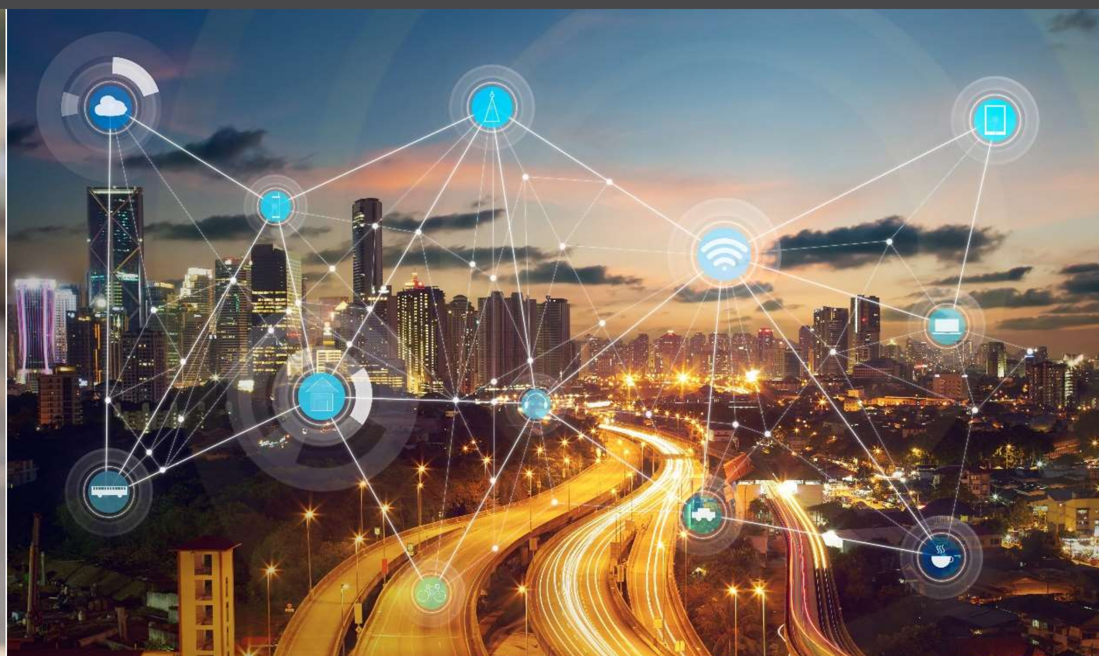
the science of insight

Metropolitan Council

ACTIVITYSIM IMPLEMENTATION PHASE 1 REPORT

July 31, 2022



PREPARED FOR:
METROPOLITAN COUNCIL

SUBMITTED BY:
RSG

55 Railroad Row
White River Junction, VT 05001
802.295.4999
www.rsginc.com

IN COOPERATION WITH:
INSIGHT TRANSPORTATION CONSULTING, INC.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 INTRODUCTION

The Metropolitan Council model is a transportation demand model implemented in Cube Voyager. The starting point of this model was a TourCast model implemented in Cube Voyager. This project's focus was to replace TourCast with ActivitySim and ensure that all model parts work correctly while targeting some portions of ActivitySim for a selective calibration. The Metropolitan Council is a member of the Activitysim Consortium and ActivtySim is continually improved via consultants hired by the ActivitySim Consortium.

The model estimates and forecasts transportation for 3.8 million people, 1.5 million households, and just under 2 million employees. The model area is 10,000 square miles covering 19 counties, including Anoka, Carver, Chisago, Dakota, Goodhue, Hennepin, Isanti, Le Sueur, McLeod, Ramsey, Rice, Scott, Sherburne, Sibley, Washington, and Wright counties in Minnesota and Pierce, Polk, and St. Croix counties in Wisconsin. This is larger than the Council's transportation planning area, which includes Anoka, Carver, Dakota, Hennepin, Ramsey, Scott, and Washington counties , as well as developed portions of Sherburne and Wright counties.

ActivitySim is an advanced, open-source, activity-based travel behavior modeling software platform. This software simulates the movement of persons throughout their day by simulating decisions that are made, including their primary work and school locations; whether they will go to work ,telecommute, or if they work from home; other tours they may make throughout the day; if stops will be made on their tours and if so, how many and where those stops will be; and how and when they will travel. More information on ActivitySim can be found on the project website at https://activitysim.github.io/.

Throughout this project, detailed model methodologies were added to the Metropolitan Council Model's Github Wiki at https://github.com/Metropolitan-Council/metc-asim-model/wiki/Activitysim-conversion. This allows the model methodologies to be a living document and can easily be updated if a change is implemented.

The next section of this document reports on the model implementation. Following that section is a summary of the targeted calibration. Next is a report on the sensitivity testing that was undertaken as part of the project. The final section of this document recommends actions for further improvement to the model, and whether those improvements should come from improved data or improved model calibration.

2.0 MODEL IMPLEMENTATION

The starting point for this model was the SEMCOG single-zone ActivitySim example as transferred in June, 2021. This starting point provided a setup for all major parts of the model system, which includes initialization steps, accessibility, mandatory tour locations, transit pass ownership, work from home, telecommute, auto ownership, daily activity pattern, mandatory tour frequency and scheduling, joint tour models, non-mandatory tour models, tour mode choice models, at-work subtour models, and trip models. Single-zone refers to the use of only traffic analysis zones as a geography in the model.

The implementation of this model in the Cube model stream involved removing the steps that call TourCast and minor Cube script updates. The Cube script updates include the addition of scripts that convert the output Cube TP+ matrices into Open Matrix Format matrices and the addition of drive-access-transit driving distance, which skims the distance from TAZs to the nearest park-n-ride lot or kiss-n-ride drop-off location. Additionally, a step was added to convert some input files to CSV format files to be read by ActivitySim and another step to convert the output ActivitySim Open Matrix Format matrices back into Cube TP+ matrices to continue with the highway and transit assignment steps.

As part of the work, the Metropolitan Council model was added to Github at https://github.com/Metropolitan-Council/metc-asim-model, and the uploaded code includes all ActivitySim configuration files, Cube scrips, and instructions to run the model.

3.0 MODEL CALIBRATION SUMMARY

The calibration of this model was a selective calibration that served two purposes. The first purpose was proof that the model is functional and usable starting point for the council's next generation of travel model. The second purpose was to prepare the travel model for a set of sensitivity tests.

There is an interactive digital visualizer file that has been delivered to the Metropolitan Council that provides interactive summaries of these and many more components of the model. For these summaries, totals have been included and the interactive file can be used to look at segments of the model, such as county, person type, tour type, etc. The Visualizer used in this document is available upon request.

This section is split into three sections, long-term models, tour-level models, and trip-level models. This is not a full summary of the model. For a full summary of the model, please refer to the visualizer.

3.1 LONG TERM MODELS

Long term models are the models for choices that are not easily changed. In some cases, the models are something that has major financial constraints, such as the number of autos owned in a household. In other cases, there may be constraints based on other long-term decisions, like the ability to telecommute, which is related to one's occupation (factory workers can rarely telecommute, whereas office workers can frequently telecommute). The long-term models include auto ownership, work from home, workplace location, school location, and telecommute frequency models. This project included adjustments to the auto ownership, work from home, and telecommute frequency models, which are summarized in this section.

Auto Ownership

The auto ownership model is a multinomial logit model that estimates the number of autos owned by the household. This was calibrated by use of alternative-specific factors for each alternative (0 autos, 1 auto, 2 autos, 3 autos, and 4 or more autos). The intent for this model was to correct 0 autos to prepare for a transit sensitivity test. The output summary is shown in Figure 1. The model overpredicts zero-auto households by 2.7%. 1, 3, and 4+ auto households are very close, and the model underpredicts 2-auto households by 2.5%. The overall summary of the model is shown in Figure 1, for county-level auto ownership model results, please refer to the visualizer.

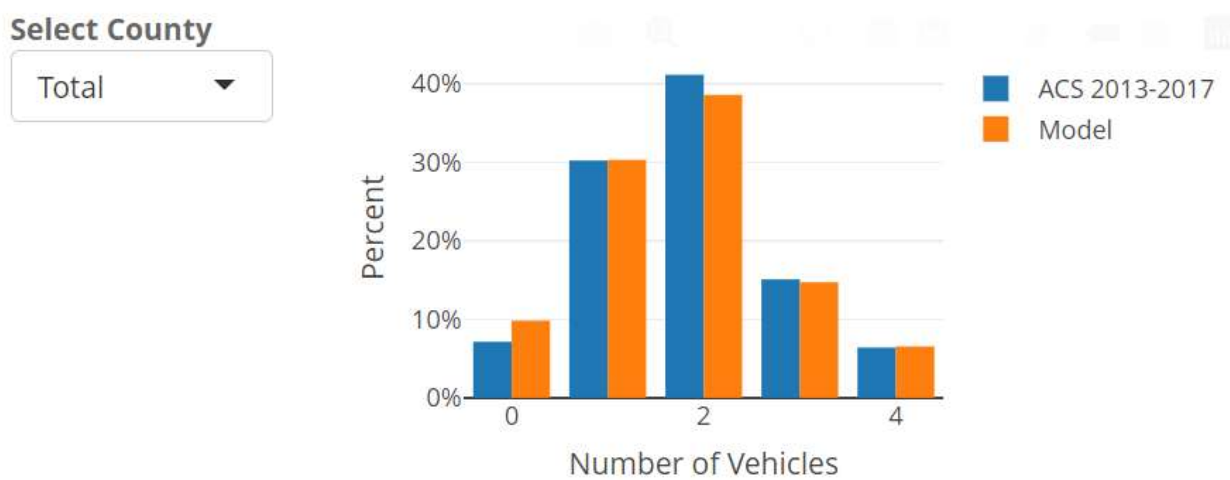


FIGURE 1: AUTO OWNERSHIP MODEL SUMMARY

Work From Home

The work from home model is a multinomial logit model that estimates whether a worker will not have a primary workplace outside their home. This is for workers that do not make any regular office commute, not for workers that telecommute a portion of a week or month (those workers are included in the telecommute frequency model). The summary of results of the model is shown in Figure 2.

