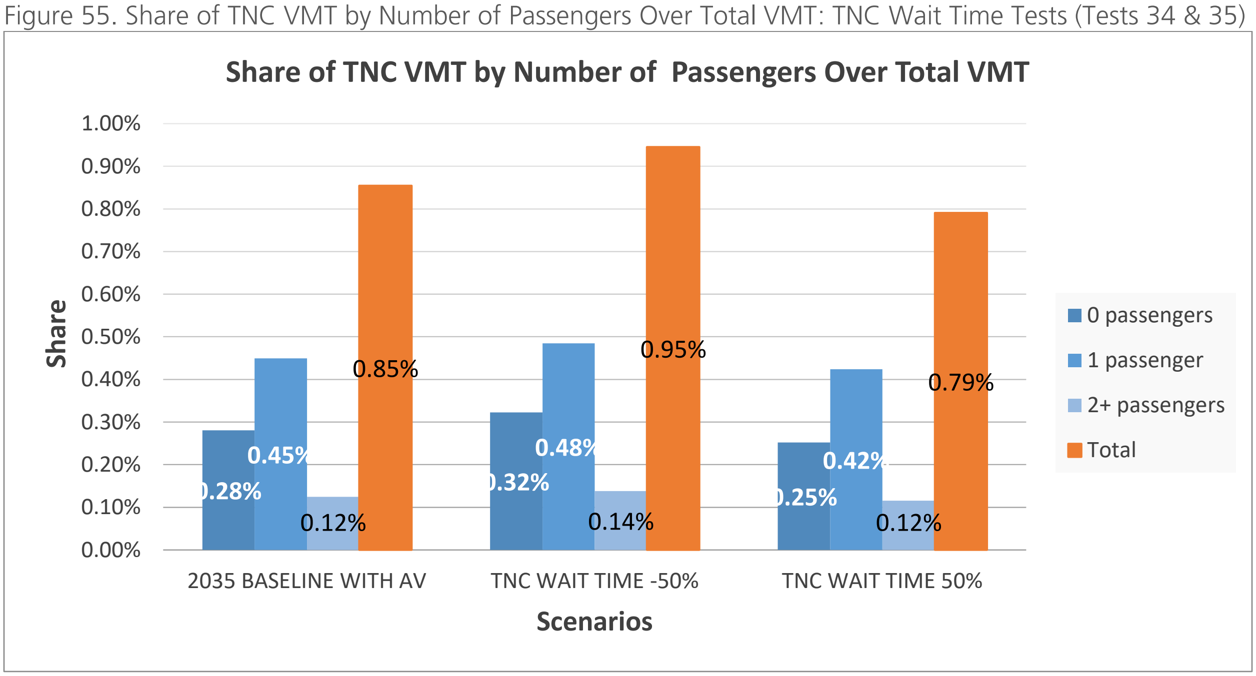


Figure 55. Share of TNC VMT by Number of Passengers Over Total VMT: TNC Wait Time Tests (Tests 34 & 35)



Micromobility Speed Tests (Tests 36 & 37)

In comparison with the 2035 baseline, a test increasing micromobility speed from 12mph to 30 mph had the following results:

- VMT decreased slightly by 0.1% (Figure 56)
- Insignificant mode share changes (Figure 57)

- Transit boarding decreased by nearly 1% (Figure 58)
- Total micromobility trips increased by 33% (Figure 59)
- Although average trip distance change was insignificant, micromobility trip distance increased from 0.9 miles to 1.0 mile (Table 12).

In comparison with the 2035 baseline, a micromobility focus test with micromobility speed set to 20mph, 0 constant, and halved wait time and costs had the following results:

- VMT decreased by 0.8% (Figure 56)
- Mode share changes of all models (Figure 57):
  - DA decreased from 45.3% to 44.6%
  - SR2 decreased from 21.7% to 21.3%
  - SR3 decreased from 16.7% to 16.3%
  - Transit decreased from 2.7% to 2.5%
  - Active modes (walk, bike, and micromobility) increased from 9.7% to 11.4%, with the micromobility mode increasing significantly from 0.1% to 1.7%.
- Transit boarding decreased by nearly 5% (Figure 58)
- Total micromobility trips increased significantly by over 15 times (Figure 59)
- Although average trip distance change was insignificant, micromobility trip distance decreased from 0.9 miles to 0.6 mile (Table 12).

The results suggest micromobility speed alone had limited impact on VMT and mode shares, primarily because speed is one of many variables in the micromobility choice structure. When micromobility speed increased, the model indicated higher micromobility trips, but the overall mode share impact was insignificant. The test of giving significant benefit to micromobility by reducing cost, wait time, penalty constant, and increasing speed suggested that the model is sensitive to micromobility if enough benefit is given to micromobility.

Figure 56. TNC Trips Change from Baseline: Micromobility Speed Tests (Tests 36 & 37)

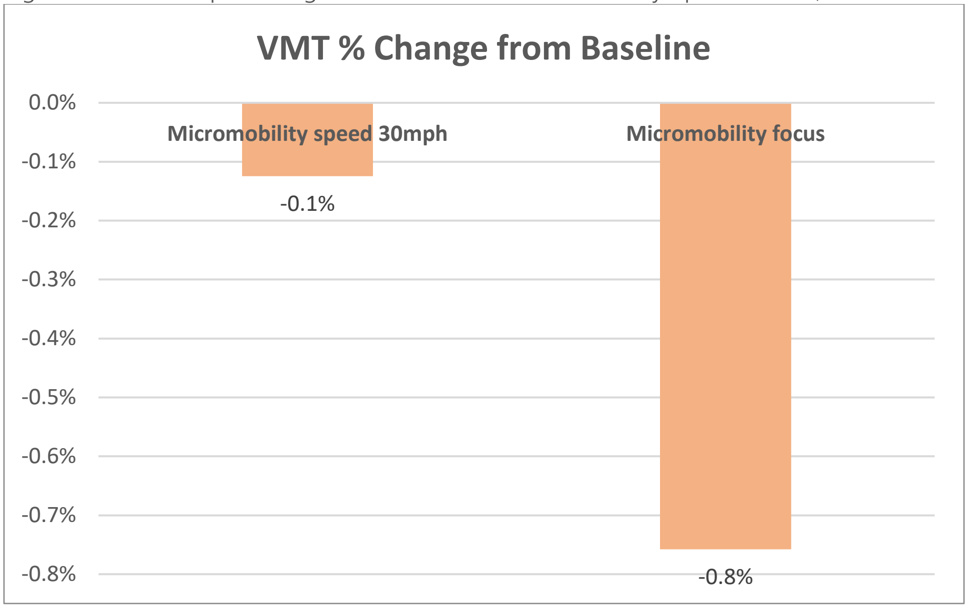


Figure 57. Mode Share of Person Trips: Micromobility Speed Tests (Tests 36 & 37)

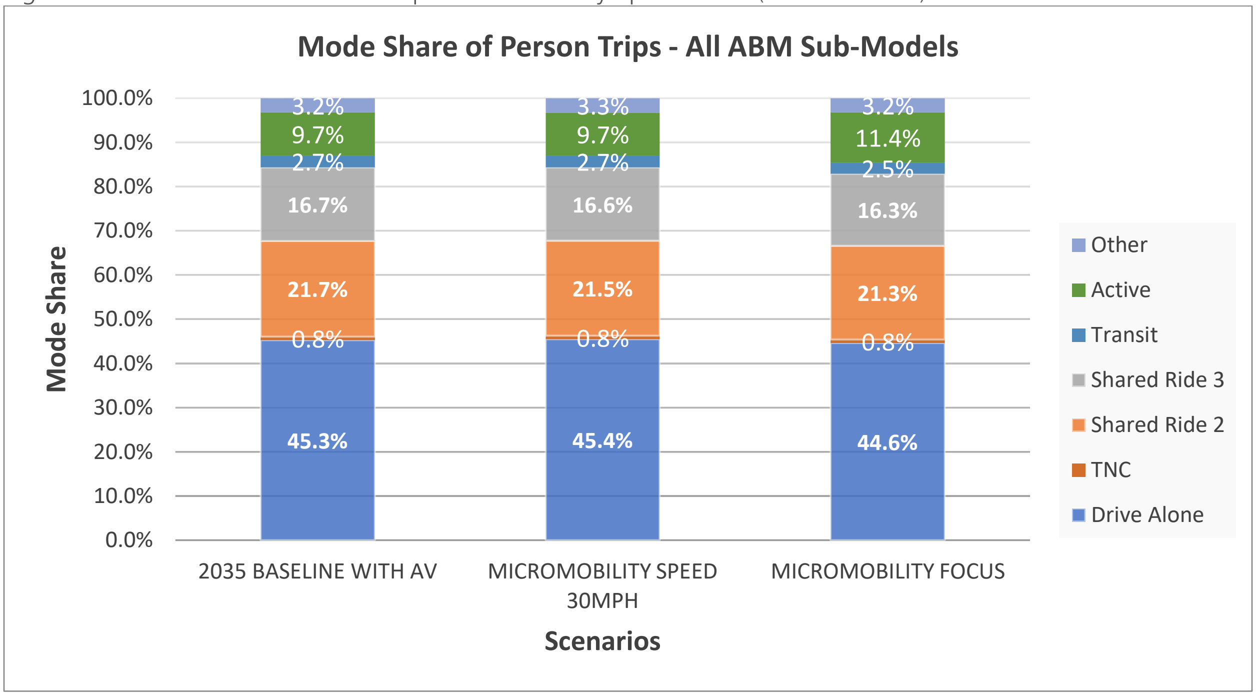


Figure 58. Transit Boarding Change from Baseline: Micromobility Speed Tests (Tests 36 & 37)

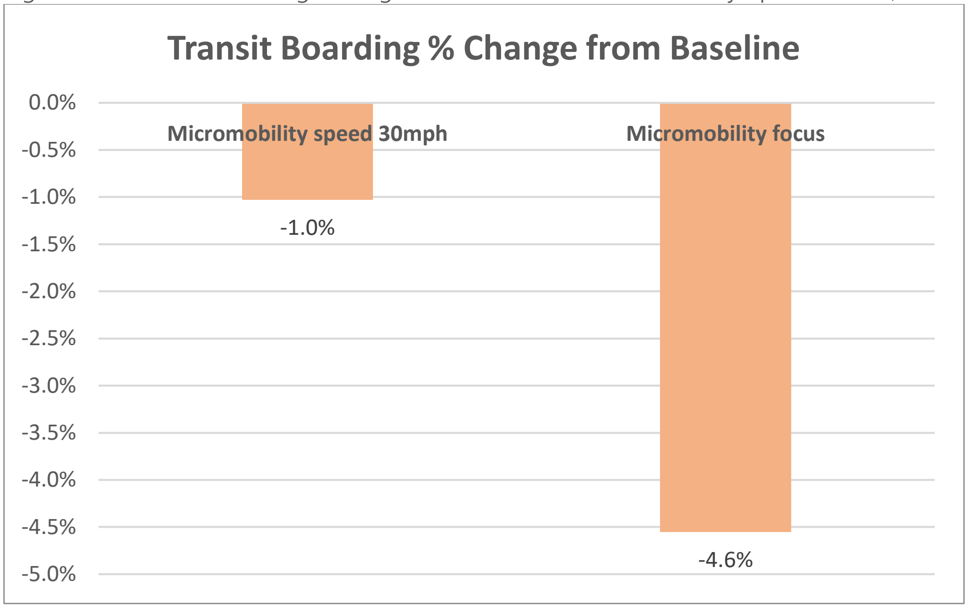


Figure 59. Micromobility Trips Change from Baseline: Micromobility Speed Tests (Tests 36 & 37)

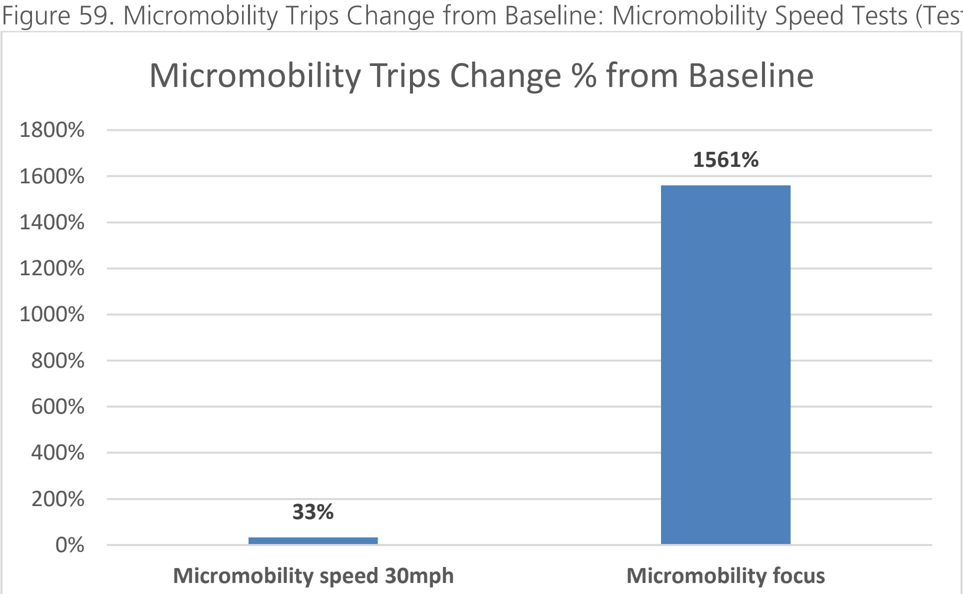


Table 12. Person Trip Distance by Mode: Micromobility Speed Tests (Tests 36 & 37)

description	DA	SR2	SR3	TNC	Pooled TNC	Walk	MM	Bike	Transit	Total
2035 baseline with AV	8.0	7.2	8.3	7.7	6.0	0.8	0.9	3.3	9.1	7.3
Micromobility speed 30mph	7.9	7.2	8.3	7.7	8.7	0.8	1.0	3.3	9.1	7.2
Micromobility focus	8.0	7.3	8.4	7.9	6.2	0.7	0.6	3.5	9.4	7.2

Micromobility Access Time Tests (Tests 38 & 39)

In comparison with the 2035 baseline, a test improving micromobility access time (see description of test 37 in the previous chapter) had the following results:

- Insignificant VMT change
- Insignificant mode share changes
- Total MM trips increased by over 120% (Figure 60).
- The share of micromobility trips for the total walk and micromobility trips increased from 2.0% to 4.0% (Figure 62).

In comparison with the 2035 baseline, a test significantly improving micromobility access time (see description of test 38 in the previous chapter) had the following results:

- Insignificant VMT change
- Insignificant mode share changes
- Total MM trips increased by 375% (Figure 60)
- The share of micromobility trips for the total walk and micromobility trips increased from 2.0% to 9.0% (Figure 62).

