Baltimore Metropolitan Council InSITE Activity Based Travel Model

Model Validation Report

draft

report

prepared for

Baltimore Metropolitan Council

prepared by

Cambridge Systematics, Inc.

with

Gallop Corporation
AECOM
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January 31, 2017

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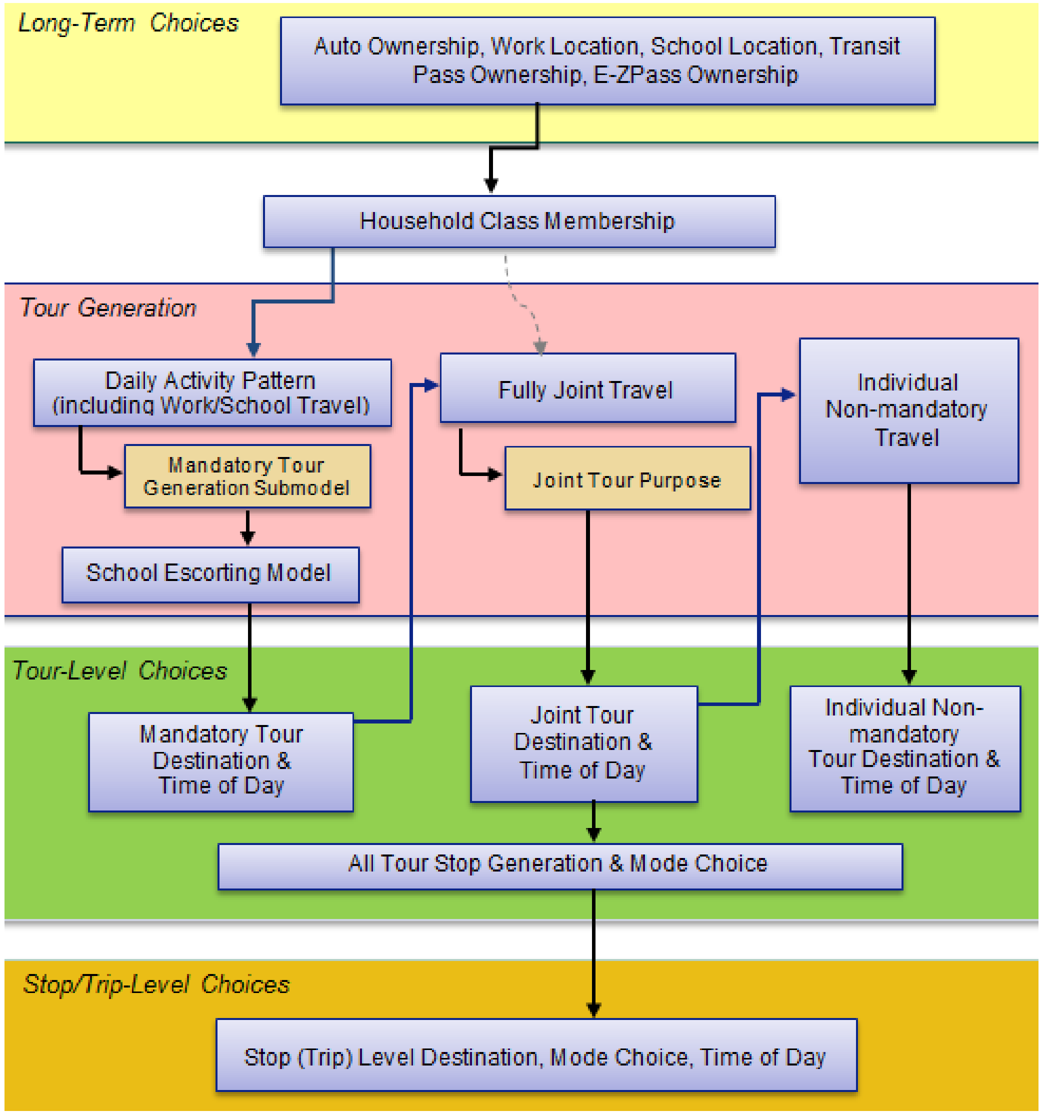
1.0 Summary of Validation and Sensitivity Testing Process

This report summarizes the validation of the activity based model developed for the Baltimore region. This model was developed for the Baltimore Metropolitan Council (BMC) by a team led by Cambridge Systematics, Inc. (CS) and including Gallop Corporation, AECOM, and Sabra-Wang Associates. The model estimation results are documented by Cambridge Systematics, Inc. (2016), and user documentation is provided in a separate document.

The model is applied disaggregately using a synthetic population, generated by the PopGen synthetic population generator (Konduri and Pendyala, 2015), representing the population of the model region, which includes the entire BMC region, plus the District of Columbia and the Maryland portion of the region covered by the Metropolitan Washington Council of Governments (MWCOG). The portion of Maryland in the model region consists of Baltimore City and Anne Arundel, Baltimore, Carroll, Harford, Howard, Frederick, Montgomery, and Prince George's Counties.