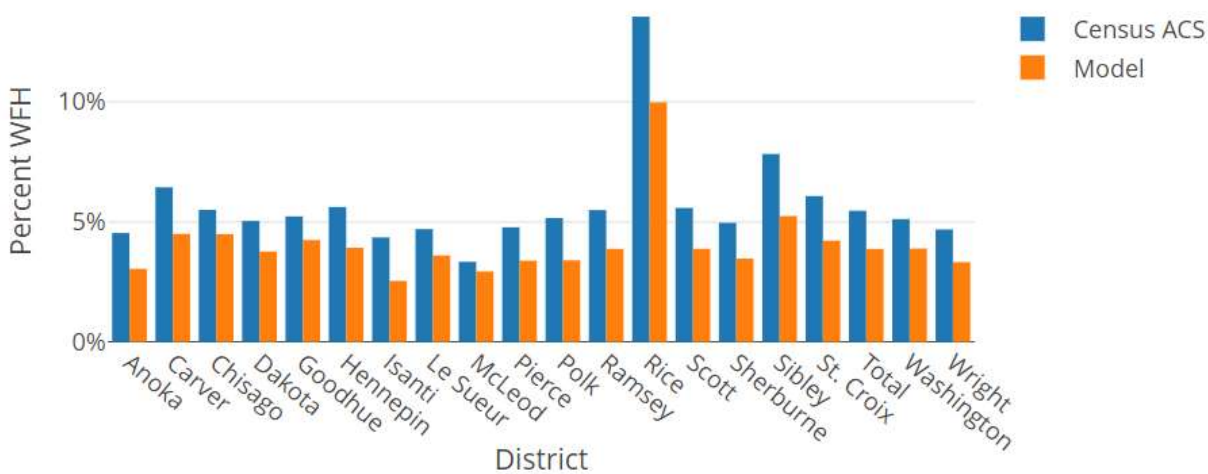


FIGURE 2: WORK FROM HOME MODEL SUMMARY

Telecommute Frequency

The telecommute frequency model is a multinomial logit model that estimates the number of workers with a workplace outside the home that will periodically telecommute. This is limited to partial weeks – not telecommuting, telecommuting 1 day per week, 2-3 days per week, and 4 days per week. A summary of the model results is in Figure 3.

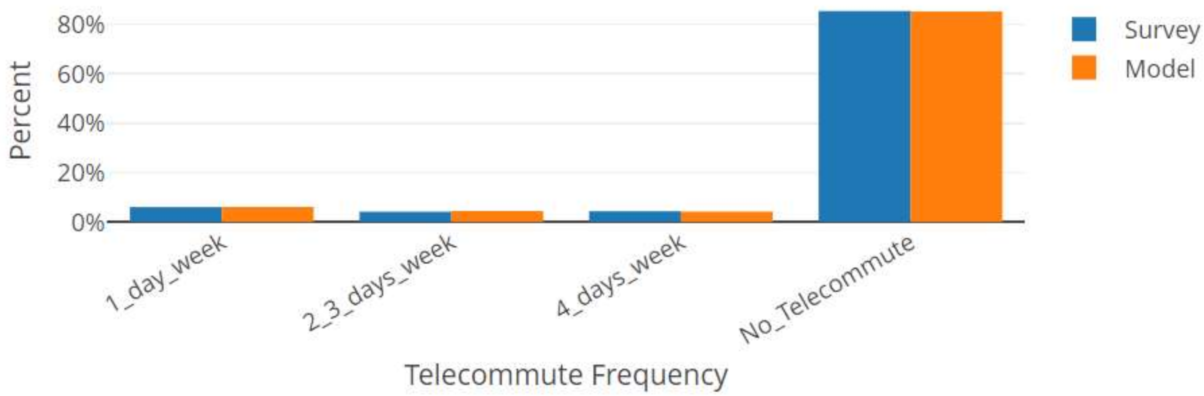


FIGURE 3: TELECOMMUTE FREQUENCY MODEL SUMMARY

3.2 TOUR-LEVEL MODELS

Tour-level models are models that estimate if, why, and how often someone travels away from their home for a set of trips with a specific destination. Tours include mandatory tours, which are work or school tours, and non-mandatory tours that include all other tour purposes. Tour choices provide a foundation for trip choices. The tour models include the Coordinated Daily Activity Pattern model, which determines if a person will be making:

- A mandatory tour pattern
- A strictly non-mandatory tour pattern
- Staying home

Other tour models include the tour frequency, scheduling, and destination choice models for mandatory, non-mandatory, joint, and at-work tours. Following those models, the tour mode choice model determines the primary mode for the tour, and a stop choice model determines how many stops will be made throughout the tour.

The models that were adjusted include the coordinated daily activity pattern, mandatory tour frequency, joint tour frequency, and tour mode choice models. These are described below.

Coordinated Daily Activity Pattern

The coordinated daily activity pattern model is a multinomial logit model that determines if a person is going to make one or more mandatory tours, one or more non-mandatory tours, or stay home. This model is run in a dependency order to coordinate decisions made by household members where necessary, such as when preschool children are staying home, an adult stays home. Figure 4 shows the overall model output for this model, for a comparison by person type, please refer to the visualizer.

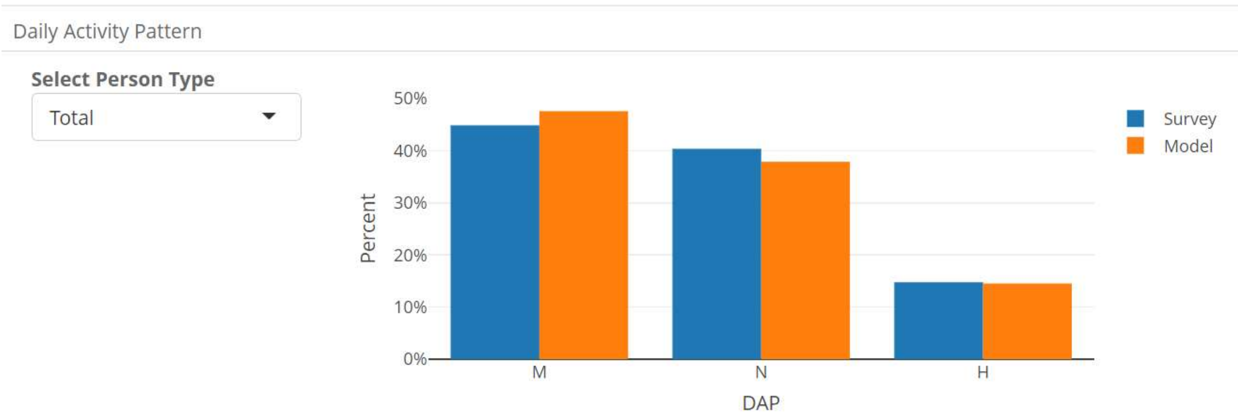


FIGURE 4: COORDINATED DAILY ACTIVITY PATTERN MODEL SUMMARY

Mandatory Tour Frequency

The mandatory tour frequency model is a multinomial logit model that is applied for persons with a mandatory tour pattern from the coordinated daily activity pattern model, and it determines if a person goes on one work tour, two work tours, one school tour, two school tours, or one work and one school tour. Not all options are available for all person types – part time workers may not make school tours (persons working part time and going to school are considered university students in ActivitySim), and persons under 16 (school pre-driving and preschool person types) may not make any work tours. Figure 5 shows a summary of the mandatory tour frequency validation; for a comparison by person type, please refer to the visualizer.

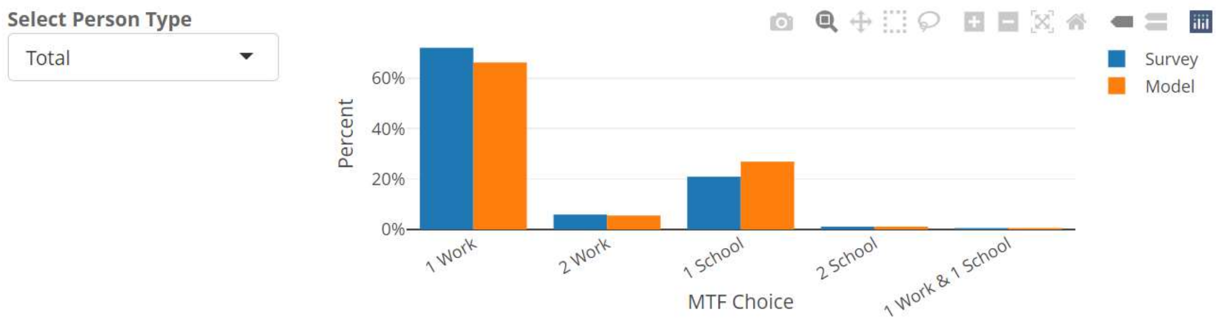


FIGURE 5: MANDATORY TOUR FREQUENCY SUMMARY

Joint Tour Frequency

The joint tour frequency model is a multinomial logit model that estimates the number and type of joint tours made by a group of persons in the model. These tours are entirely joint – all tour members travel together on all trips in the tour. The model selects one or two of shopping, maintenance, eating out, visiting, or other discretionary tours. Figure 6 shows the model calibration for joint tour frequency.