The results suggest micromobility access time had significant impact on micromobility trips and the share of micromobility trips, but limited impact on VMT and mode shares. When access time was improved, the total micromobility trips and share of micromobility increased significantly, but the effect on VMT was insignificant. This is likely due to the low share of micromobility and the relatively short trip length of micromobility trips. In the 'Good MM Access' scenario, the change in total walk and micromobility trips was negative but very small - possibly insignificant when compared to Monte Carlo simulation error.

Figure 60. Micromobility Trips Change from Baseline: Micromobility Access Time Tests (Tests 38 & 39)

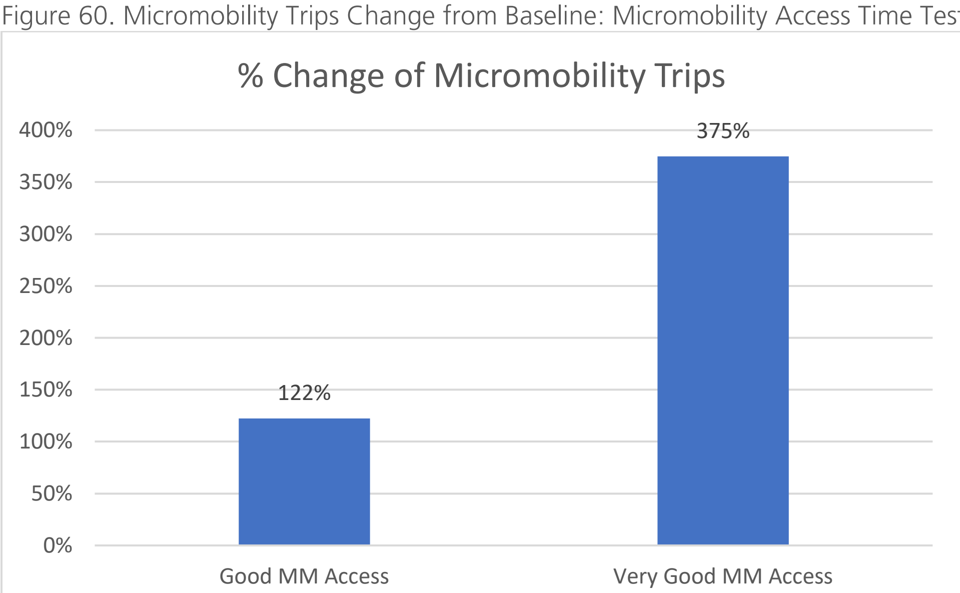


Figure 61. Walk & Micromobility Trips Change from Baseline: Micromobility Access Time Tests (Tests 38 & 39)

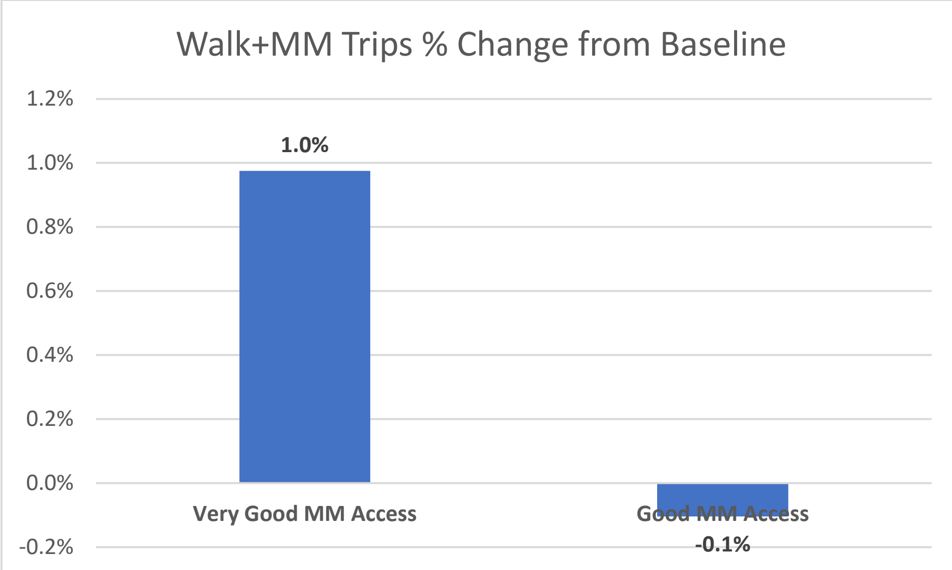
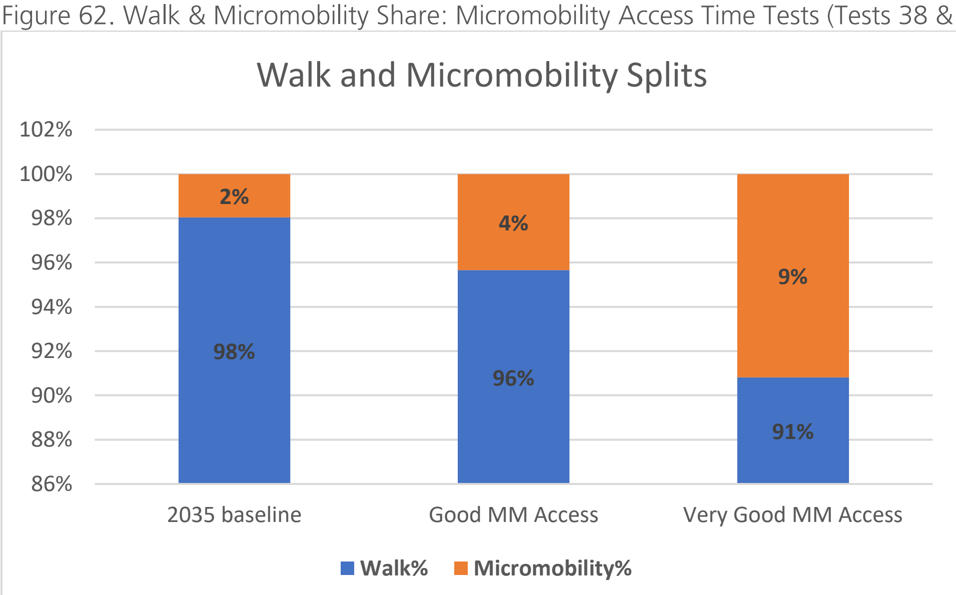


Figure 62. Walk & Micromobility Share: Micromobility Access Time Tests (Tests 38 & 39)



Micromobility Cost Tests (Tests 40 & 41)

In comparison with the 2035 baseline, a test increasing micromobility cost by 50% had the following results:

- Insignificant VMT change
- Insignificant mode share changes

- Total micromobility trips decreased by 40%, suggesting that a 1 percent increase in micromobility cost will lead to a micromobility trip decrease of 0.8% (elasticity of -0.8) (Figure 63).
- The share of micromobility trips for the total walk and micromobility trips decreased from 2.0% to 1.2% (Figure 65).

In comparison with the 2035 baseline, a test decreasing micromobility cost by 50% had the following results:

- Insignificant VMT change
- Insignificant mode share changes
- Total micromobility trips increased by 19%, suggesting that a 1 percent decrease in micromobility cost will lead to a micromobility trip increase of -0.38% (elasticity of -0.38) (Figure 63).
- The share of micromobility trips for the total walk and micromobility trips increased from 2.0% to 2.3% (Figure 65).

The results suggest micromobility cost had significant impact on micromobility trips and the share of micromobility trips, but limited impact on VMT or total walk and micromobility trip share. The number of micromobility trips responded reasonably to changes in cost, with derived elasticity of -0.4 to -0.8. However, the total share of walk and micromobility trips predicted by the model was not sensitive to these cost changes. This is in part due to the way that the model is formulated, where most of the model competition is between the micromobility and walk mode. Simply increasing or decreasing the cost of the mode was not enough to change the generalized walk time and subsequently impact the competition between walk\micromobility and other modes in the model.

Figure 63. Micromobility Trips Change from Baseline: Micromobility Cost Tests (Tests 40 & 41)

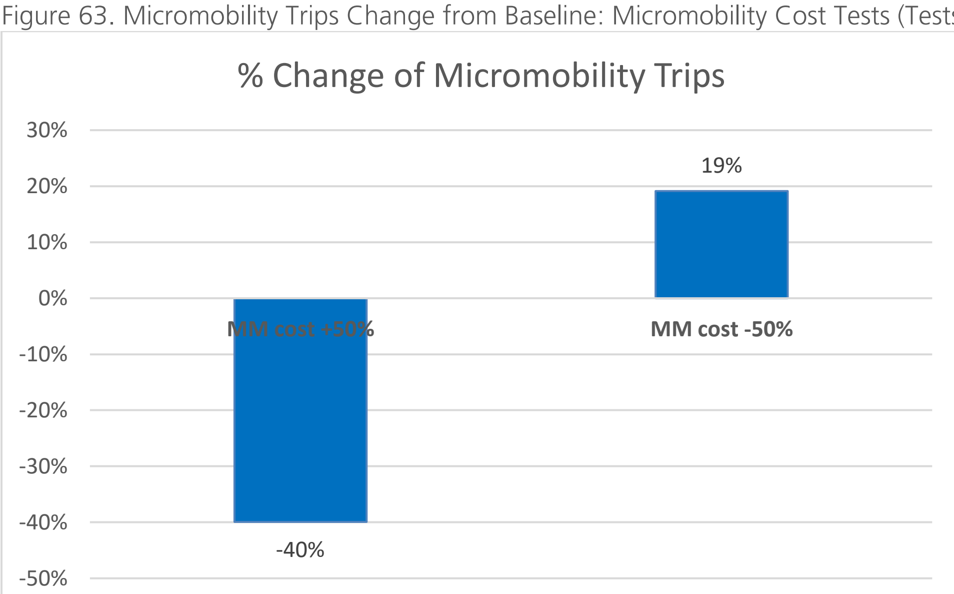


Figure 64. Walk & Micromobility Trips Change from Baseline: Micromobility Cost Tests (Tests 40 & 41)

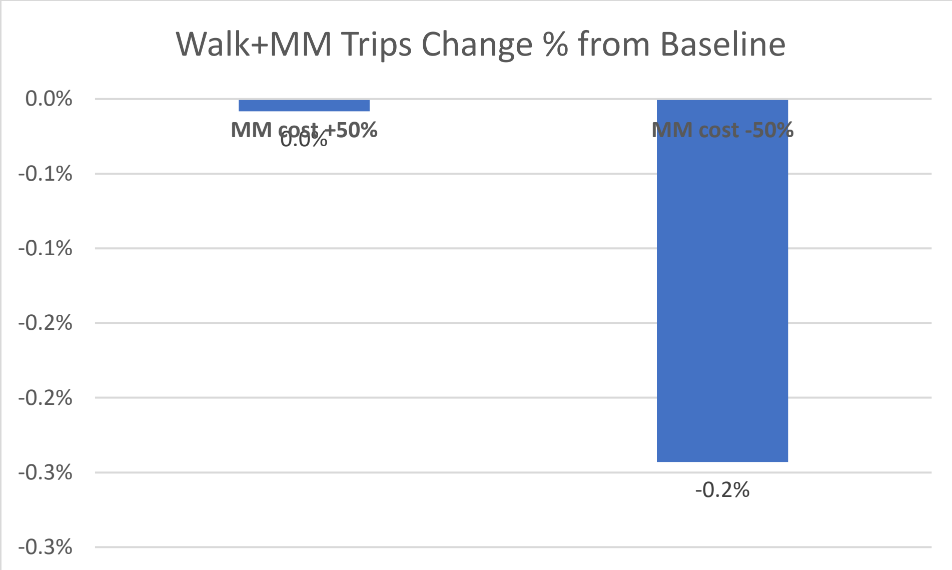
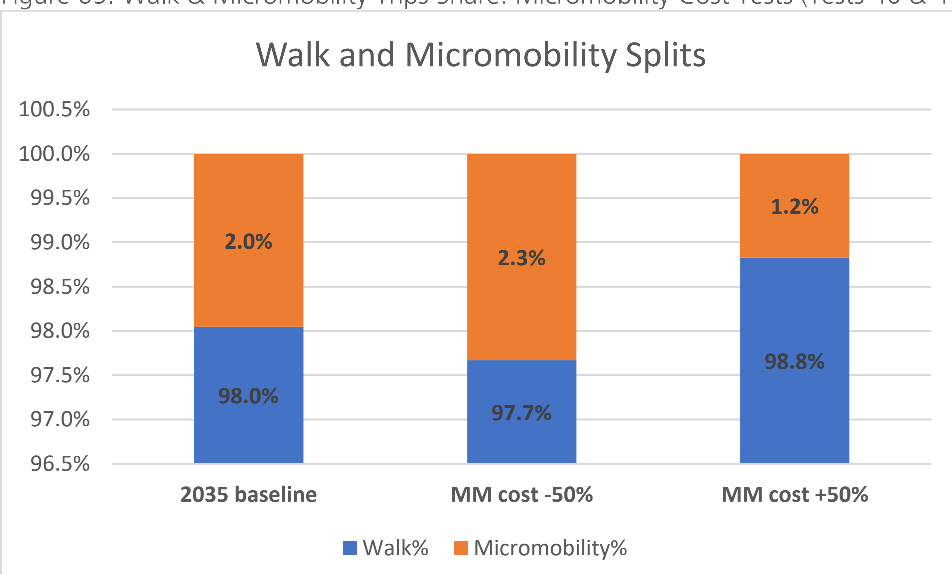


Figure 65. Walk & Micromobility Trips Share: Micromobility Cost Tests (Tests 40 & 41)



AV Penetration Rate Tests (Tests 42 & 43)

Compared with the 2035 baseline without AV, the 20% AV penetration test had the following results:

- VMT increased by 12%, suggesting that a 1 percent increase in AV penetration rate will lead to a VMT increase of 0.6% (elasticity of 0.6) (Figure 66).

- AV trips account for 19% of regional total vehicle trips, suggesting that a 1 percent increase in AV penetration rate will lead to an AV trip increase of 0.95% (elasticity of 0.95) (Figure 67).
- About 40% of AV VMT was generated by 'zombie' AV trips with no passengers; only 2% of AV VMT was generated by trips with 2 or more passengers (Figure 68).
- Total trips decreased slightly by 0.3% (Figure 69)
- Mode share changes for San Diego resident models (Figure 70):
  - SR2 increased from 23.6% to 24.0%
  - SR3 decreased from 16.6% to 16.1%
  - Transit increased from 2.6% to 2.7%
- Transit boarding increased by nearly 3% (Figure 71)
- Average trip distance increased from 6.1 miles to 6.2 miles (Table 13).

Compared with the 2035 baseline without AV, the 50% AV penetration test had the following results:

- VMT increased by 21%, suggesting that a 1 percent increase in AV penetration rate will lead to a VMT increase of 0.4% (elasticity of 0.4) (Figure 66).
- AV trips account for 33% of regional total vehicle trips, suggesting that a 1 percent increase in AV penetration rate will lead to an AV trip increase of 0.66% (elasticity of 0.66) (Figure 67).
- Total trips decreased slightly by 2.1% (Figure 69)
- About 40% of AV VMT was generated by 'zombie' AV trips with no passengers; only 2% with 2 or more passengers (Figure 68).
- Mode share changes for San Diego resident models (Figure 69):
  - DA decreased from 45.8% to 45.0%
  - SR2 increased from 23.6% to 24.4%
  - SR3 decreased from 16.6% to 14.8%
  - Transit increased from 2.6% to 3.2%
  - Active modes increased from 9.9% to 10.8%
- Transit boarding increased by over 20% (Figure 71)
- Average trip distance increased from 6.1 miles to 6.2 miles; trip distance of all auto modes increased (Table 13).