The model structure is shown in Figure 1.1. The activity and travel choices made by each household and person in the synthetic population are realized through Monte Carlo simulation, with the choice probabilities determined by the individual model components.

Figure 1.1 Activity Based Model Design



A model validation plan (Cambridge Systematics, Inc., 2014) was developed prior to model development. This plan laid out the process that was followed for the model validation and specified the tests that were performed. A few tests changed slightly or were more specifically defined for the final model validation, but in general the plan was followed. The tests in the plan included verification of the input highway and transit skim data and the synthetic population data, checks of the results of all model components compared to the 2007-2008 regional household survey data set, checks of the highway and transit assignment, and tests of the sensitivity of the model to changes in input data. The remainder of this report focuses on the checks of the activity and travel data from the model components, the assignment results, and the tests of the model sensitivity.

1.1 Model Component Validation

Note that some of the smaller boxes in Figure 1.1 include multiple model components. The components that were validated include the following:

- Vehicle availability
- Regular workplace location
- School location
- Daily activity pattern (segmented by person type)
- School escorting
- Fully joint travel (number and purpose of tours)
- Individual non-mandatory tour generation
- Work based subtour generation
- Tour destination choice (segmented by aggregated tour purpose)
- Tour time of day choice (segmented by aggregated tour purpose)
- Tour stop generation (segmented by aggregated tour purpose)
- Tour mode choice (segmented by aggregated tour purpose)
- Stop destination choice
- Stop time of day choice
- Trip mode choice (segmented by aggregated tour purpose)

The tests consisted of comparisons of model results for various market segments to the expanded household survey data. These tests are summarized in Chapter 2.0.

1.2 Highway and Transit Assignment

Since the highway and transit assignment processes are essentially the same static, aggregate process used in BMC's previous (trip based) model, the checks are similar to those performed for the validation of the previous model. They consist mainly of comparisons of model results to observed data, i.e., traffic and transit ridership counts. Highway assignment checks include:

- Volume/vehicle-miles traveled (VMT) by facility type
- Volume/VMT by area type
- Volume/VMT by county
- Volume/VMT by volume level
- Volume/VMT by time of day
- Volume/count ratio on key routes

- Sum of volumes on screenlines/cutlines

Transit assignment checks include:

- Boardings by service category (Metrobus local, Metrobus park-and-ride, MetroRail)
- Boardings by service category and geographic orientation, defined as follows:
  - Local-Radial
  - Local-Crosstown
  - Local-Circulator
  - Local-Limited
  - Local-Shuttle
  - Park-and-Ride-CBD
  - Park-and-Ride-Secondary
  - MetroRail
- Boardings per linked trip (transfer rate)
- Boardings by route
- Boardings by MetroRail station

The highway and transit assignment testing is summarized in Chapter 3.0.

1.3 Sensitivity Testing

One goal of activity-based models is an increased sensitivity to model inputs. Sensitivity testing involves adjusting key factors in the model and observing the effects on forecasted travel. These adjustments can be made to model parameter values (e.g., the mode choice cost coefficient) and to model inputs (e.g., land use variables, socioeconomic conditions, fuel costs, etc.).

The following sensitivity tests were performed:

- Aging population showing more retirees
- Brownfield development
- Time of day switching due to congestion

The sensitivity tests are summarized in Chapter 4.0.

2.0 Model Component Validation

This chapter summarizes the activity based model component validation. The tests consisted of comparisons of model results for various market segments to the expanded household survey data. These comparisons were done in Excel spreadsheet files. The model application software, TourCast, outputs .dbf files that were imported into a relational database and processed with stored procedures using MySQL. The processed summaries were exported to comma delimited files that can be read directly into the Excel spreadsheets, which were populated in advance with the survey data results. The model results presented in this chapter are based on a model application with three iterations of speed feedback.

The comparisons described in this chapter reflect model calibration adjustments. In some cases, model parameters were adjusted to produce more reasonable results although there was not a universal attempt to match all results from the expanded household survey for all market segments by adjusting model constants or other parameters. This type of adjustment was only made when the uncalibrated model results did not appear reasonable and the survey data results were based on a substantial number of observations. The specific calibration adjustments are documented in the Excel files.

Because of the extensive number of comparisons, the spreadsheet files themselves are incorporated as appendices to this report. The remainder of this chapter summarizes the validation results as presented in these spreadsheet files.