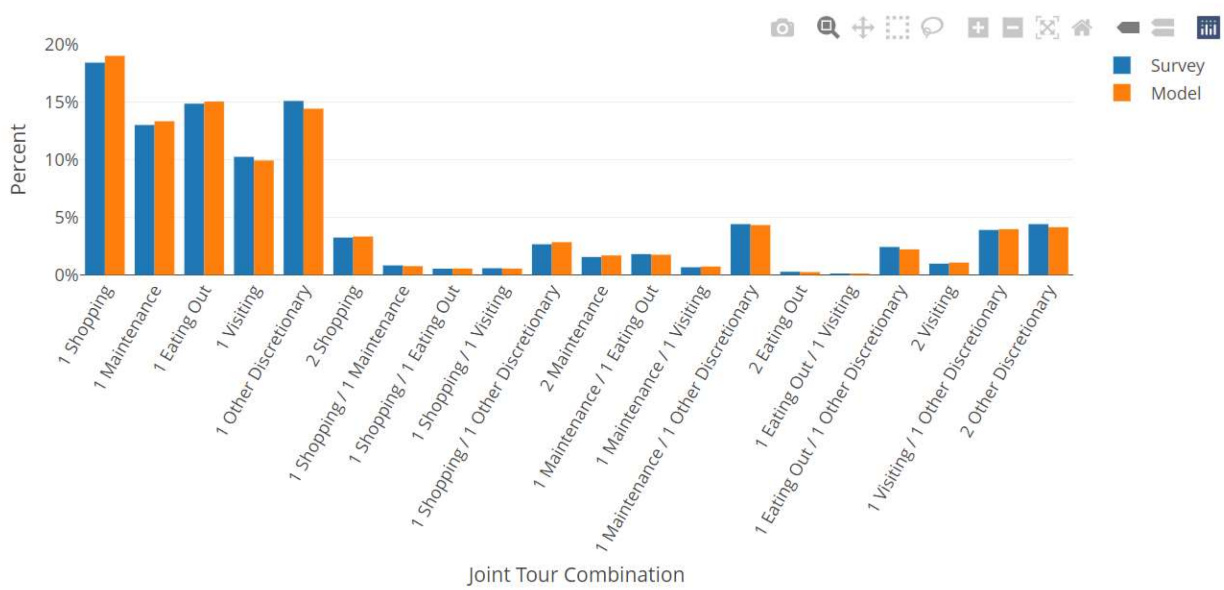


FIGURE 6: JOINT TOUR FREQUENCY MODEL SUMMARY

Tour Mode Choice

The tour mode choice model determines the primary mode for the tour. This mode is not necessarily used for all trips in the tour, but it does limit the modes that can be used in any trip. For example, if the tour mode choice is walk-access transit then drive-alone automobile is not available for any trips in that tour because the person does not have an auto accessible to them. The tour mode choice is a nested logit model with a form as shown in Figure 7. Figure 8 shows the tour mode choice summary. For detailed summaries by tour purpose, please refer to the visualizer. Specific mode choice inputs are included in the tour_mode_choice configuration file.

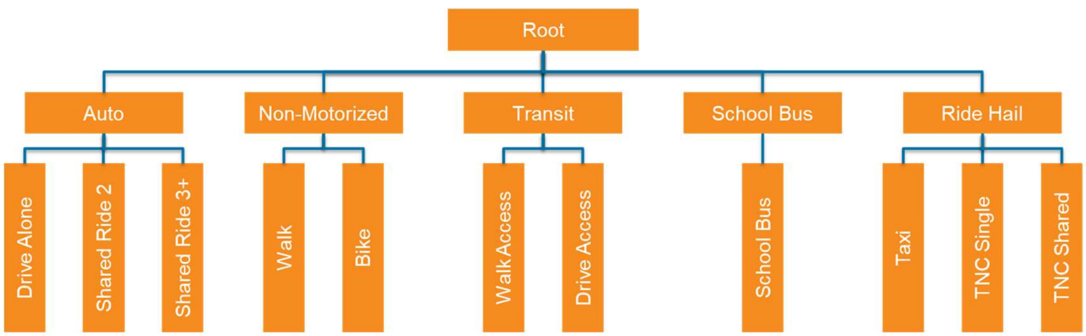


FIGURE 7: MODE CHOICE MODEL FORM

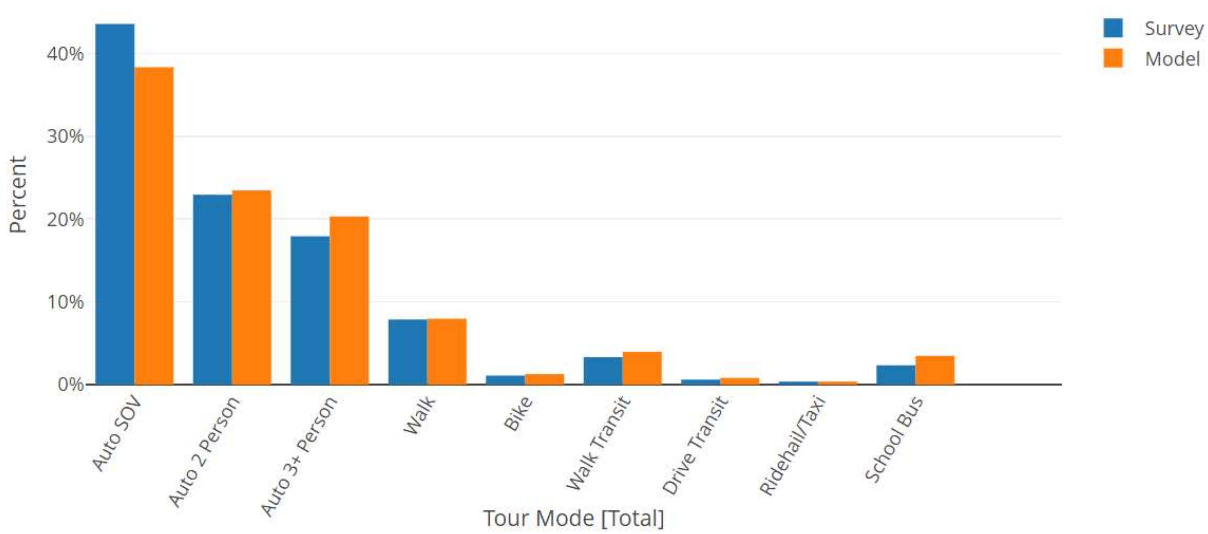


FIGURE 8: TOUR MODE CHOICE SUMMARY

3.3 TRIP-LEVEL MODELS

Trip level models include the decisions made on specific trips within each tour. These include the trip purpose, destination, scheduling, and mode choice models. In all cases, the decisions made at this stage are heavily influenced by tour decisions. For example, a person is not able to use a car on a tour that has a walk transit tour mode, and trips must be scheduled within the tour schedule (trips cannot leave before their tour departure time nor arrive after the tour arrival time).

The only model adjusted at this level is the trip mode choice model, which is described below.

Trip Mode

The trip mode choice model is a nested logit model that determines the mode for each individual trip on each tour. The model uses the same form as the tour mode choice model, which is shown in Figure 7. Figure 9 shows a summary of the model calibration. For detailed summaries by tour purpose and/or tour mode, please refer to the visualizer.

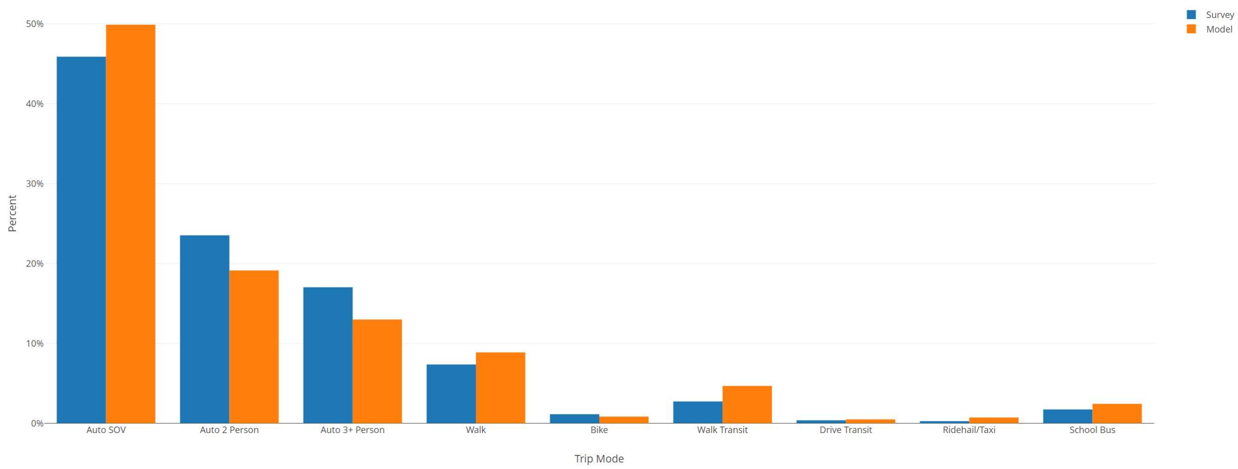


FIGURE 9: TRIP MODE CHOICE SUMMARY

3.4 ASSIGNMENT MODELS

Since the model is not fully calibrated, the scope of the project did not include assignment validation. However, a reasonable assignment is a sign that the model is in the range of where it should be, and as such, some validation statistics were tabulated.