The results of the experiment indicated a significant VMT increase as the household AV penetration rate increased. Nearly 40% of AV VMT was from 'zombie' AV trips. Zombie AV VMT accounted for 10% and 18% of regional VMT and were the majority of the regional VMT increases in the two tested scenarios (Figure 74). Total trips decreased as AV penetration rate increased, probably because the model was calibrated to factor in 10% and 25% reductions in auto ownership for 20% and 50% AV penetration rates, respectively (Figure 69). Average trip distance increased slightly, indicating AV trips tend to be longer. Drive alone mode share decreased while transit and active (walk, bike, and micromobility) mode shares increased, probably because the reduced auto ownership (Figure 75) shifted some auto trips to transit and non-motorized trips.

Figure 66. VMT Change from Baseline: AV Penetration Rate Tests (Tests 42 & 43)

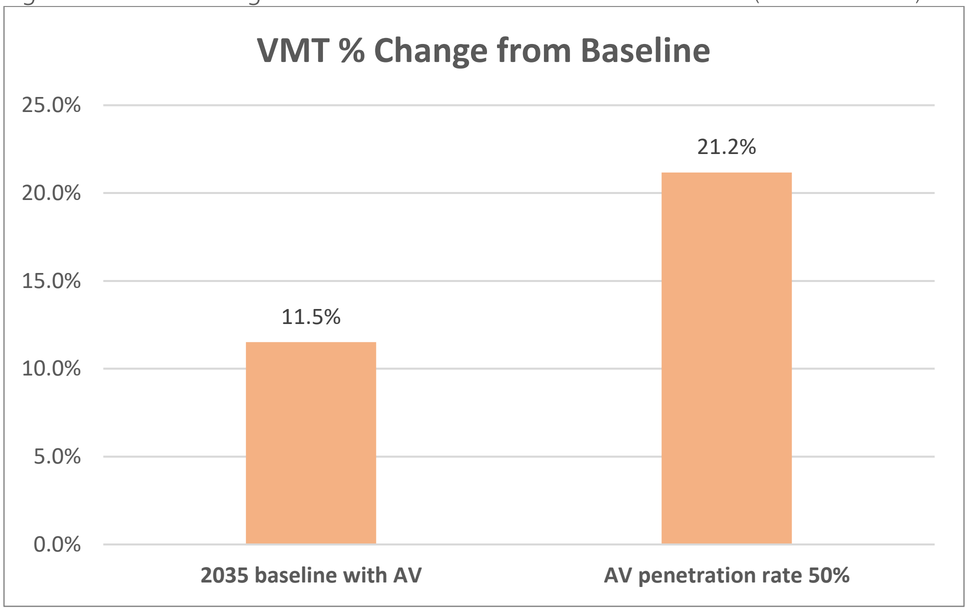


Figure 67. Share of AV Trips and AV VMT of Reginal Total: AV Penetration Rate Tests (Tests 42 & 43)

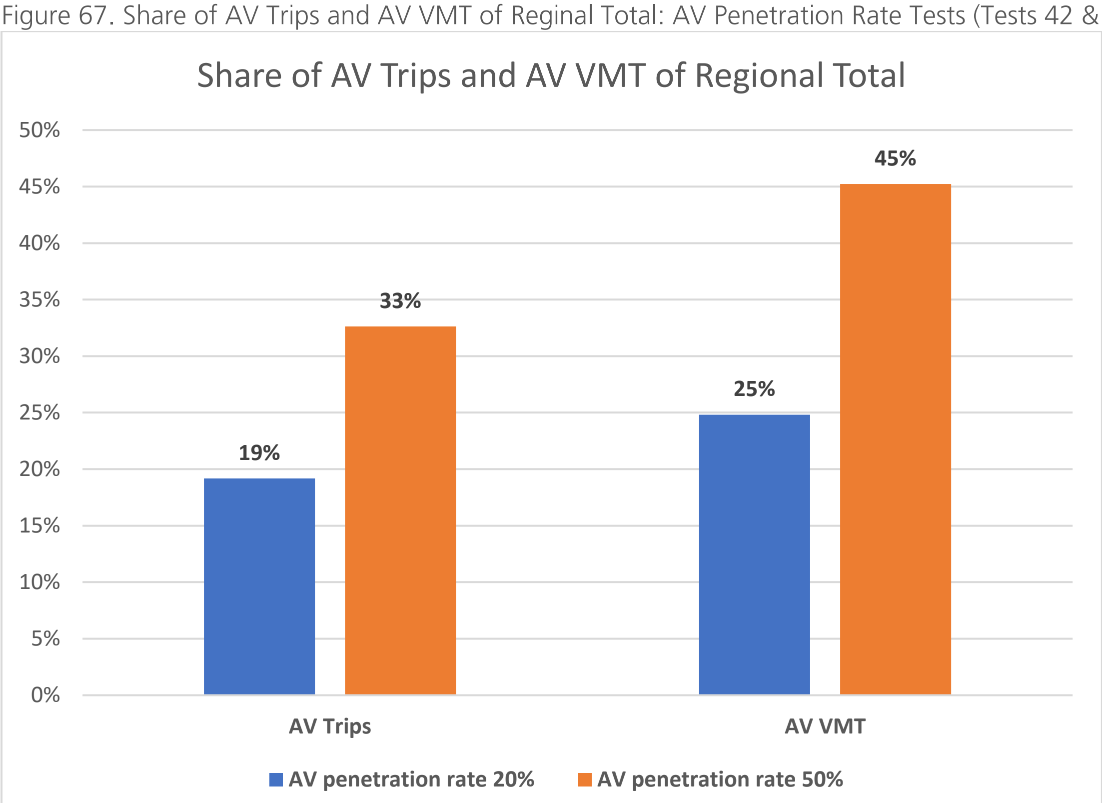


Figure 68. AV VMT by Occupancy: AV Penetration Rate Tests (Tests 42 & 43)

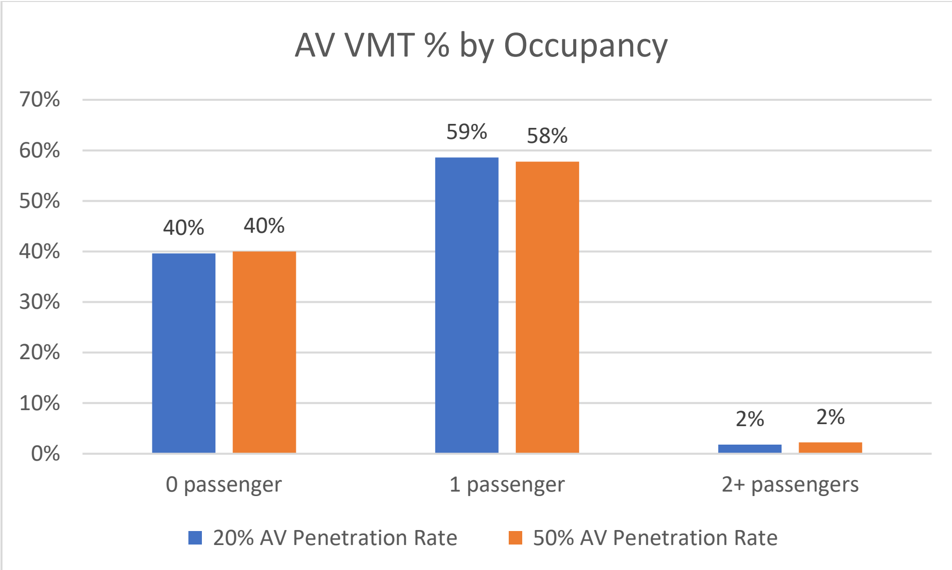


Figure 69. Total Trips Change from Baseline: AV Penetration Rate Tests (Tests 42 & 43)

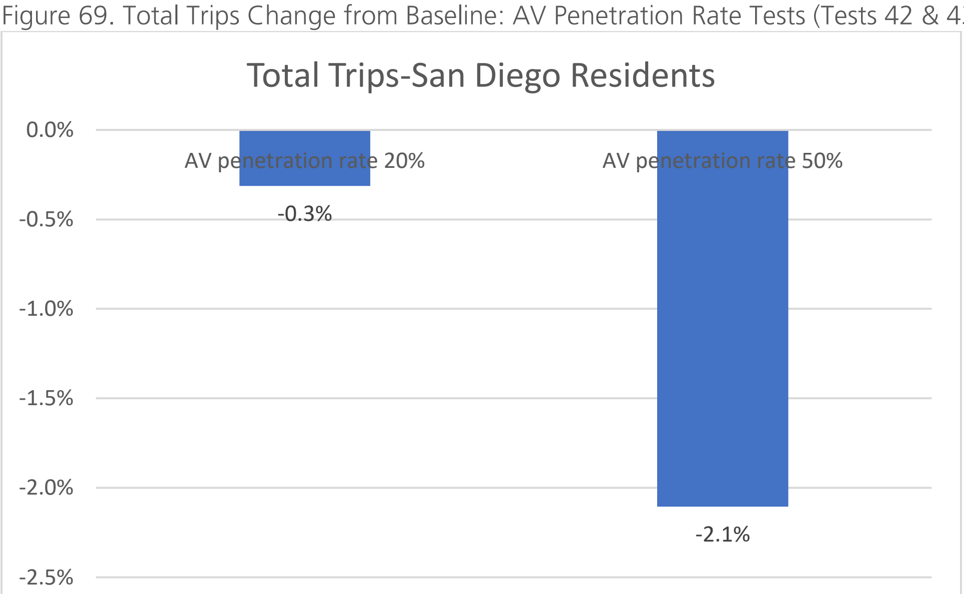


Figure 70. Mode Share of Person Trips: AV Penetration Rate Tests (Tests 42 & 43)

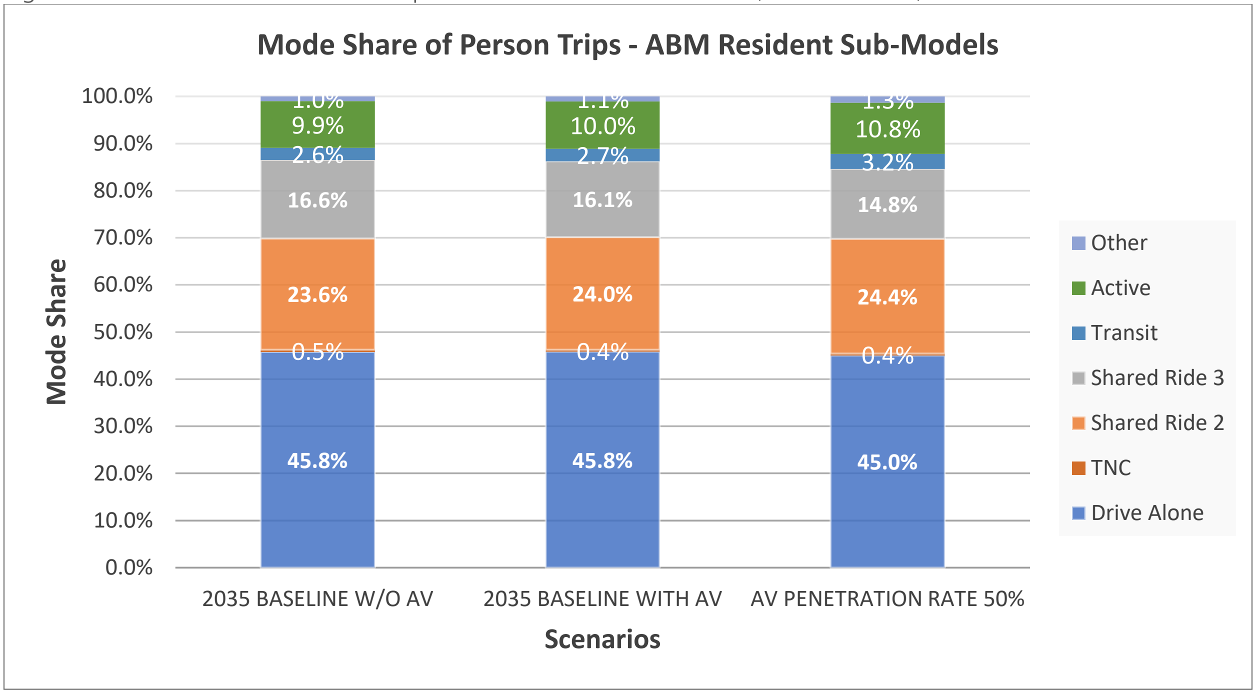


Figure 71. Transit Boarding Change from Baseline: AV Penetration Rate Tests (Tests 42 & 43)

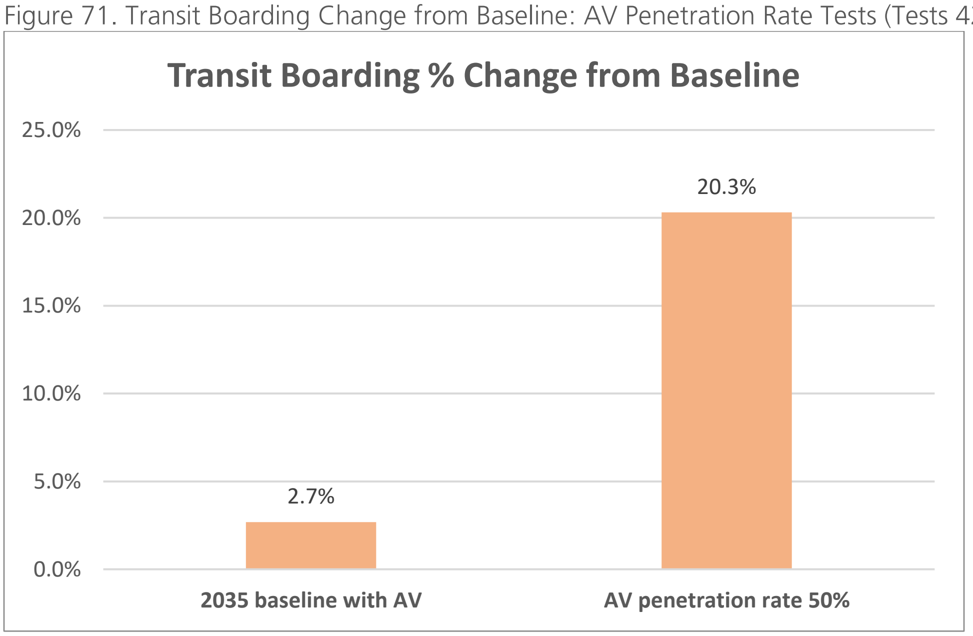


Figure 72. Zombie AV VMT & Regional VMT Increase: AV Penetration Rate Tests (Tests 42 & 43)