2.1 Long Term Choice Models

Vehicle Availability Model

The vehicle availability model simulates the number of vehicles owned by each household in the synthetic population. The Excel file with the results of the vehicle availability model is *VehicleAvailability.xlsm*. Table 2.1 summarizes the regional results of the calibrated model. On a regional basis, the number of households by number of vehicles owned matches well.

Table 2.1. Vehicle Availability Model – Regional Validation

Vehicles	Expanded household survey data Households	Expanded household survey data Percentage	Model Results Households	Model Results Percentage	Percentage Point Difference	Percentage Difference
0	231,695	11.2%	208,160	10.0%	-1.2%	-10.3%
1	690,202	33.3%	652,543	31.4%	-1.9%	-5.6%
2	753,072	36.3%	806,458	38.8%	2.5%	6.9%
3+	398,131	19.2%	409,036	19.7%	0.5%	2.6%
Total	2,073,100		2,076,197			

The more detailed comparisons in the Excel files show the following results:

- The modeled percentage of households owning each number of vehicles matches the survey data well for each county in the model region. The model slightly underestimates vehicle ownership in Carroll County, the smallest county in the model region.
- Vehicle availability levels were compared for cross-classifications of household size (1, 2, 3, 4+) by income level (<$15,000, $15,000-$29,999, $30,000-$49,999, $50,000-$99,999, >$100,000). The model results match the expanded survey data well.
- Vehicle availability levels were compared for cross-classifications of number of workers (0, 1, 2, 3, 4+) by income level (<$15,000, $15,000-$29,999, $30,000-$49,999, $50,000-$99,999, >$100,000). The model results match the expanded survey data well, considering the relatively low number of households surveyed for many of the cells.
- Vehicle availability levels were compared for cross-classifications of number of workers (0, 1, 2, 3+) by number of children (0, 1, 2+). The model results match the expanded survey data well, again considering the relatively low number of households surveyed for many of the cells, especially those representing households with zero vehicles.

Regular Workplace Location

The regular workplace location model simulates for each worker in the synthetic population whether he or she has a regular workplace and the location of that workplace. The Excel file with the results of the regular workplace location model is *UsualWork.xlsm*. Table 2.2 summarizes the regional modeled and observed (from the survey data set) percentages of workers by type (full time, part time, senior) with regular workplaces. The survey data closely matches the survey data.

Table 2.2. Percentage of Workers by Type with Regular Workplaces

	Expanded household survey data			Model			
Worker Status	No Usual Workplace	Total	Percentage	No Usual Workplace	Total	Percentage	Diff.
Full-Time	317,530	2,143,942	14.8%	175,681	2,317,432	7.6%	-7.2%
Part-Time	84,267	266,015	31.7%	72,338	339,193	21.3%	-10.4%
Total	401,796	2,409,957	16.7%	248,019	2,656,625	9.3%	-7.3%

Figure 2.1 and Figure 2.2 show the comparison between the observed (survey) and modeled tour length frequency distributions for distance and highway time, respectively. While there are some differences in the distributions, the fits are good; the coincidence ratios are 92 percent for both distance and time. The average tour times are 25.3 minutes (observed) and 25.5 minutes (modeled); the average tour distances are 13.1 miles (observed) and 12.7 miles (modeled).

The more detailed comparisons in the Excel files show the following results:

- Full time workers have longer tour lengths than part time workers. The model results match the survey results well in this case.
- The distance between home and the regular workplace increases with income. In the survey data, this increase is a little steeper than in the model results.
- The distance between home and the regular workplace increases as the home location becomes less urban, the survey data trend is well reflected in the model results.
- The modeled percentage of workers whose regular workplaces are in the same zone as their homes (the "intrazonal percentage") is 1.8 percent, compared to 2.0 percent in the survey data.
- The modeled and observed intrazonal percentages are slightly lower for full time workers than for part time workers.

Figure 2.1. Home to Regular Workplace Tour Length Frequency Distribution (Distance)