Highway Assignment

Metropolitan Council provided highway counts to be used for validation. These were joined to the highway network and compared to the assigned volumes. Figure 10 shows a scatterplot comparison of the daily traffic counts and the daily model assignment. A majority of the points are close to the unity line where the count is the same as the model volume. Additionally, Figure 11 shows the root mean square error by volume group, which is clustered around the line for most volume groups, which is a very good starting point for further model calibration.

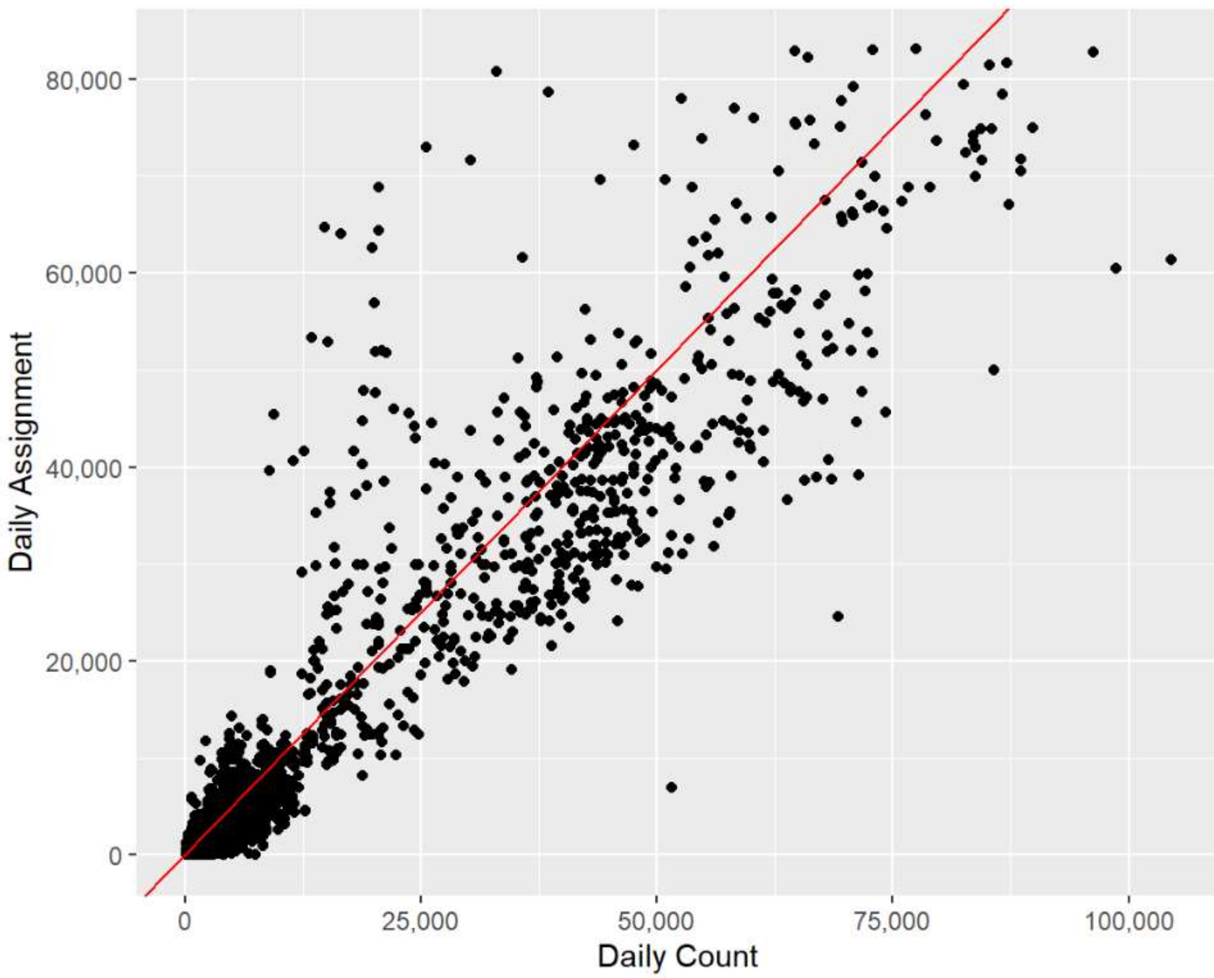


FIGURE 10: HIGHWAY TRAFFIC COUNT TO ASSIGNMENT COMPARISON

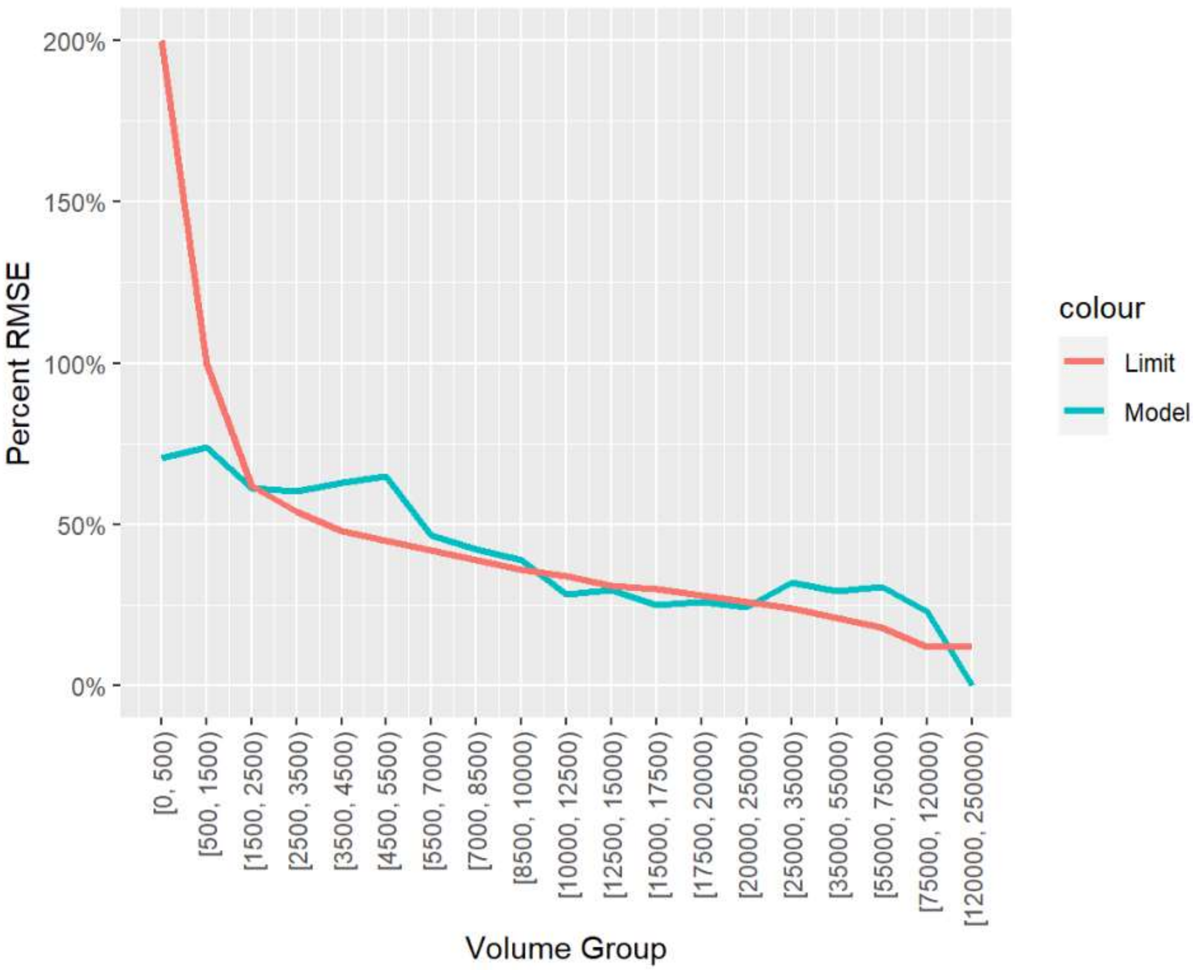


FIGURE 11: HIGHWAY ASSIGNMENT DAILY RMSE BY VOLUME GROUP

Transit Assignment

The transit model is significantly over-assigned. This is unexpected since the mode choices are close and highway VMT is close also. A comparison of boardings by mode is listed in Table 1, and some of the recommendations for Phase 2 would likely improve this.

TABLE 1: TRANSIT ASSIGNED AND OBSERVED BOARDINGS COMPARISON

MODE	MODEL BOARDINGS	OBSERVED BOARDINGS
5.0	613,969	169,778
6.0	90,930	18,855
7.0	106,140	30,701
8.0	97,427	82,235
9.0	1,590	2,703
Total	910,056	304,272

4.0 SENSITIVITY TESTING

A baseline model run (against which all the four sensitivity scenarios were compared) along with the four sensitivity test runs were performed on Insight's Windows 10 server with the following configuration – 192 GB RAM with 52 logical processors. The model runs were set to use 140 GB RAM and 20 cube cluster nodes. Each model run took approximately 18 hours to complete.

4.1 SENSITIVITY TEST METHODOLOGY

The following four scenarios were modeled.