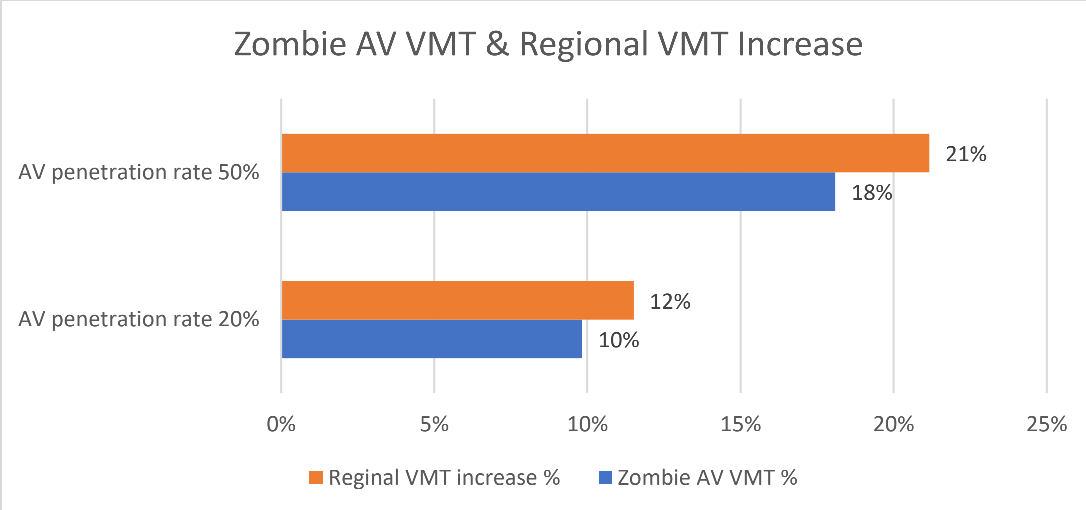


Figure 73. Auto Ownership by Vehicle Type: AV Penetration Rate Tests (Tests 42 & 43)

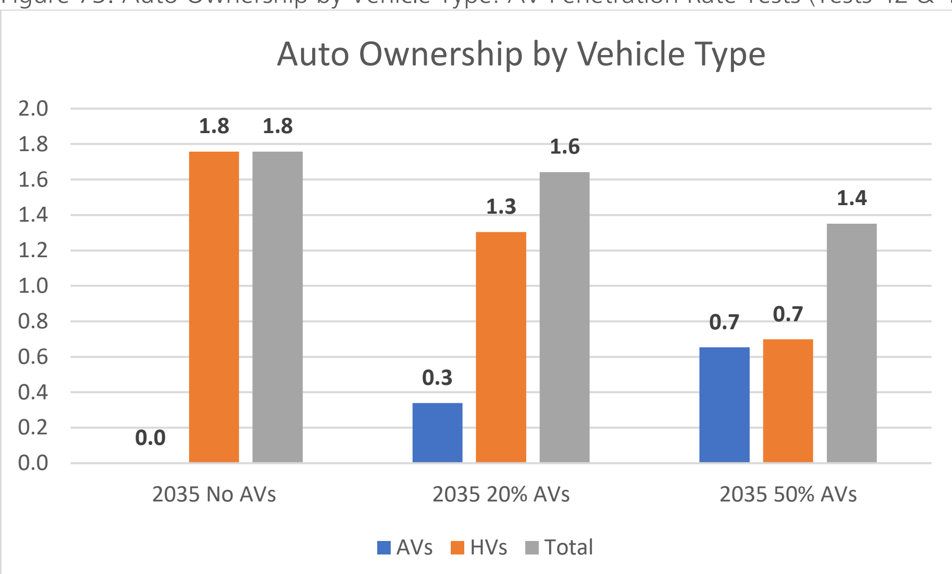


Table 13. Person Trip Distance by Mode: AV Penetration Rate Tests (Tests 42 & 43)

description	DA	SR2	SR3	TNC	Pooled TNC	Walk	Bike	Transit	Total
2035 baseline w/o AV	7.5	5.7	5.9	3.3	3.4	0.8	3.2	8.9	6.1
2035 baseline with AV	7.5	5.7	5.9	3.3	3.2	0.8	3.3	8.7	6.2
AV penetration rate 50%	7.6	5.8	6.1	3.3	3.3	0.8	3.4	8.5	6.2

AV In-Vehicle Time (IVT) Coefficient Tests (Tests 44 & 45)

Compared with the 2035 baseline with a 0.75 AV IVT coefficient, the 0.6 AV IVT coefficient test had the following results:

- Regional VMT increased by 0.5% (Figure 74)
- Insignificant mode share changes (Figure 75)
- Share of AV VMT in regional total increased from 24.8% to 25.1% (Figure 76)

Compared with the 2035 baseline with a 0.75 AV IVT coefficient, 0.9 AV IVT coefficient test had the following results:

- VMT decreased by 0.4% (Figure 74)
- Insignificant mode share changes (Figure 75)
- Share of AV VMT in regional total decreased from 24.8% to 24.6% (Figure 76).

The results suggest that the ABM2+ is sensitive to the AV in-vehicle time coefficient. As AV IVT coefficient decreased, both regional VMT and AV VMT increased slightly. However, the AV IVT coefficient had limited impact on mode shares. When AV IVT coefficient increased, the opposite patterns was observed.

Figure 74. VMT Change from Baseline: AV In-Vehicle Time (IVT) Coefficient Tests (Tests 44 & 45)

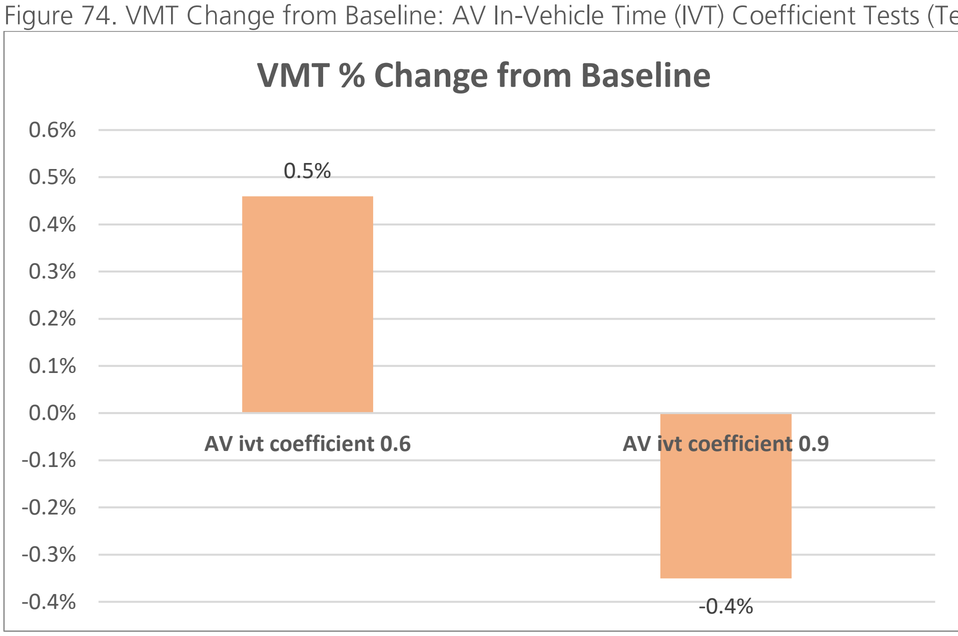


Figure 75. Mode Share of Person Trips: AV In-Vehicle Time (IVT) Coefficient Tests (Tests 44 & 45)

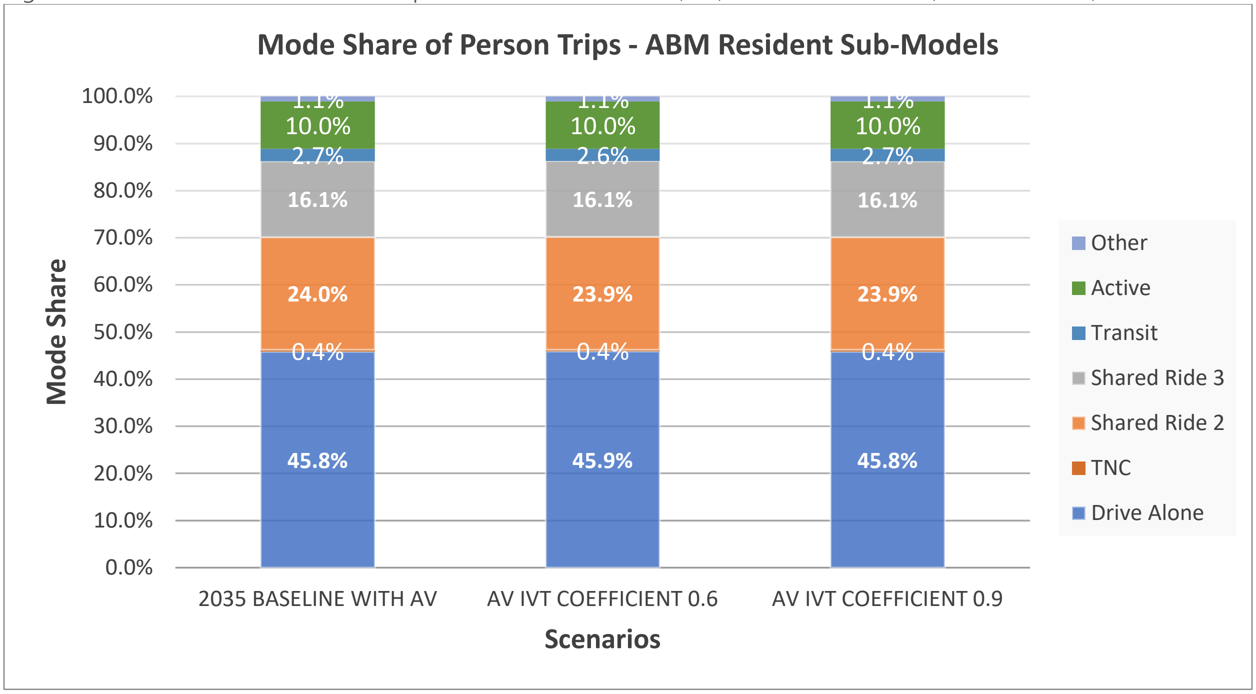
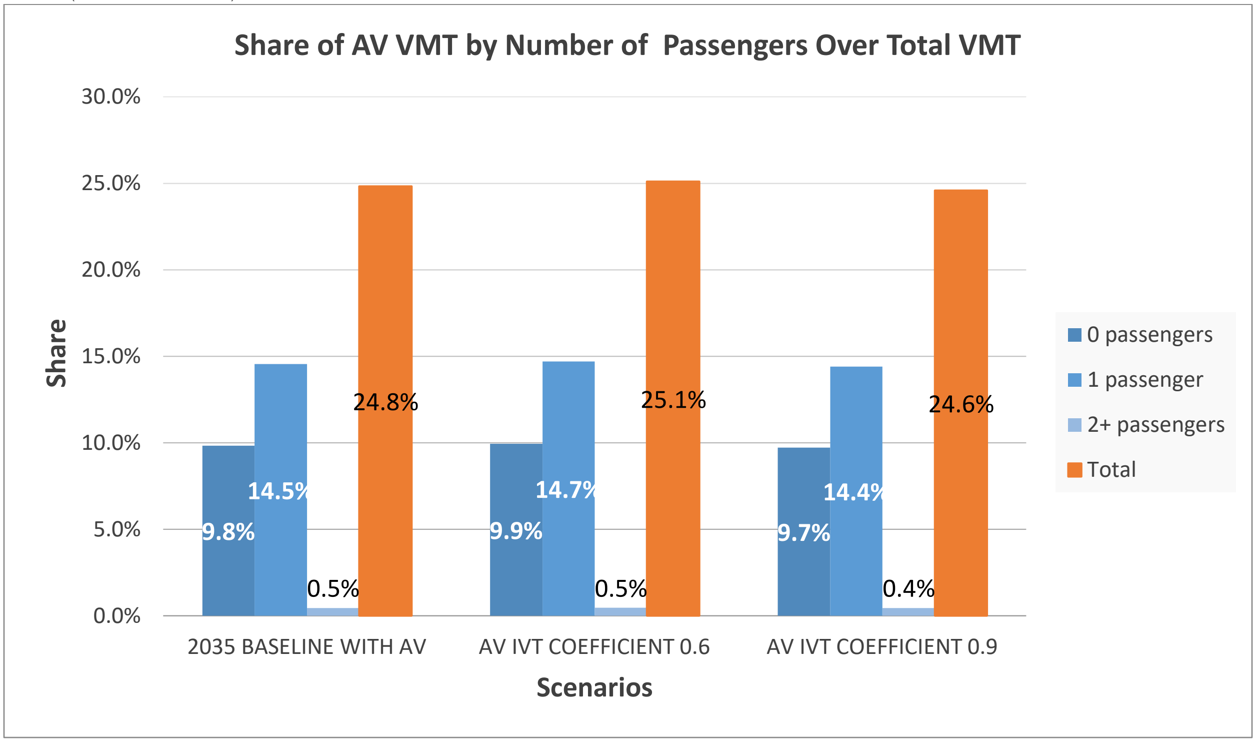


Figure 76. Share of AV VMT by Number of Passengers Over Total VMT: AV In-Vehicle Time (IVT) Coefficient Tests (Tests 44 & 45)



AV Auto Operating Cost Scaler Tests (Tests 46 & 47)

Compared with the 2035 baseline with a 0.7 AV AOC scaler, 0.5 AV AOC scaler test had the following results:

- Regional VMT increased by 0.7% (Figure 77)
- Insignificant mode share changes (Figure 78)
- Share of AV VMT in regional total increased from 24.8% to 25.0% (Figure 79).

Compared with the 2035 baseline with 0.7 AV AOC scaler, 0.9 AV AOC scaler test had the following results:

- VMT decreased by 0.4% (Figure 77)
- Insignificant mode share changes (Figure 78)
- Share of AV VMT in regional total increased from 24.8% to 24.6% (Figure 79).

The results suggest that ABM2+ is sensitive to AV AOC. As the AV AOC scaler decreased, both regional VMT and AV VMT increased slightly. However, the AV AOC scaler had limited impact on mode shares. When the AV AOC scaler increased, the opposite patterns were observed.

Figure 77. VMT Change from Baseline: AV Auto Operating Cost Scaler Tests (Tests 46 & 47)

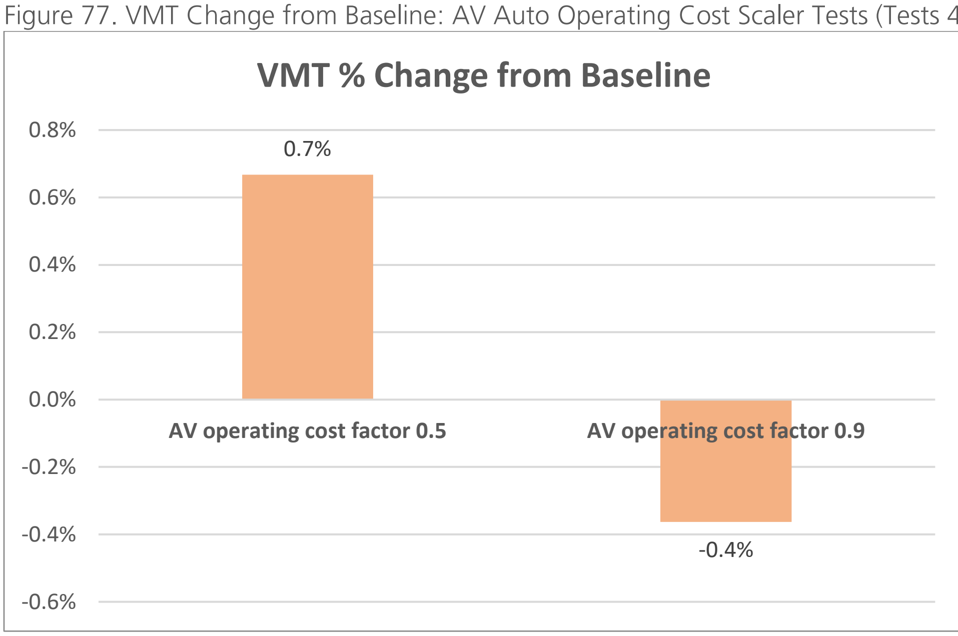


Figure 78. Mode Share of Person Trips: AV Auto Operating Cost Scaler Tests (Tests 46 & 47)

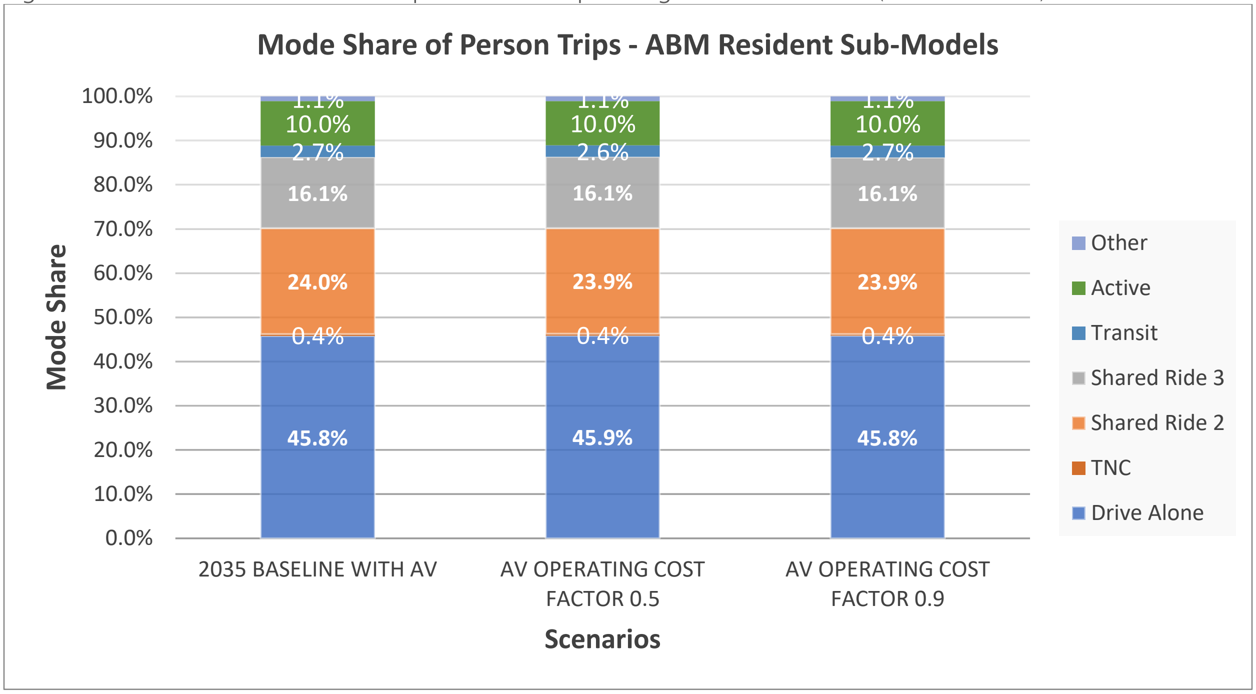
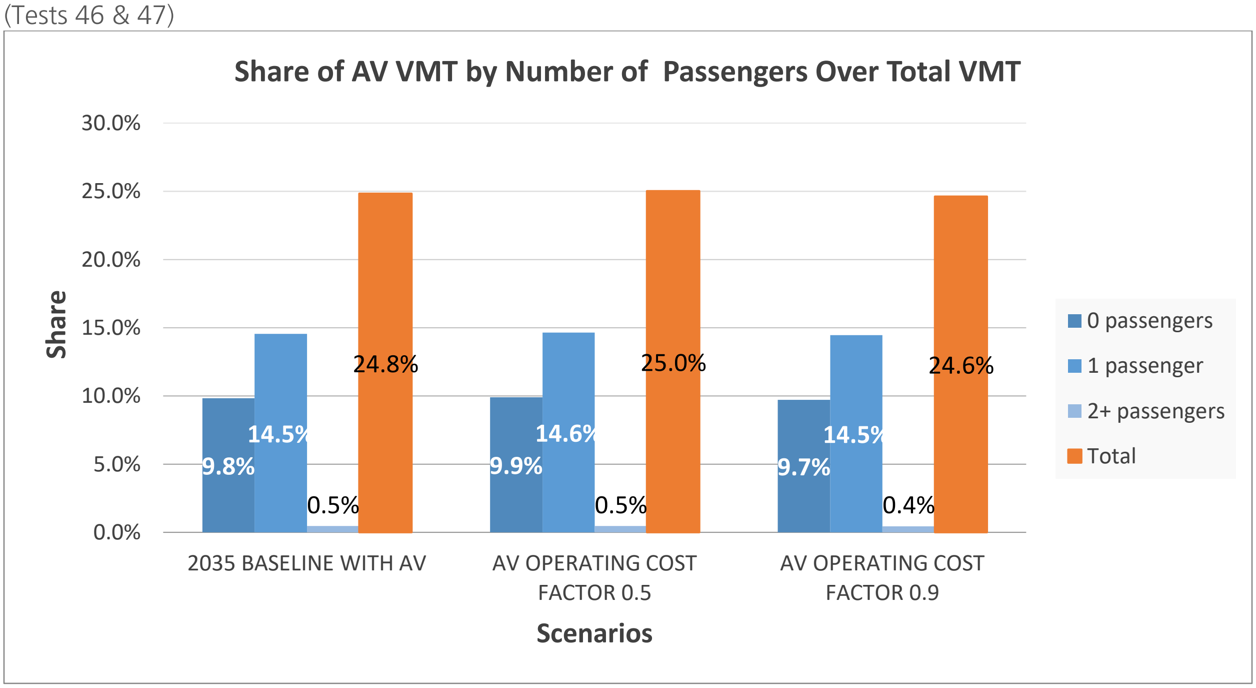


Figure 79. Share of AV VMT by Number of Passengers Over Total VMT: AV Auto Operating Cost Scaler Tests (Tests 46 & 47)



AV Terminal Time Tests (Tests 48 & 49)

In comparison with the 2035 baseline with a default AV terminal time factor of 0.65, a 0.5 AV terminal time factor test had the following results:

- Overall regional VMT increased slightly by 0.1% (Figure 80)
- Insignificant mode share changes (Figure 81)

In comparison with the 2035 baseline with a default AV terminal time factor of 0.65, a larger 0.8 AV terminal time factor test had the following results:

- Insignificant VMT change (Figure 80)
- Insignificant mode share changes (Figure 81)

The results suggest that the model had limited sensitivity to the AV terminal time scaler. When the AV terminal time changed in either direction, VMT and mode share changes were insignificant.

Figure 80. VMT Change from Baseline: AV Terminal Time Tests (Tests 48 & 49)

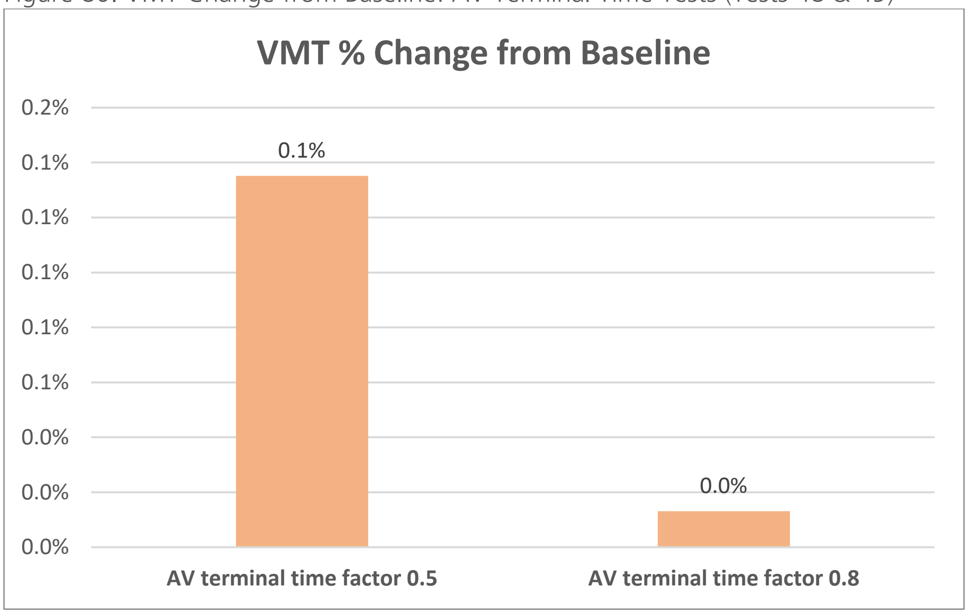
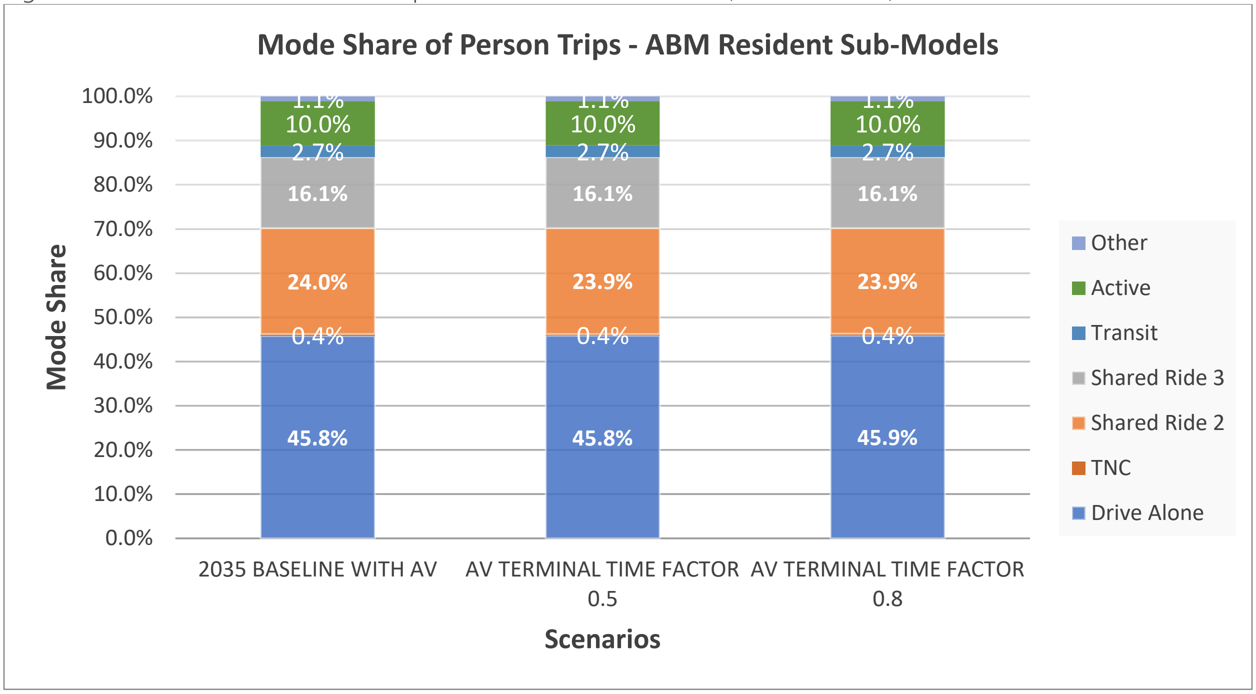


Figure 81. Mode Share of Person Trips: AV Terminal Time Tests (Tests 48 & 49)



TNC Optimization Tests (Tests 50 & 51)

In comparison with the 2035 baseline without AVs, the TNC optimization scenario had the following results:

- VMT increased slightly by 0.3% (Figure 82)
- Mode share for all models (Figure 84):
  - Drive alone decreased from 45.3% to 45.0%.
  - TNC increased from 0.9% to 1.9%.
  - Transit decreased from 2.6% to 2.5%.
  - Active modes (walk, bike, and micromobility) decreased from 9.7% to 9.6%.
- Transit boarding decreased by 2.2% (Figure 83)
- Share of TNC VMT in regional total increased from 1.1% to 1.9% (Figure 85).

In comparison with the 2035 baseline without AVs, the transit TNC optimization scenario had the following results:

- Insignificant VMT change (Figure 82).
- Insignificant mode share changes (Figure 84).
- Transit boarding increased slightly by 0.2% (Figure 83).

The results suggest that the model was sensitive to the TNC optimization scenario when all TNC were given 30-minute benefits. While TNC mode share increased significantly, auto, transit and active mode shares all decreased, indicating competition between TNC and all other modes.

On the other hand, the results suggest that the model had limited sensitivity to the TNC transit optimization scenario when only TNC transit were given 30-minute benefits. The lack of sensitivity could be explained by the very small TNC transit mode share (roughly 0.01%). Regardless of how much benefit was given to TNC transit, with such a small mode share, the impact of TNC transit on model results was insignificant.