1. A VMT tax scenario. In this scenario, the auto operating cost was increased by 10 cents per mile to reflect a vehicle tax or increase in fuel cost.
2. A new transit project. MetCouncil prepared the input file for this test tun. The transit line file, PT_2015.Lin, was modified to include F Line along the Central Avenue corridor as well as the Green Line's Southwest extension projects. The headway on the underlying local bus, Route 10, was reduced to 30 minutes. Insight ran the sensitivity test using the file prepared by MetCouncil.
3. Increased telecommuting. This scenario doubled the regionwide telecommuting percentages. RSG modified the telecommuting frequency coefficients for Insight to run the model.
4. A TNC cost change. In this scenario, a 75% cost discount was implemented for the lowest income household category. RSG modified the appropriate files for Insight to run the model.

Baseline Model

The 2018 base-year model was used as the Baseline scenario for all tests. To support future model calibration and validation, RSG implemented a visualization tool (ABM Visualizer) to compare ActivitySim outputs against survey/observed data or compare results from two different model runs. The ABM Visualizer creates a static HTML dashboard of summary comparisons of various models in the ActivitySim framework. Figure 12 shows the screenshot of the overview page. In this case, the comparison is between a survey and model output.

FIGURE 12: BASELINE MODEL VISUALIZER OVERVIEW PAGE – COMPARE SURVEY/OBSERVED DATA TO MODEL OUTPUTS

The current implementation of the model is not adequately calibrated for transit demand. The total boardings on the transit routes estimated by the model is approximately three times higher than the observed boardings. Therefore, the results comparing transit demand may not be reliable, but they do help in understanding the relative change in the model estimates compared to the baseline scenario.

4.2 SENSITIVITY SCENARIOS

This chapter describes the four sensitivity tests performed along with the expected and actual outcomes.

Test 1: VMT Tax Scenario

In this scenario, the auto operating cost (AOC) used in tour and trip mode choice models was increased by 10 cents per mile, from 18.29 cents per mile to 28.29 cents per mile. This change emulates a vehicle-mile tax policy scenario. This was implemented by changing line 41 in the tour_mode_choice.yaml file and line 41 in the trip_mode_choice.yaml file, from costPerMile: 18.29 to costPerMile: 28.29.

Expected Outcomes

By increasing the auto operating cost, we expect the following outcomes:

- We expect the tour length to decrease due to the increased auto operating cost.
- We expect an increase in non-motorized and transit trips due to increased auto mode impedances.
- We expect the overall auto speeds and total vehicle miles traveled (VMT) to decrease.

Actual Outcomes

The model test run suggests the following outcomes, which are consistent with the above expectations:

- The average mandatory tour lengths in the baseline model are 14.47 miles, 6.11 miles, and 6.40 miles for work, university, and school tour purposes respectively. These tour lengths decrease to 13.97 miles, 5.76 miles, and 5.95 miles for the three purposes respectively in this scenario.
- Both non-motorized and transit trips increase due to the increased auto operating costs. Table 2 compares the total trips by travel modes between the baseline and the AOC scenario.
- The daily VMT goes down from 76.44 million miles to 69.97 million miles, a decrease of 8.47% compared to the baseline scenario. The decrease in auto travel results in slightly higher overall networkwide auto speeds during the AM peak period – the auto speeds during the AM peak period increase by approximately 0.5 mph (a 1% overall speed increase).

TABLE 2: TOTAL DAILY TRIPS BY TRAVEL MODE IN BASELINE AND AOC SCENARIOS

TRAVEL MODE	BASELINE	AOC	% CHANGE
Auto 2 Person	2,470,530	2,395,127	-3.1%
Auto 3+ Person	1,677,418	1,604,314	-4.4%
Auto SOV	6,442,500	6,289,072	-2.4%
Bike/Moped	108,513	137,880	27.1%
Ride Share	93,481	97,246	4.0%
School Bus	314,195	364,064	15.9%
Walk	1,145,818	1,262,828	10.2%
Walk-Transit	604,522	644,798	6.7%
Drive-Transit	63,433	93,574	47.5%
Total	12,920,410	12,888,903	-0.2%

Test 2: Introduction of New Transit Services

In this scenario, two changes to the transit network were made to understand the model's sensitivities to transit scenarios:

- The transit service along the Central Avenue corridor was modified to include F Line, a rapid bus service soon to be introduced in the Minneapolis region.
- Green Line was extended west of the downtown Target Field Station to the Southwest Station in Eden Prairie. A total of 16 new stations were added to the line file.

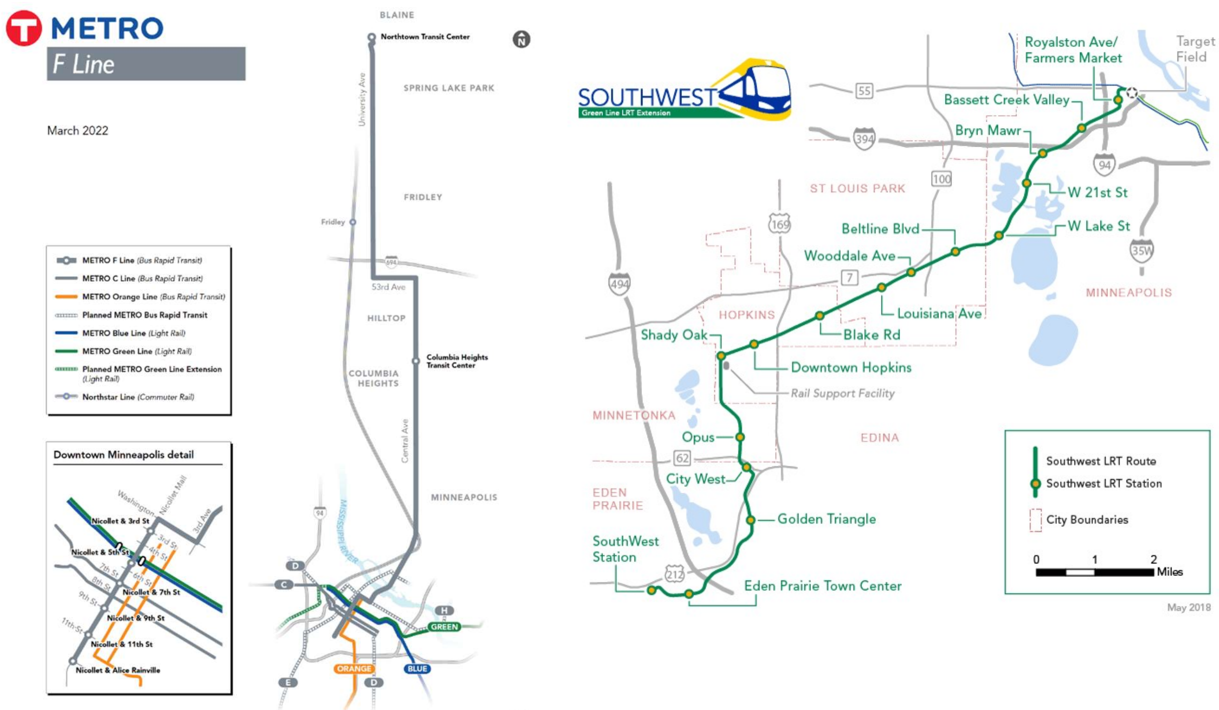


FIGURE 13: SCREENSHOTS OF F LINE AND SOUTHWEST LRT PROJECTS (SOURCE: METRO)

Expected Outcomes

We expected the following outcomes:

- We expect a small decrease in auto trips and VMT
- We expected a slight increase in transit trips
- Combined boardings on Route 10 and F Line should exceed the baseline boardings on Route 10.

Actual Outcomes

The model test run suggests the following outcomes:

- This scenario does not change the total tours or trips. There is a slight decrease in daily VMT by about 1,500 miles.
- The systemwide transit boardings go up by 0.3%. The combined ridership in the Central Avenue Corridor (Route 10 and F Line combined) increases by 31%. The ridership on Green Line increases by 17%. The directionality of the change is consistent with the expectations.

Test 3: Increased Telecommute Scenario

In this test, the coefficient for telecommuting options for 1 day, 2-3 days, or 4+ days are increased so that the percent of telecommuting doubles. Telecommute applies to only those workers with a usual workplace outside their homes who participate in a telecommute program, which involves telecommuting at least one day a week. Table 3 shows the coefficient in the baseline scenario as well as this test scenario. This change was made to the telecommuteFrequency.csv file in the ActivitySim\configs folder. No other change was made in this test compared to the baseline scenario.

TABLE 3: TELECOMMUTE TEST COEFFICIENTS

COEFFICIENT NAME	COEFFICIENT DESCRIPTION	BASELINE VALUE	SCENARIO VALUE
coef_Calib_1dpw	Calib TC 1 day per week	-3.53	-2.60
coef_Calib_23dpw	Calib TC 2-3 days per week	-3.28	-2.40
coef_Calib_4pdpw	Calib TC 4+ days per week	-3.16	-2.25

Expected Outcomes

We expected the following outcomes:

- We expect an increase in the amount of telecommuting in the region.
- We also expect a decrease in total person trips and VMT.

Actual Outcomes

The model test run suggests the following outcomes:

- The amount of telecommuting almost doubles. In the baseline scenario, 14.8% of the workers telecommute 1 or more days of the week. This doubles to 29.7% of workers telecommuting 1 or more days of the week. See Figure 14.
- The increased telecommute scenario results in a decrease in the total tours, trips, and VMT as shown in Table 4.
- The change in trips by various travel modes is shown in Table 5. The decrease in total daily trips in the travel mode makes sense. Unexpectedly, three or more carpool trips increase slightly.