Figure 82. VMT Change from Baseline: TNC Optimization Tests (Tests 50 & 51)

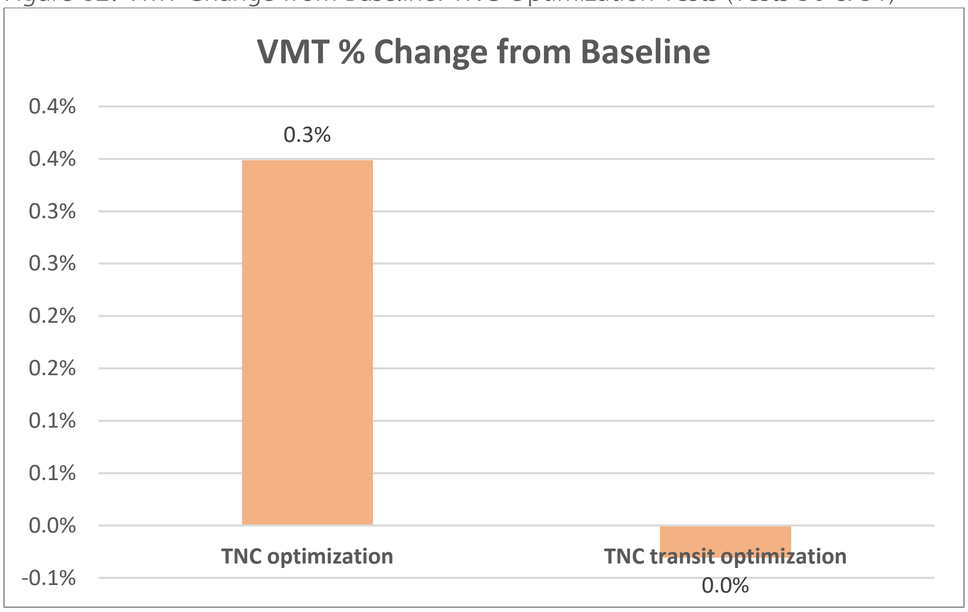


Figure 83. Transit Boarding Change from Baseline: TNC Optimization Tests (Tests 50 & 51)

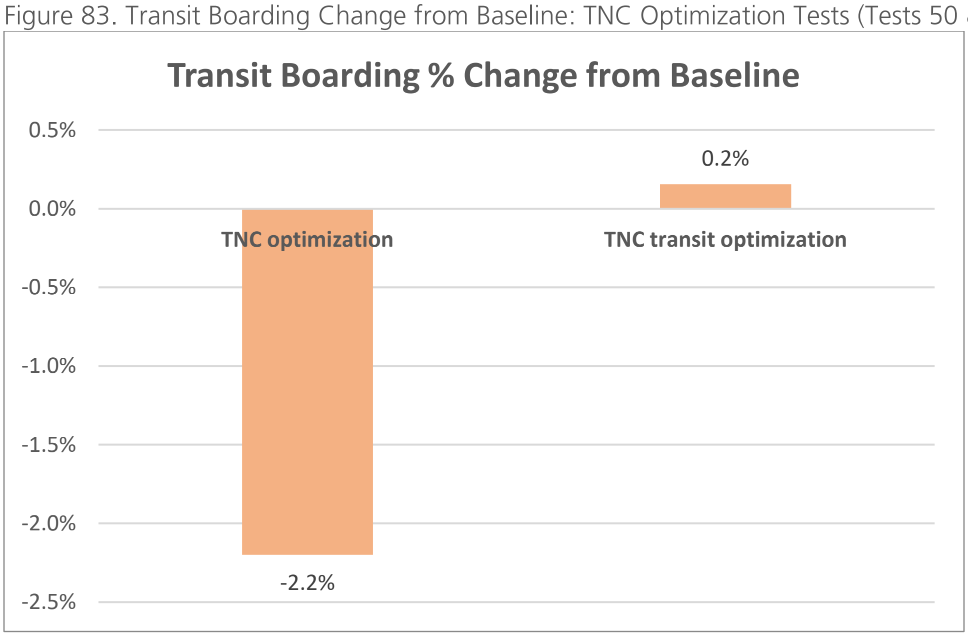


Figure 84. Mode Share of Person Trips: TNC Optimization Tests (Tests 50 & 51)

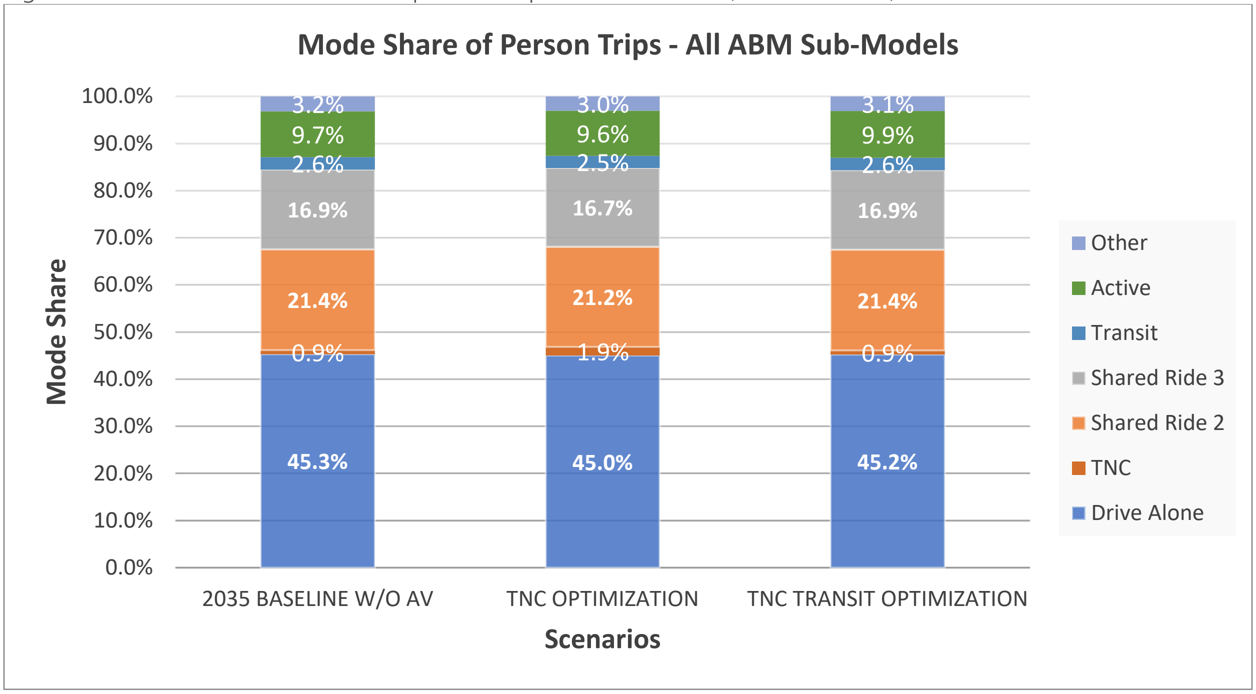
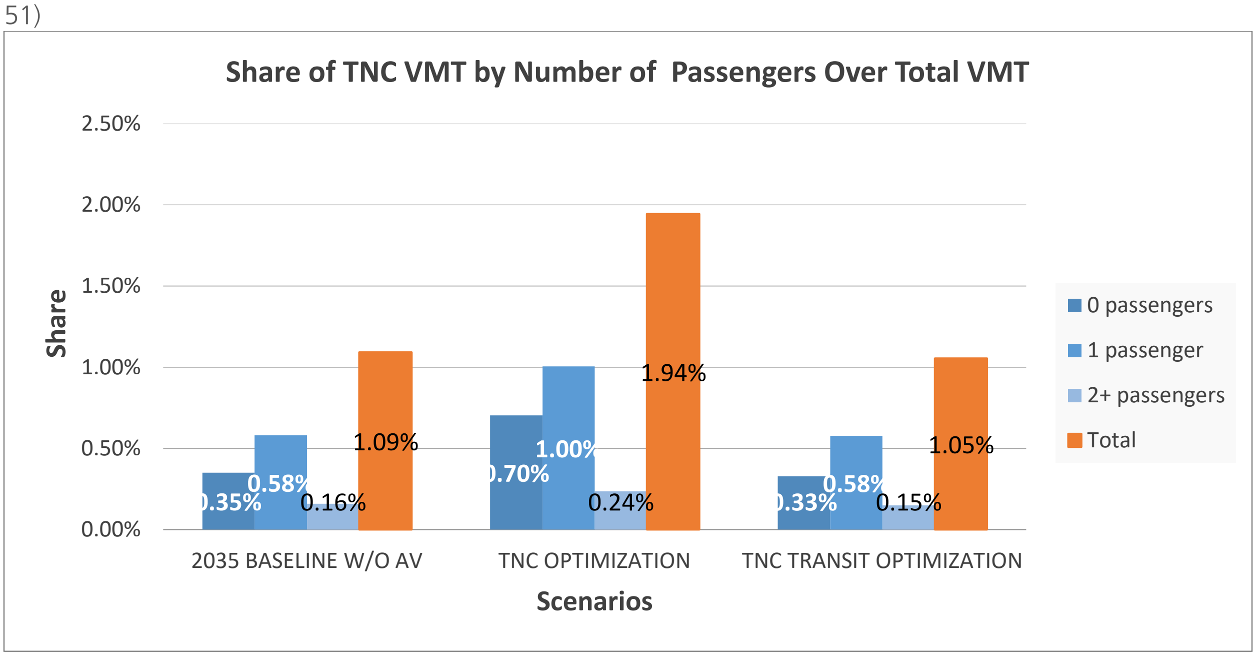


Figure 85. Share of TNC VMT by Number of Passengers Over Total VMT: TNC Optimization Tests (Tests 50 & 51)



AV and TNC Combo Tests (Tests 52-54)

In comparison with the 2035 baseline with 20% AV, the 20% AV with 30 minutes TNC benefit test had the following results:

- VMT increased slightly by 0.1% (Figure 86)
- Mode share of all models (Figure 87):
    - Drive alone decreased from 45.3% to 45.1%.
    - SR3 decreased from 16.7% to 16.4%.
    - TNC increased from 0.8% to 1.7%.
    - Active modes (walk, bike, and micromobility) decreased from 9.7% to 9.6%.
- Share of TNC VMT in regional total increased from 0.9% to 1.6% (Figure 89).
- Overall trip distance change was insignificant; Regular TNC trip distance decreased from 7.7 miles to 6.3 miles; Pooled TNC trips decreased from 6.0 miles to 5.4 miles (Table 14).

In comparison with the 2035 baseline with 20% AV, the 20% AV with 7.5 minutes TNC benefit test had the following results:

- VMT change was insignificant (Figure 86)
- Mode share changes were insignificant, except TNC mode share increased from 0.8% to 1.0% (Figure 87).
- Share of TNC VMT in regional total change was insignificant (Figure 89).
- Overall trip distance change was insignificant; Regular TNC trip distance decreased from 7.7 miles to 7.5 miles; Pooled TNC trips decreased from 6.0 miles to 5.8 miles (Table 14).

In comparison with the 2035 baseline with 20% AV, the 50% AV with 15 minutes TNC benefit test had the following results:

- VMT increased by nearly 9% (Figure 86)
- Mode share of all models (Figure 87):
    - Drive alone decreased from 45.3% to 44.6%.
    - SR2 increased from 21.7% to 21.9%.
    - SR3 decreased from 16.7% to 15.5%.
    - Transit increased from 2.7% to 3.2%.
    - TNC increased from 0.8% to 1.1%.
    - Active modes (walk, bike, and micromobility) increased from 9.7% to 10.3%.
- Transit boarding increased by 17% (Figure 88)
- Share of TNC VMT in regional total increased from 0.9% to 1.0% (Figure 86).
- Overall trip distance change was insignificant; Regular TNC trip distance decreased from 7.7 miles to 7.0 miles; Pooled TNC trips decreased from 6.0 miles to 4.7 miles (Table 14).

The results suggest that the model is sensitive to the combined AV penetration rate and TNC benefit changes. Regional VMT increased significantly in the 50% AV scenario but not in the 7.5

minutes and 30 minutes TNC benefit scenarios (both with 20% AV), indicating that the key driver of VMT is AV penetration rate not TNC benefit. The results also indicate ABM2+ is sensitive to TNC benefits; with 30 minutes TNC benefits, the TNC mode share increased significantly from 0.8% to 1.7%.

Figure 86. VMT Change from Baseline: AV and TNC Combo Tests (Tests 52-54)

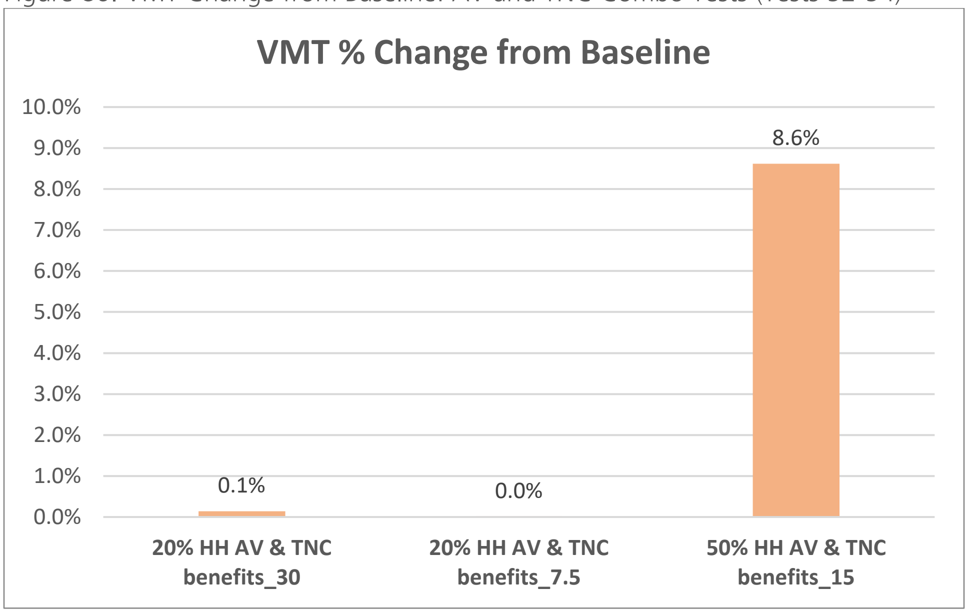


Figure 87. Mode Share of Person Trips: AV and TNC Combo Tests (Tests 52-54)