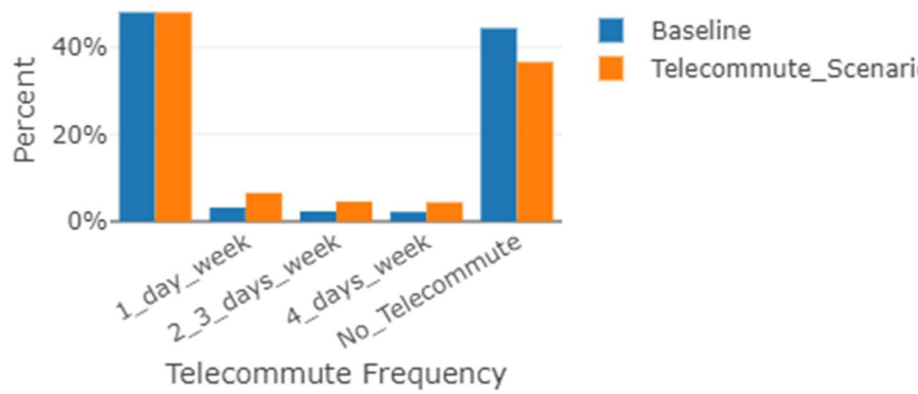


FIGURE 14: TELECOMMUTE SCENARIO COMPARISON

TABLE 4: TELECOMMUTE SCENARIO COMPARISON

Baseline Sample Rate: 100%	Telecommute_Scenario Sample Rate: 100%
3,733,766 Population	3,733,766 Population
1,472,591 Households	1,472,591 Households
5,177,145 Total Tours	5,119,546 Total Tours
12,015,003 Total Trips	11,815,021 Total Trips
3,899,717 Total Stops	3,867,918 Total Stops
76,442,956 Total VMT	74,447,580 Total VMT

TABLE 5: TELECOMMUTE SCENARIO TOTAL DAILY TRIPS BY MODE

TRIP MODE	BASELINE	TELECOMMUTE SCENARIO	% CHANGE
Auto SOV	6,442,500	6,296,734	-2.3%
Auto 2 Person	2,470,530	2,455,457	-0.6%
Auto 3+ Person	1,677,418	1,679,892	0.1%
Walk	1,145,818	1,140,712	-0.4%
Bike	108,513	108,571	0.1%
Walk Transit	604,522	592,627	-2.0%
Drive Transit	63,433	61,282	-3.4%
School Bus	314,195	310,901	-1.0%
Rideshare	93,481	93,035	-0.5%
Total	**12,920,410**	**12,739,211**	**-1.4%**

Test 4: Discounted TNC Cost Scenario

In this test, a 75% discount on the TNC cost is given to the lowest income group (income group 1, which is less than $20,000 annual household income). The TNC model was updated to use the income (df.HHINC5S) in mode choices. This update was made to lines 82 and 86 in the tour_mode_choice.csv and to lines 103 and 107 in the trip_mode_choice.csv files. The cost equation for both TNC_Single and TNC_Shared was adjusted to be:

```
ivt_cost_multiplier * df.ivot * (1 - (df.HHINC5S == 1) * 0.75) *
np.maximum(TNC_single_baseFare + odt_skims['HOV2_DIST'] *
TNC_single_costPerMile + odt_skims['HOV2_N_TIME'] *
TNC_single_costPerMinute, TNC_single_costMinimum) * 100
```

The bold-red text reflects the change made to model this test scenario. The change ensures that if the household income is in the income group 1, the cost is multiplied by 0.25; otherwise, the full cost is assessed.

Expected Outcomes

We expected the following outcomes:

- We do not expect any significant change in the daily trips, tours or VMT
- We expect that the TNC trips from transit-dependent households to increase, i.e., trips on other modes of travel should decrease.

Actual Outcomes

The model run suggests the following outcomes, which are consistent with the expectations.

- The model results show a minimal change in total tours, trips or VMT as shown in Table 6.
- Overall, there is a 35% increase in the ride share trips due to the TNC cost discount to the low-income group as shown in Table 7.

TABLE 6: TNC COST SCENARIO OVERALL SUMMARY

Baseline Sample Rate: 100%	TNC_Scenario Sample Rate: 100%
3,733,766 Population	3,733,766 Population
1,472,591 Households	1,472,591 Households
5,177,145 Total Tours	5,177,072 Total Tours
12,015,003 Total Trips	12,015,299 Total Trips
3,899,717 Total Stops	3,900,205 Total Stops
76,442,956 Total VMT	76,292,155 Total VMT

TABLE 7: TNC SERVICE CHARGE TOTAL DAILY TRIPS BY MODE

TRIP MODE	BASELINE	TELECOMMUTE SCENARIO	% CHANGE
Auto SOV	6,442,500	6,431,618	-0.2%
Auto 2 Person	2,470,530	2,465,581	-0.2%
Auto 3+ Person	1,677,418	1,675,061	-0.1%
Walk	1,145,818	1,143,677	-0.2%
Bike	108,513	107,828	-0.6%
Walk Transit	604,522	593,569	-1.8%
Drive Transit	63,433	63,151	-0.4%
School Bus	314,195	314,181	0.0%
Rideshare	93,481	126,061	34.9%
Total	**12,920,410**	**12,920,727**	**0.0%**

5.0 RECOMMENDATIONS FOR PHASE 2

Improvement recommendations fall into one of two categories: data improvements or model improvements. Data improvements relate to the data going into the model and are critical to ensuring the outputs of the model are representative of the current conditions and that future year applications of the model are accurate to the inputs. Model improvements relate to modeling system improvements, which includes both calibration improvements as well as feature improvements.

Many of the improvements work together, so the priority levels reflect the interconnectedness. In general, everything that is a high priority should be completed before starting on any medium priority items, since the high priority data improvements lay the foundation for many of the model improvements.

It is important to note that this section only includes items that were noticed as they affect ActivitySim. Parts of the travel model that do not affect ActivitySim, such as the auxiliary models (airport, freight, internal-external, and external-external models) were not inspected in this project.

5.1 DATA IMPROVEMENTS

These improvements are specific to the data utilized for modeling and calibration. Six major items were noticed during the model implementation process.

Updated/Improved Survey Weighting

The team faced multiple challenges with the weighted survey data that was used for calibration.

Issues were found in the student person-types in the survey data, and part of the issue is because the weighting for students (both university and K-12) is based on a full-year of surveying, while the model is based on a peak season. Some students have non-school-day travel that is being weighted the same as in-school-day travel. This presents some difficulties since the coordinated daily activities and mandatory tour frequencies can be different during these two times. The council is working on a second round of surveys, and the process of weighting and expansion should pay special attention to whether students are collected during the school year and ensure the expansion factors used for model calibration purposes reflect peak season travel.

A second set of issues was found with some of the coordinated daily activity patterns and tour frequency models where various person types were staggeringly different from other surveys. In particular, the following items were found that when compared to other surveys, these should be investigated:

- School driving-age persons have a very high 1-work mandatory tour frequency
- Preschool students have a high 2-school mandatory tour frequency
- University students have a high 1-work mandatory tour frequency and a low 1-school mandatory tour frequency

A final item that was noted is that at the end of the phase, the VMT on the highway network was fairly close when compared to the traffic counts and the trip mode choice percentages were close to the survey values, but the modeled transit boardings are incredibly high. This suggests an error somewhere that should be fixed prior to any model estimation or calibration.

Upon updating this data, several models will need to be estimated or calibrated and as such, this should be the first item undertaken in phase 2.

Priority: Extremely High

Synthetic Population Improvements

The synthetic population has some issues that created some issues in the model calibration and validation process. One of the issue groups is the representation of the population compared to the survey, and the second issue group is related to the data formatting.

Population Representation

The synthesized population shows more university students and significantly more non-workers, while showing fewer workers, students, and retirees. While it is unexpected to have these perfect, the differences between workers+students and nonworkers+retirees can become an issue since workers and students have mandatory trip patterns that tend to be at certain times while nonworkers and retirees tend to make trips at less-congested times and have different trip patterns. A comparison of the persons by type are shown in Figure 15. Additionally, the synthesized population shows significantly more two-person households to the detriment of three, four, and five person households, which is shown in Figure 16. This has lesser effects on the model except that the model will show more two-person joint tours and fewer three-, four-, and five-person joint tours.