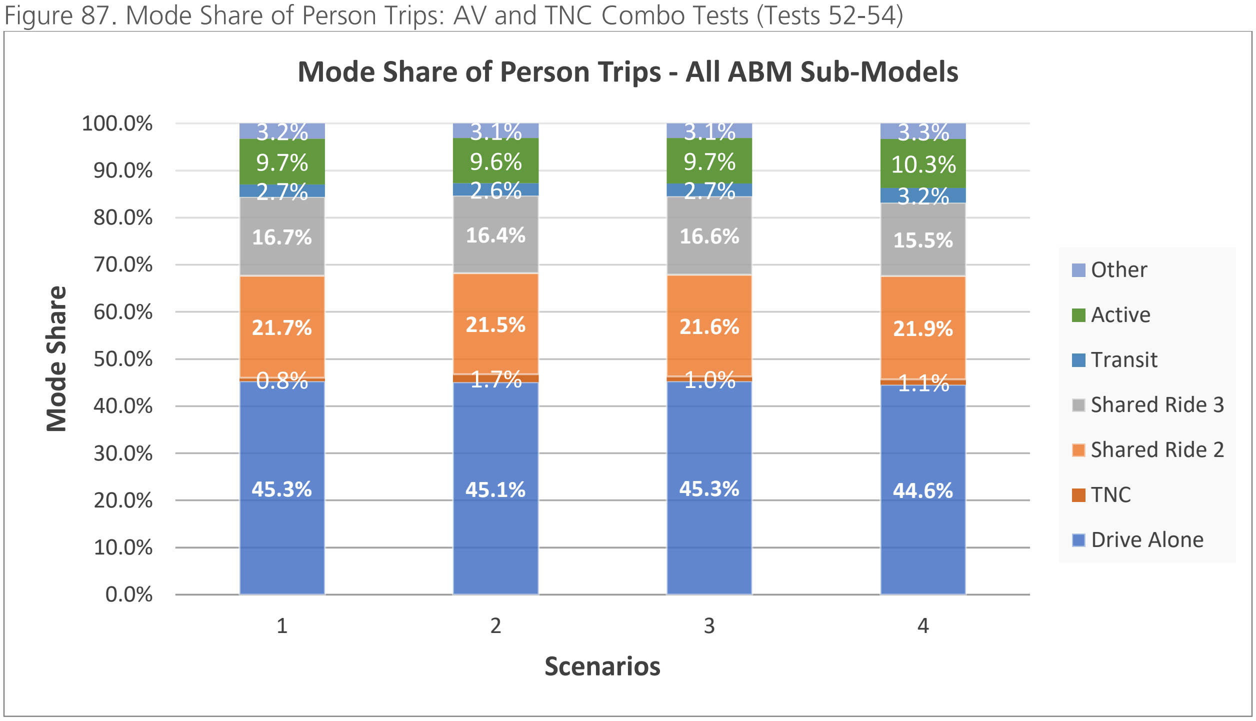


Figure 88. Transit Boarding Change from Baseline: AV and TNC Combo Tests (Tests 52-54)

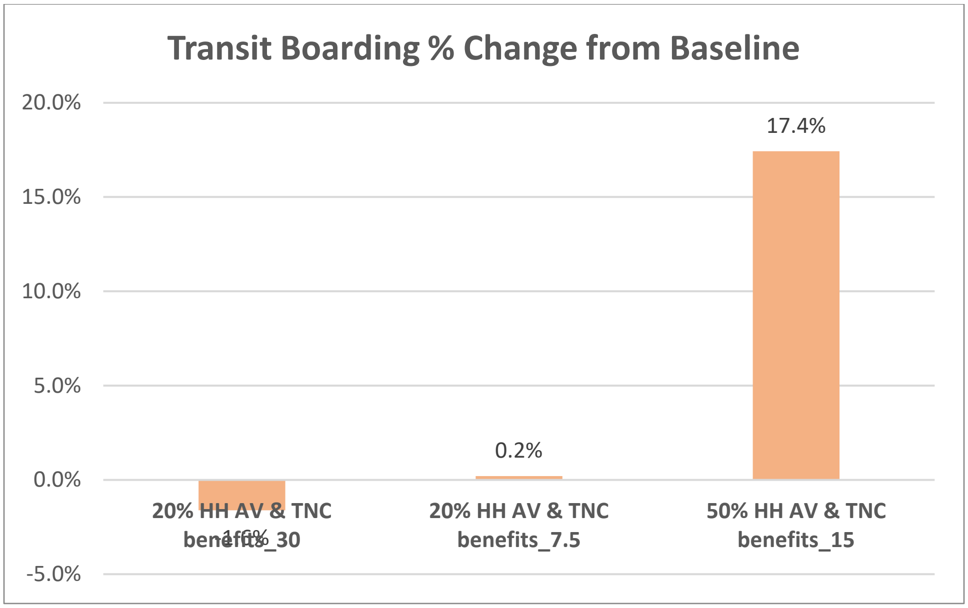


Figure 89. Share of TNC VMT by Number of Passengers Over: AV and TNC Combo Tests (Tests 52-54)

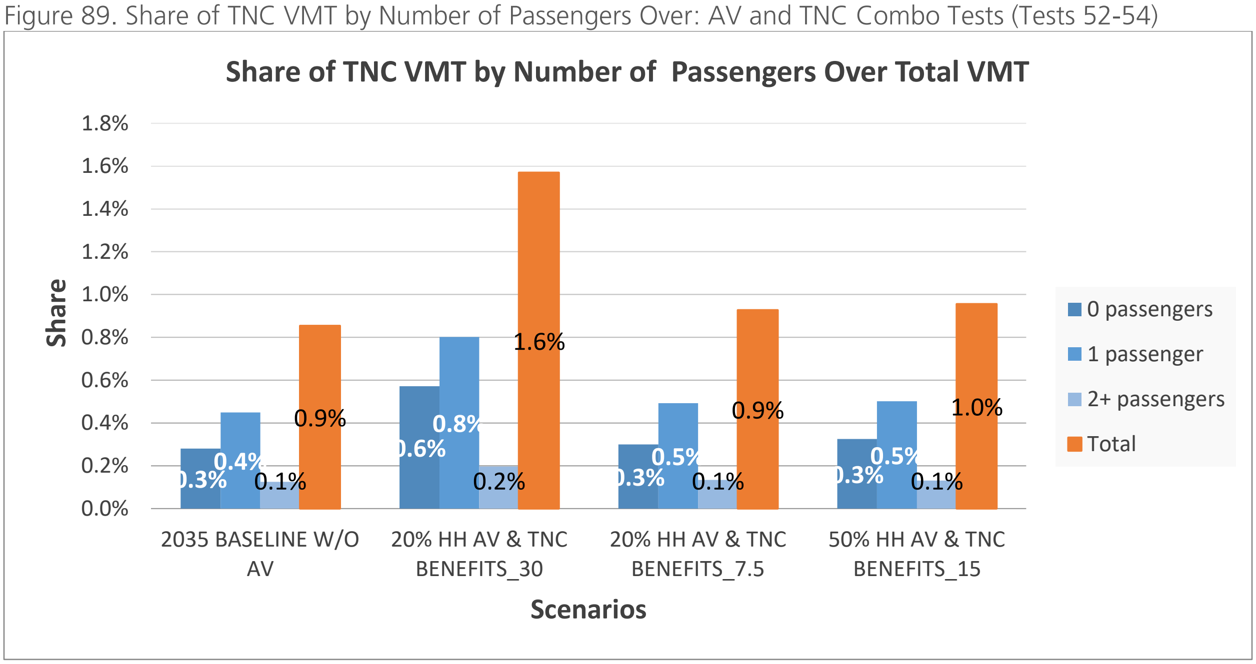


Table 14. Person Trip Distance by Mode: AV Penetration Rate Tests (Tests 52-54)

description	DA	SR2	SR3	TNC	Pooled TNC	Walk	Bike	Transit	Total
2035 baseline with AV	8.0	7.2	8.3	7.7	6.0	0.8	3.3	9.1	7.3
20% HH AV & TNC benefits_30	8.0	7.2	8.3	6.3	5.4	0.8	3.3	9.2	7.3
20% HH AV & TNC benefits_7.5	8.0	7.2	8.3	7.5	5.8	0.8	3.3	9.1	7.3
50% HH AV & TNC benefits_15	8.0	7.3	8.6	7.0	4.7	0.8	3.4	8.9	7.3

Telework

Telework Rate (Tests 55, 56 & 57)

In May 2020, amid the COVID19 pandemic, staff conducted telework sensitivity tests to evaluate the responsiveness of ABM2+ to various telework scenarios. In ABM2+, there are two types of telework, permanent and occasional telework. Permanent telework is modeled in the work from home model, while the impact of occasional telework is reflected in daily activity pattern, telework frequency, non-mandatory tour frequency, and non-mandatory tour stop frequency models. Since telework modeling in ABM2+ is based on the 2016/2017 household travel behavior survey, ABM2+ telework results represent the pre-COVID19 'normal' condition. Neither temporary COVID19 shelter in place nor post-COVID19 new 'normal' conditions are reflected in ABM2+ telework modeling.

Staff tested three 2035 telework alternatives (Table 15): existing pattern (business as usual) scenario, moderate growth scenario, and maximum growth scenario.

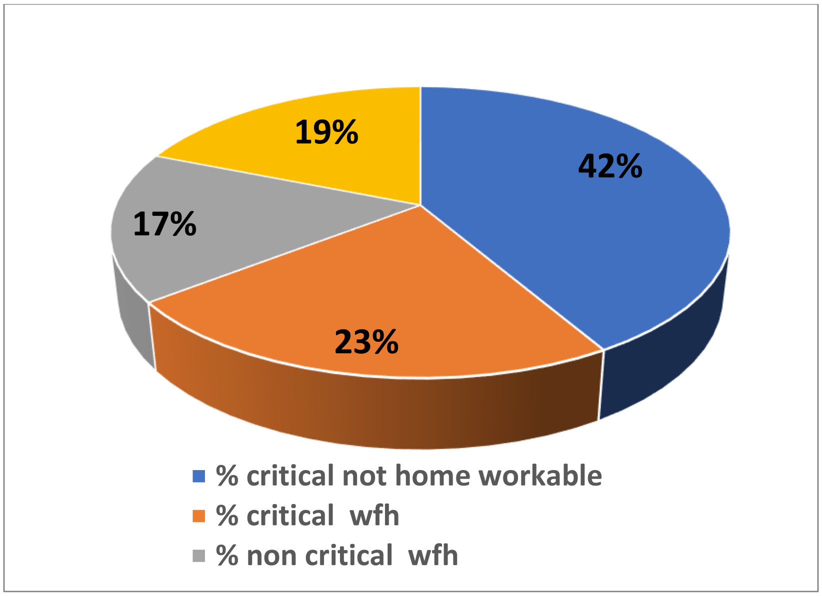
Table 15. 2035 telework alternatives

CARB Category	Description	Test ID	Scenario	Year
Telework	Existing pattern	56	Existing telework rates	2035
	Moderate growth pattern	57	Moderate telework rate growth	2035
	Maximum growth pattern	58	Maximum telework rate growth	2035

In each of the three scenarios, occasional telework is further broken down to 1 day a week, 2-3 days a week, and 4+ days a week categories using the observed proportions from the 2016/2017 household survey.

The maximum telework scenario is constructed using data from an analysis by a SANDAG economist. In the analysis, workers in San Diego are categorized into four categories (below). Combining both critical and non-critical workers who can work from home, roughly 40% of San Diego's workforce are telework-able, while the other 60% are not. In test 56, the combined permanent and occasional telework rate is 38%, roughly representing a maximum possible telework scenario.

- Critical workers but not home workable (42%)
- Critical workers who can work from home (23%)
- Non-critical workers but not home workable (19%)
- Non-critical workers who can work from home (17%)



Telework Sensitivity Testing Results

In comparison with the existing telework pattern, the moderate telework growth scenario had the following results:

- Overall trip rate decreased from 4.51 to 4.49 (Figure 90). All categories except teleworking 2-3 days/week decreased (Figure 91).
- Mode shares (Figures 92 & 93):
  - Drive alone decreased from 45.9% to 45.5%.
  - SR2 increased from 23.5% to 23.6%
  - SR3 increased from 16.6% to 16.7%.
  - Walk mode increased from 8.8% to 9.0%
  - Transit decreased from 2.6% to 2.5%
- Auto trip length decreased from 6.1 to 6.0 (Figure 94). Walk trip length decreased from 3.2 to 3.1 (Figure 95).
- Transit boardings decreased by 1.7% (Figure 96)
- VMT decreased by 1.5% (Figure 94). VMT per capita decreased from 24.3 to 23.9 (Figure 95). All Worker VMT telework types decreased (Figure 99).

In comparison with the existing telework pattern, the maximum telework scenario had the following results:

- Trip rate decreased from 4.51 to 4.47 (Figure 90). All telework categories decreased (Figure 91).
- Mode shares (Figures 92 & 93):
  - Drive alone decreased from 45.9% to 43.6%.

- SR2 increased from 23.5% to 24.7%
- SR3 increased from 16.6% to 17.5%.
- Walk mode increased from 8.8% to 9.2%
- Transit decreased from 2.6% to 2.4%

- Auto trip length decreased from 6.1 to 5.8 (Figure 94). Walk trip length decreased from 3.2 to 2.9 (Figure 95).
- Transit boardings decreased by 5.4% (Figure 96)
- VMT decreased by 4.7% (Figure 94). VMT per capita decreased from 24.3 to 23.1 (Figure 98). All Worker VMT telework types decreased (Figure 99).

The results suggest that the model is sensitive to permanent and occasional telework rate changes. When compared with non-teleworkers, teleworkers generally generate fewer and shorter trips, drive alone less while shareriding and walking more, avoid peak-time travel, and have a smaller VMT per capita. Additionally, those who primarily work from home tend to have a higher trip rate, shorter trip distances, and smaller drive alone mode share, rates of peak-time travel, and VMT per capita when compared to occasional teleworkers. In general, as telework rate increases, the regional VMT, transit ridership, and peak-hour congestion all decrease.

Figure 90. Worker Trip Rate: Telework Rate Tests (Tests 55-57)

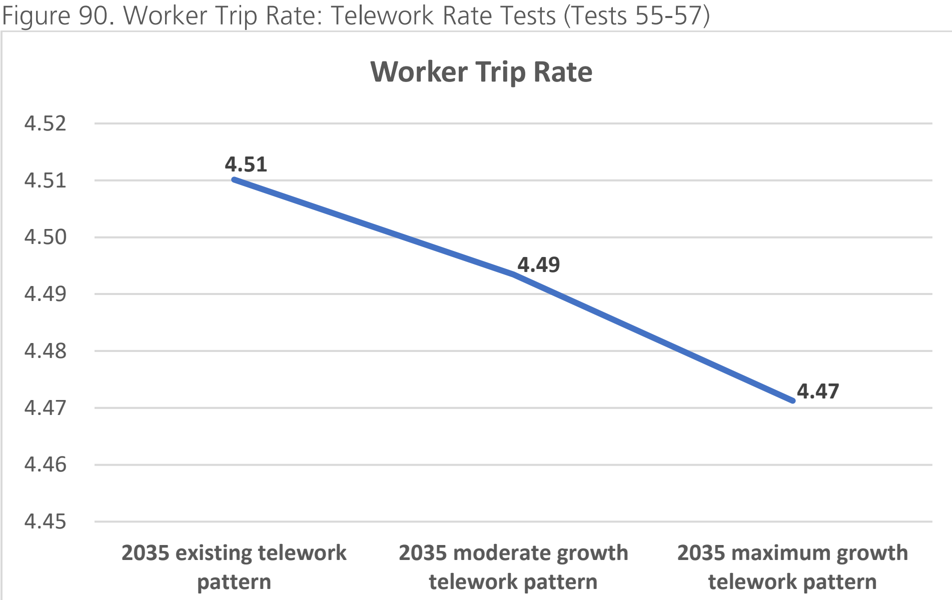


Figure 91. Worker Trip Rate by Telework Type: Telework Rate Tests (Tests 55-57)

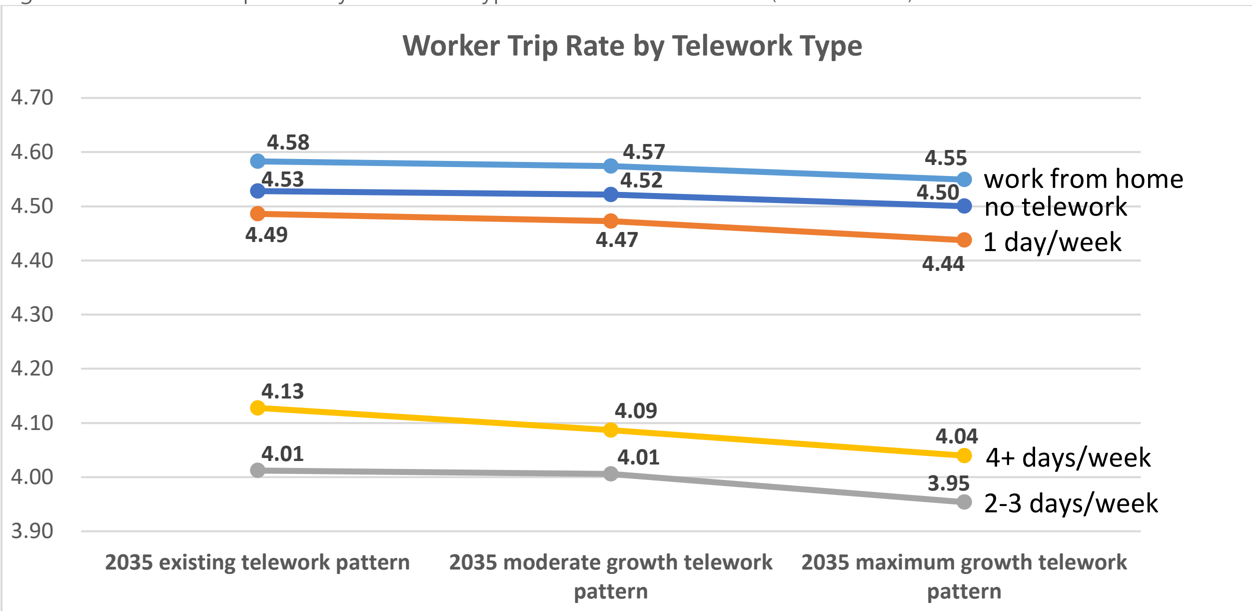


Figure 92. Auto Mode Shares: Telework Rate Tests (Tests 55-57)

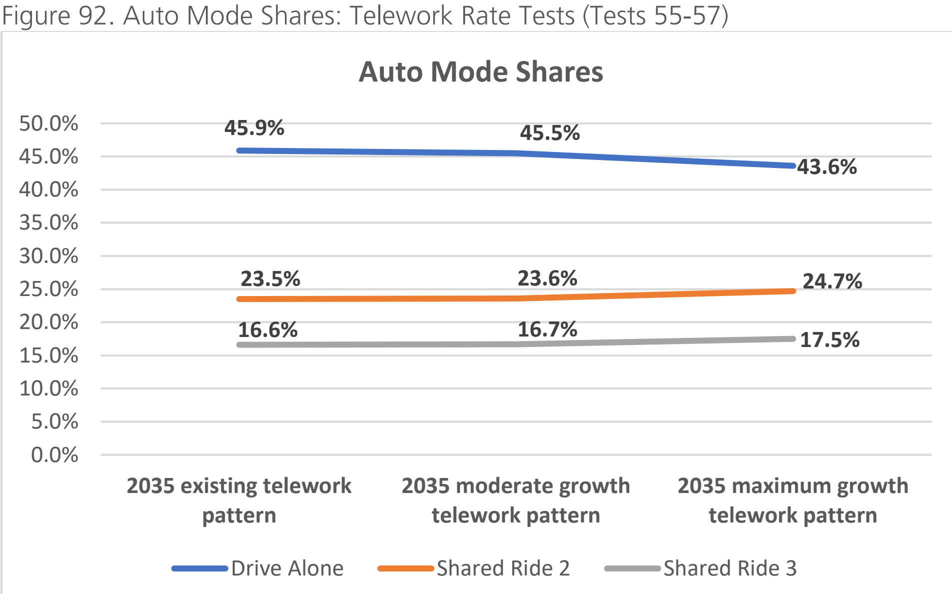


Figure 93. Non-Auto Mode Shares: Telework Rate Tests (Tests 55-57)

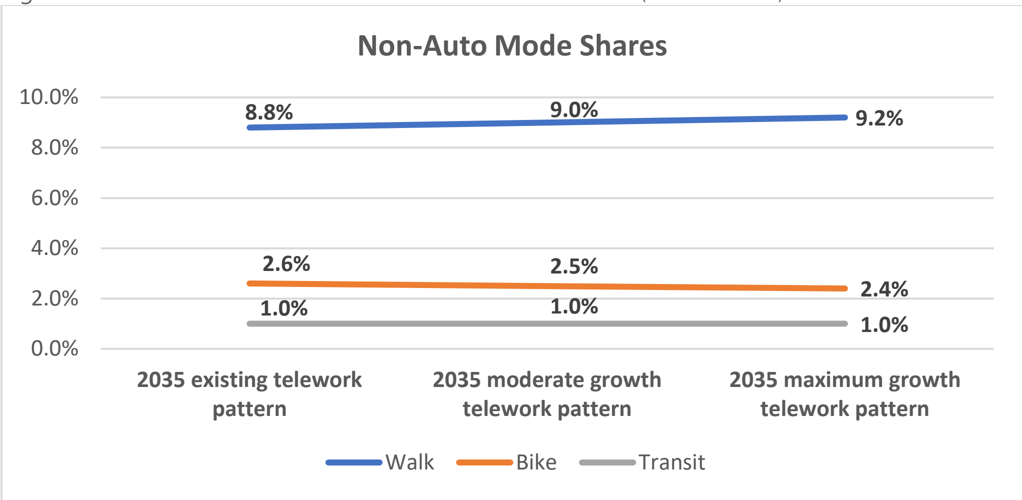


Figure 94. Auto Trip Length: Telework Rate Tests (Tests 55-57)

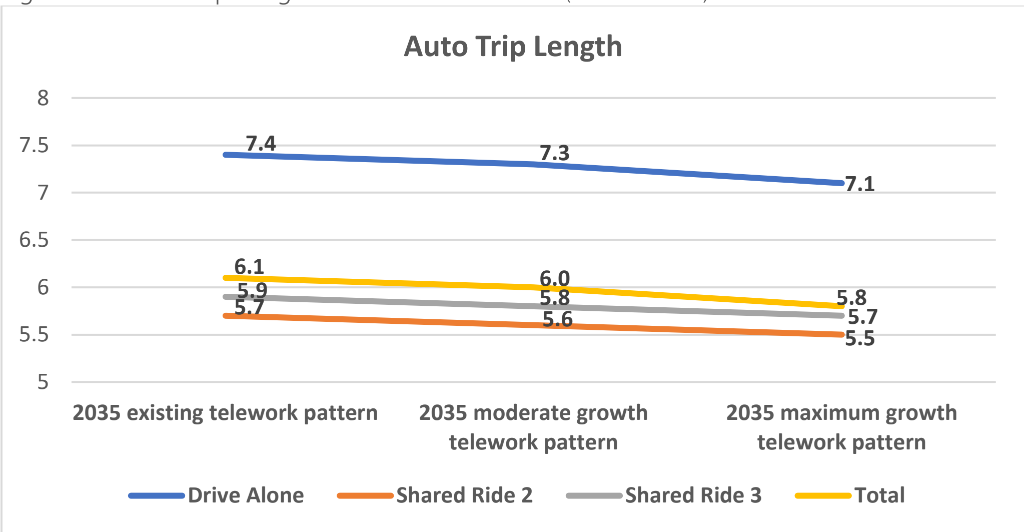


Figure 95. Auto Trip Length: Telework Rate Tests (Tests 55-57)

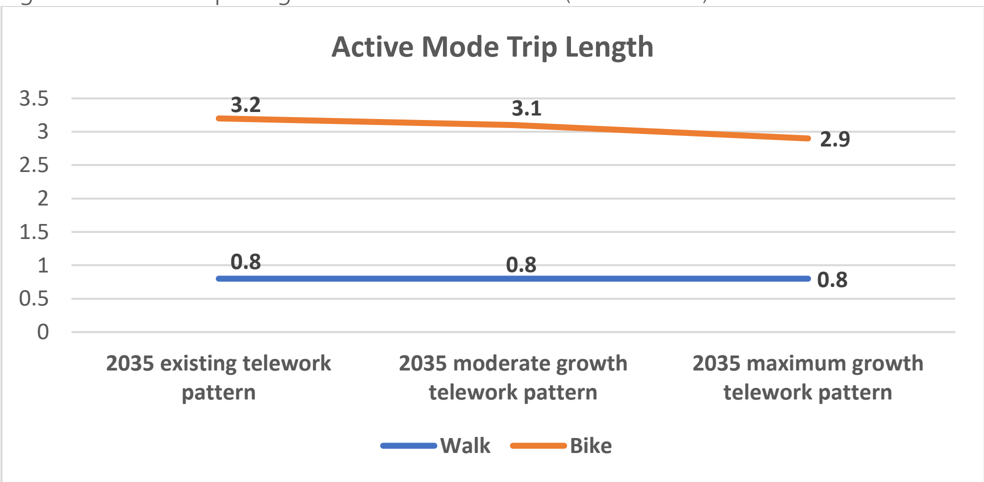


Figure 96. Transit Boarding Change from Baseline: Telework Rate Tests (Tests 55-57)

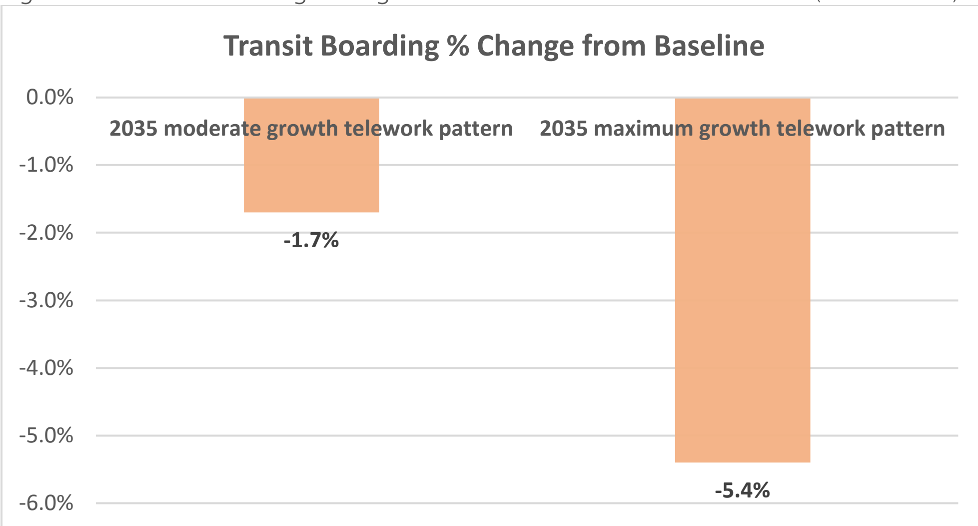


Figure 97. Telework Rate & VMT Reduction: Telework Rate Tests (Tests 55-57)

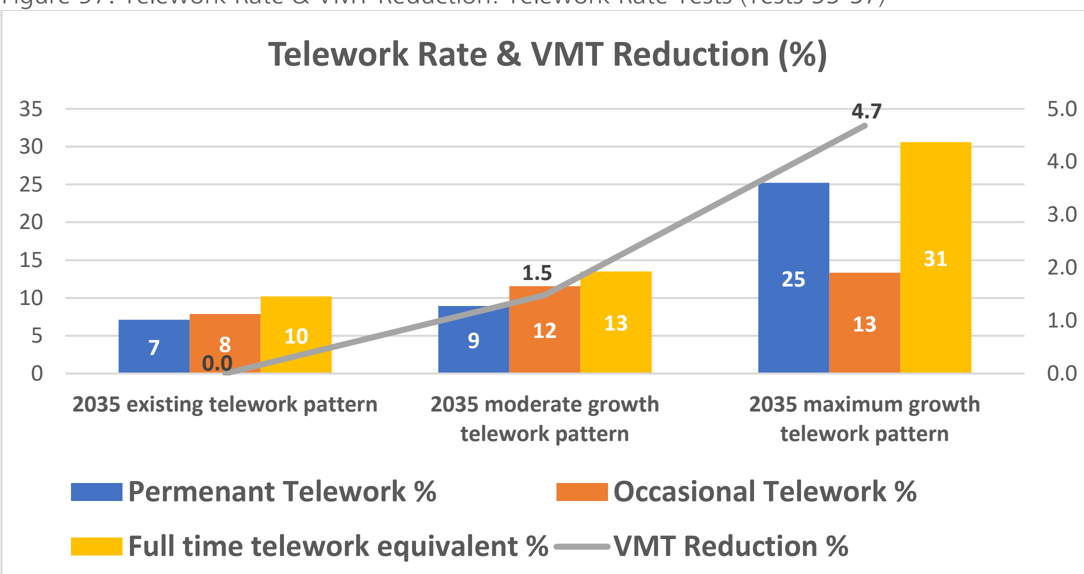


Figure 98. VMT Per Capita: Telework Rate Tests (Tests 55-57)

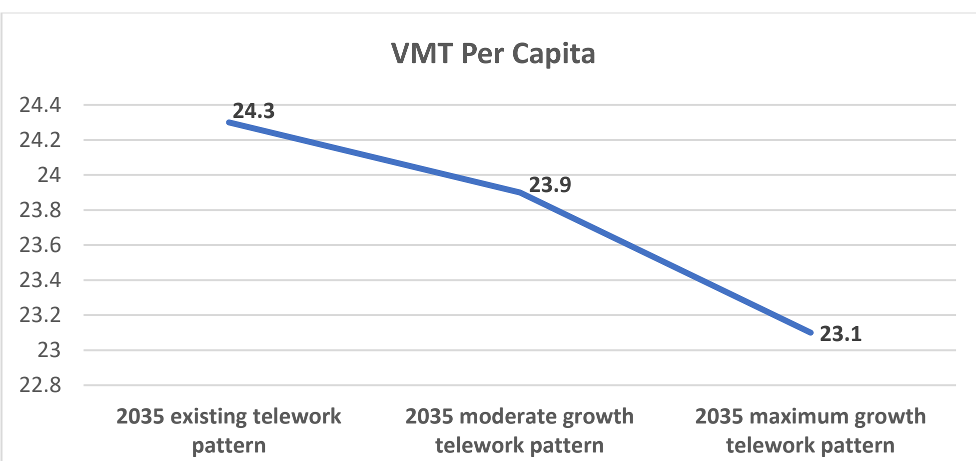


Figure 99. Worker VMT Per Capita by Telework Type: Telework Rate Tests (Tests 55-57)