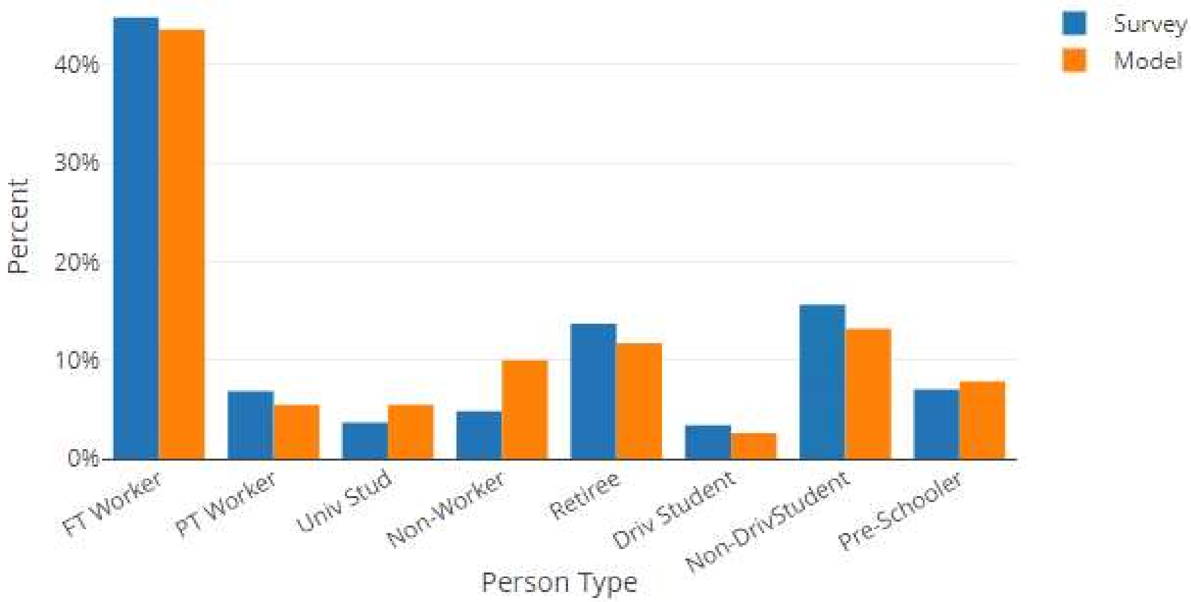


FIGURE 15: SURVEY VS. MODEL SYNTHESIZED POPULATION BY PERSON TYPE

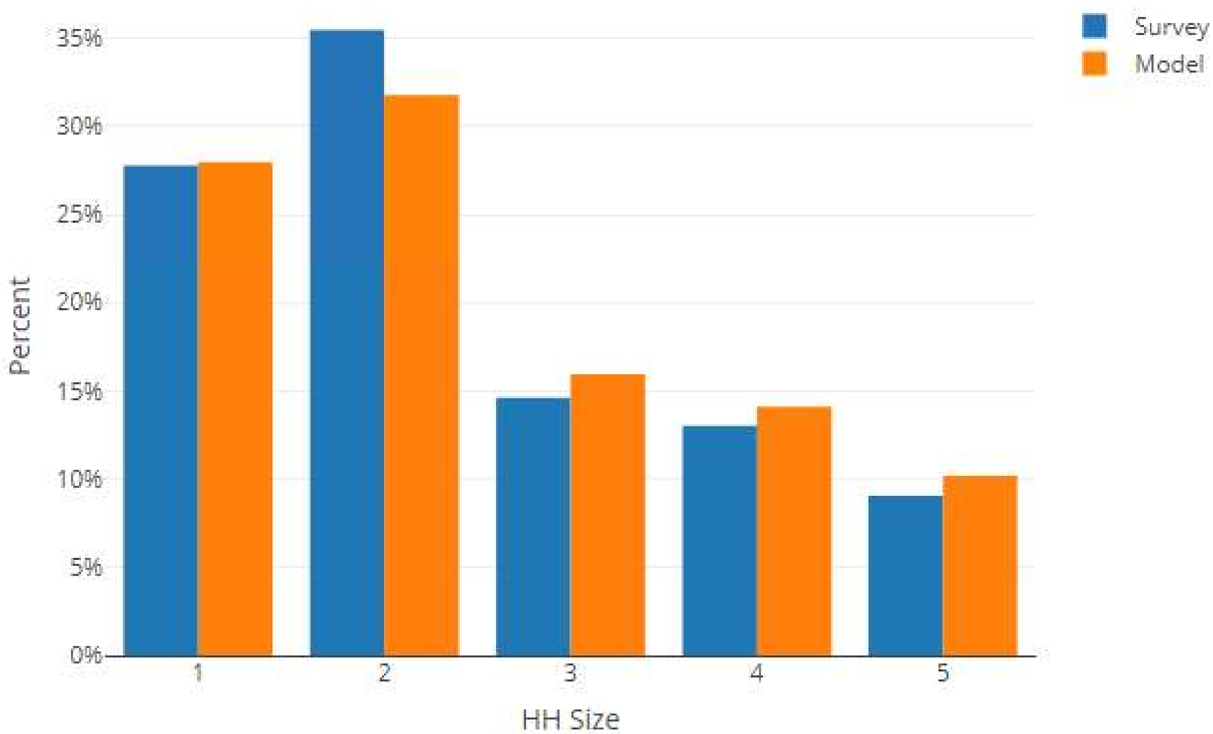


FIGURE 16: SURVEY VS. MODEL SYNTHESIZED POPULATION BY HOUSEHOLD SIZE

Synthesized Population Data Format

The major issues include the household income, person ages, person type, worker, and student variables. An additional issue was created by the lack of a person-education level variable.

The household income and person ages in the synthesized population are in ranges. In many cases, we were able to work around this, but there are some where the grouping created issues, which are noted below.

Age 0-1 and 4-5 in Coordinated Daily Activity Pattern Model

Both age groups, 0-1 and 4-5 are in age category 1. In the Coordinated Daily Activity Pattern model. In other locations, children aged 1 and younger are considerably less likely to be given a mandatory pattern (daycare). Conversely, children ages 4 and 5 are considerably more likely to be given a mandatory pattern (daycare).

Household Income Categories

In many cases, we were able to work around the limits to the income categories, but the tour scheduling models are currently generalized to the nearest match, which isn't always on category breaks. For example, many of the model components break at $25k, $35k, $60k and $120k, and the income categories break at $20k, $40k, $70k, and $100k.

Person Types and Student Status

The person types were translated from the input synthesized population to the values shown in Table 8 to move to ActivitySim standard person types. This is done automatically for each model run. The ActivitySim standards are recommended. Additionally, the student status for some groups is questionable and causes some changes to person types not shown in Table 8, and are listed below:

- Part time workers that go to school are changed to university students
- University students that do not go to school are changed to part time workers

TABLE 8: SYNTHESIZED PERSON TYPES AND STUDENT STATUS

PERSON TYPE		STUDENT STATUS	
		1	2
1 => 8	Child 1	90,853	204,935
2 => 7	Child 2	498,877	0
3 => 6	Child 3	92,893	2,237
4 => 3	Adult Student	96,335	25,117
5 => 1	FT Worker	111,515	1,517,405
6 => 2	PT Worker	83,019	206,660
7 => 4	Nonworking Adult	0	370,333
8 => 5	Senior	1,867	431,720

Priority: High

Micro Analysis Zones

Micro analysis zones improve the model’s resolution for non-motorized modes and transit. This can improve the mode choices, particularly in the urban and CBD areas where more modes are available and viable. This comes with the drawback of requiring more detailed data.

Priority: Low, high if the model is expected to be used for transit or non-motorized model forecasts

SEDATA Format Updates

There are two updates that would streamline the modeling process. One is some additional variables, and the second is an improved area type.

Incorporate Additional Needed Variables

Currently, school enrollment, county name, and state FIPS code are joined to the land use table prior to executing ActivitySim and are in additional files. In the interest of efficiency as well as reducing the possibility of problems in the future, consider adding these values to the main SEDATA file.

Improve Area Type

Currently the area types are CBD, SUBURB3, SUBURB2, and RURAL. Most models use a numerical code that includes CBD (1), Urban (2), Suburban (3), and Rural (4). The current CBD and RURAL codes fit into this, but there is some ambiguity to the two suburban codes. We recommend maintaining the current CBD and Rural area types and using Urban for areas of higher density and more walkable in nature and using Suburban for areas that are less walkable and more automobile based.

Priority: High

Improved Transit Representation

Currently, the transit line files in the model represent peak and off-peak periods and the AM peak period skims were transposed for the PM peak period. This assumes that the AM peak period is the reverse as the PM peak period. For trip-based modeling, this is okay, but activity-based modeling simulates choices throughout the day and better representation is necessary to accurately reflect transit in the tour mode choice and trip mode choice steps. Additionally, the evening (post-PM peak) and early AM periods are not represented in the model, which can be a drawback for any transit forecasting use of the model.

Priority: Medium, high if the model is expected to be used for transit model forecasts

Improved University Data

University students frequently have interesting trip patterns and are not well transferrable among regions because of differences in context, policies, and transportation facilities. Context differences include the differences of where in a metropolitan area a university resides – a university near the core CBD with good transit service, such as University of Minnesota, will have different travel patterns than one near a downtown but with poor transit service or one that is not near a major city at all. Another context item is the relative size of the university in comparison to others in the region since one large university may have more transportation facilities for students whereas multiple medium-sized universities may not. Policies such as free transit passes for university students, universities prohibiting cars for freshmen, and university parking rates affect the transportation choices students make. Finally, the supply of transportation facilities, such as the forms and headways of public transit (or the complete lack thereof) affect what choices students can make.

The model can be updated with a university survey, preferably augmented with some data from the university. In some cases, a university can provide student residence locations by zip code or TAZ (Metropolitan Council would have to provide the TAZ layer), which can aid in weighting the survey. Once this is complete, ActivitySim can be updated to better represent university travel.

Priority: Low

5.2 MODEL IMPROVEMENTS

Estimate Auto Ownership Model

The auto ownership model is transferred from SEMCOG and calibrated using constants only. There are some locations in the region that appear to be outliers that can likely be improved with an estimated model.

Priority: Medium

Estimate Mandatory Location Choice Models

The mandatory location choice models – work location and school location – are not calibrated to local conditions. Since work and school locations become a ‘pin’ for other choices in the day for over 70% of the people in the model, this is critical to moving the model to a fully calibrated model.

Part of this calibration would include an update to the school location choice model, which is used for K-12 school trips. Currently, the model does not enforce students to stay within their own state, while in reality the school trips generally must stay within their own state. One way to do this is to prepare distance skims in Cube to use very large numbers (e.g. 999 miles) for school trips that would start in one state and end in another, and then update ActivitySim's configuration to use that matrix

Priority: High

Estimate Destination Choice Model

The destination size terms are not calibrated and utilize a combination of non-retail employment as well as AMC, Manufacturing, and Office employment. These overlap and should be updated to ensure that future year changes do not negatively affect model forecasts. In this case, destination choice refers to non-mandatory tour destination choice, at-work destination, and trip destination choices.

Priority: High

Estimate Mode Choice Models

Currently, the mode choice models (tour mode choice and trip mode choice) are transferred and adjusted via alternative specific constants. The model could use multiple updates to improve the calibration and reduce the reliance on constants. Additionally, the walk and bike tour and trip mode choices should have some attention paid to them since it is well known that the Minneapolis-St. Paul region has a large cycling community despite the very cold winters.

Additionally, the transit mode choice is suspect. There seems to be an issue is the data used for calibration (either the transit boardings or the survey), and the transit model is significantly different than the model that was transferred – the transferred model included three access modes for transit (walk, park-n-ride, and kiss-n-ride), while the council only uses walk and drive access. Both issues should be revised in the process of estimating the mode choice models.

Priority: High

Estimate Time of Day Models

Currently, the time-of-day models are transferred only. They are generally close for some purposes, and not-as-close for others. Time of day is generally not a transferrable model from one region to another, so an updated model would ensure that the assignment times for both highway and transit are in-line with traffic counts and transit boardings.

Priority: Medium

Calibration of Remaining Models

There are several other models in ActivitySim, and many of these can use the transferred model forms but should be calibrated to Metropolitan Council survey data. Table 9 lists the remaining models that would not be estimated in prior portions of this section and the priority of those models for the overall system.

TABLE 9: MODEL CALIBRATION PRIORITY LIST

MODEL	PRIORITY
Toll Pass Ownership	Depends on Toll Uses
Transit Pass Ownership	Depends on Transit Uses
Work From Home	Low
Free Parking	Low
Telecommute Frequency	Medium
Coordinated Daily Activity Pattern	High
Mandatory Tour Frequency	High
Joint Tour Frequency	High
Joint Tour Composition	Low
Joint Tour Participation	Medium
Non-Mandatory Tour Frequency	High
At-work Subtour Frequency	High
Stop Frequency	High
Trip Purpose	Medium

APPENDIX A. SCENARIO TESTING SUMMARIES

Table A-1: Summary of Total Daily Trips by Travel Modes under Various Scenarios

Total Daily Trips by Travel Mode

trip_mode	Baseline	AOC	% Change	Transit Scenario	% Change	Telecommute Scenario	% Change	TNC Scenario	% Change
Auto 2 Person	2,470,530	2,395,127	-3.1%	2,470,530	0.0%	2,455,457	-0.6%	2,465,581	-0.2%
Auto 3+ Person	1,677,418	1,604,314	-4.4%	1,677,418	0.0%	1,679,892	0.1%	1,675,061	-0.1%
Auto SOV	6,442,500	6,289,072	-2.4%	6,442,500	0.0%	6,296,734	-2.3%	6,431,618	-0.2%
Bike/Moped	108,513	137,880	27.1%	108,513	0.0%	108,571	0.1%	107,828	-0.6%
Drive-Transit	63,433	93,574	47.5%	63,433	0.0%	61,282	-3.4%	63,151	-0.4%
Ride Share	93,481	97,246	4.0%	93,481	0.0%	93,035	-0.5%	126,061	34.9%
School Bus	314,195	364,064	15.9%	314,195	0.0%	310,901	-1.0%	314,181	0.0%
Walk	1,145,818	1,262,828	10.2%	1,145,818	0.0%	1,140,712	-0.4%	1,143,677	-0.2%
Walk-Transit	604,522	644,798	6.7%	604,522	0.0%	592,627	-2.0%	593,569	-1.8%
Total	**12,920,410**	**12,888,903**	**-0.2%**	**12,920,410**	**0.0%**	**12,739,211**	**-1.4%**	**12,920,727**	**0.0%**

Table A-2: Summary of Transit Boardings under Various Scenarios

Transit Boardings - Different Test Scenarios

By Access Mode & Time Period

Access	Period	Baseline	AOC	Transit	Telecommute	TNC
Walk	Peak	79,229	112,652	79,599	76,994	79,345
Walk	Off peak	38,076	52,293	39,129	37,583	37,871
Drive	Peak	512,142	555,163	512,685	501,735	505,643
Drive	Off peak	344,580	355,942	345,185	337,738	335,694
Total		974,027	1,076,051	976,597	954,050	958,553
			10.5%	0.3%	-2.1%	-1.6%

By Transit Mode

Mode #	Mode Name	Baseline	AOC	Transit	Telecommute	TNC
5	Local Bus	610,447	650,698	613,919	598,384	600,734
6	Suburban Bus	120,046	143,046	120,373	117,202	117,879
7	Express Bus	146,385	174,914	142,885	143,812	144,153
8	Light Rail	95,537	105,230	97,832	93,071	94,187
9	Commuter Rail	1,612	2,163	1,589	1,581	1,600
Total		974,027	1,076,051	976,597	954,050	958,553

By Transit Operator

Operator #	Operator Name	Baseline	AOC	Transit	Telecommute	TNC
1	BX	4,869	5,581	4,869	4,734	4,858
2	MG	4,938	6,153	4,926	4,949	4,867
3	MT	902,844	987,772	906,455	883,530	887,191
4	MVTA	35,756	45,258	35,804	35,115	35,378
5	PLM	19,372	23,044	19,077	19,537	19,894
6	RS	-	-	-	-	-
7	ST	-	-	-	-	-
8	SW	6,164	8,128	5,381	6,104	6,286
9	UofM	17	33	17	16	17
Total		973,961	1,075,968	976,529	953,985	958,491

By Route

Route #	Route Name	Baseline	AOC	Transit	Telecommute	TNC
MT10	Metro Route 10	11,513	13,736	5,838	11,185	11,280
F Line	F Line	-	-	9,211	-	-
Green Line	Green Line	10,349	13,264	12,134	9,980	10,237

Table A-3: Trips by Travel Mode by Auto Sufficiency Category

Auto Sufficiency Category	Trip Mode	Baseline	AOC Scenario	Transit Scenario	Telecommute Scenario	TNC Scenario
Zero-Car HHs	BIKE	24,330	29,117	24,330	24,281	23,779
	DRIVEALONE	59,486	51,817	59,486	59,293	55,842
	SCHOOLBUS	19,181	19,688	19,181	18,992	19,179
	SHARED2	42,630	37,013	42,630	42,021	40,148
	SHARED3	18,673	16,291	18,673	18,588	17,840
	TAXI	5,402	5,656	5,402	5,386	4,568
	TNC_SHARED	46	55	46	44	48
	TNC_SINGLE	28,442	28,818	28,442	28,530	47,311
	TRNWALKACCESS	212,719	213,424	212,719	209,210	204,315
	WALK	140,646	148,682	140,646	138,493	138,728
Cars < Workers	BIKE	13,834	16,711	13,834	13,736	13,835
	DRIVEALONE	522,205	511,043	522,205	493,542	521,258
	SCHOOLBUS	21,230	23,787	21,230	20,452	21,225
	SHARED2	190,278	185,148	190,278	185,556	189,986
	SHARED3	208,822	201,798	208,822	207,253	208,527
	TAXI	4,679	4,944	4,679	4,536	4,544
	TNC_SHARED	1,410	1,584	1,410	1,348	1,851
	TNC_SINGLE	5,434	5,620	5,434	5,275	6,956
	TRNDRIVEACCESS	3,418	5,511	3,418	3,160	3,360
	TRNWALKACCESS	55,901	59,242	55,901	53,236	55,582
	WALK	93,100	101,665	93,100	90,481	93,160
Cars>= Workers	BIKE	59,108	78,015	59,108	58,751	58,983
	DRIVEALONE	5,860,809	5,726,212	5,860,809	5,743,899	5,854,518
	SCHOOLBUS	273,784	320,589	273,784	271,457	273,777
	SHARED2	1,714,546	1,656,436	1,714,546	1,698,608	1,712,320
	SHARED3	1,181,957	1,126,639	1,181,957	1,176,688	1,180,702
	TAXI	16,859	17,930	16,859	16,458	16,396
	TNC_SHARED	469	607	469	481	586
	TNC_SINGLE	30,685	31,971	30,685	30,921	43,724
	TRNDRIVEACCESS	59,736	87,377	59,736	57,845	59,506
	TRNWALKACCESS	321,960	358,172	321,960	316,094	319,743
	WALK	823,224	914,036	823,224	820,406	823,002

the science of insight

55 Railroad Row
White River Junction, VT 05001
802.295.4999
www.rsginc.com

White River Junction & Burlington, VT | Chicago, IL | Denver, CO | Portland, OR | San Diego, CA | Washington, DC

RSG promotes sustainable business practices that minimize negative impacts on the environment.
We print all proposals and reports on recycled paper that utilizes a minimum of 30% postconsumer waste.
RSG also encourages recycling of printed materials (including this document) whenever practicable.
For more information on RSG's sustainability practices, please visit www.rsginc.com.