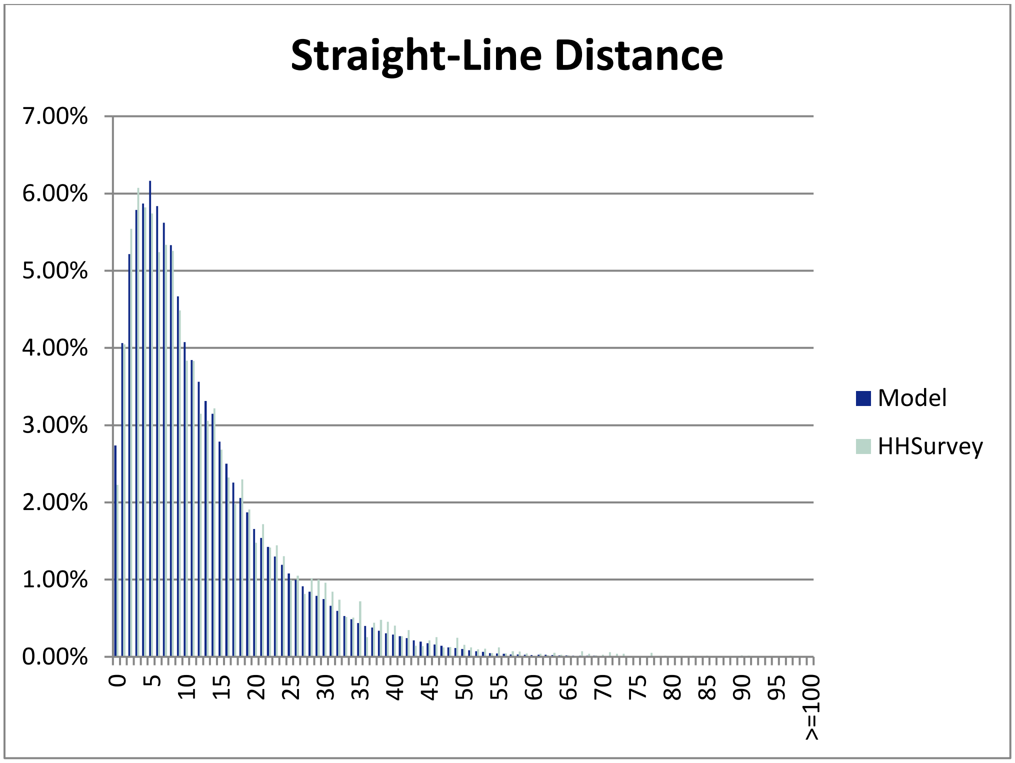
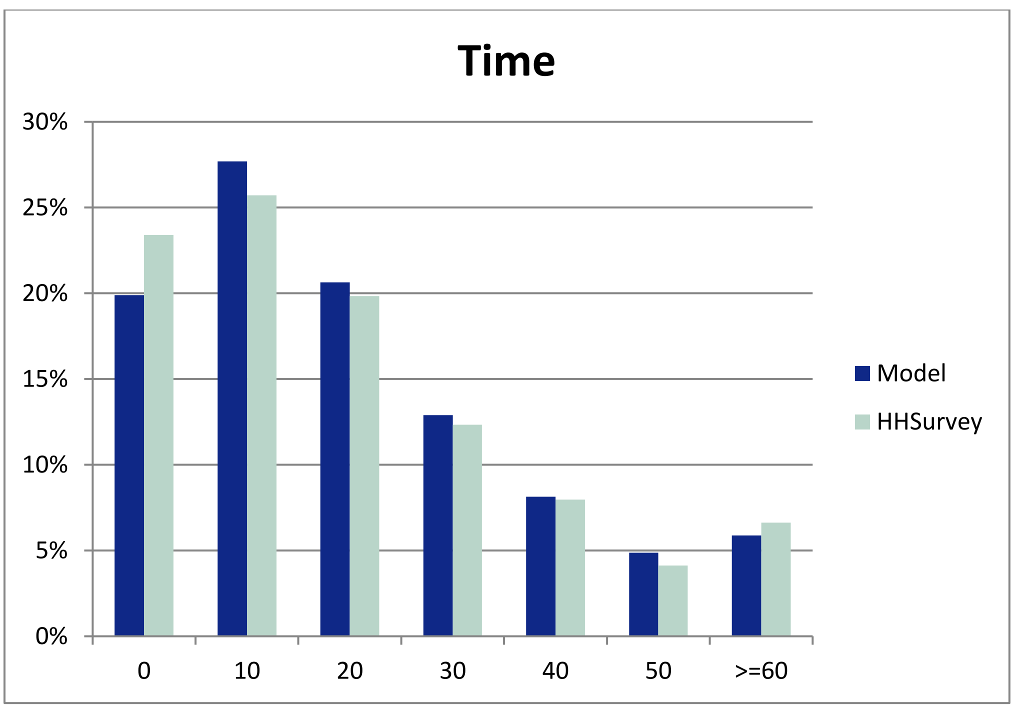


Figure 2.2. Home to Regular Workplace Tour Length Frequency Distribution (Time)



School Location

The school location model simulates the school location for each child in the synthetic population. The Excel file with the results of the school location model is *SchLocation.xlsm*.

Figure 2.3 and Figure 2.4 show the comparison between the observed (survey) and modeled tour length frequency distributions for distance and time, respectively. While there are some differences in the distributions, the fits are good; the coincidence ratios are 82 percent for distance and 70 percent for time. The average tour times are 11.4 minutes (observed) and 11.5 minutes (modeled); the average tour distances are 6.0 miles (observed) and 6.0 miles (modeled).

Figure 2.3. Home to School Tour Length Frequency Distribution (Distance)

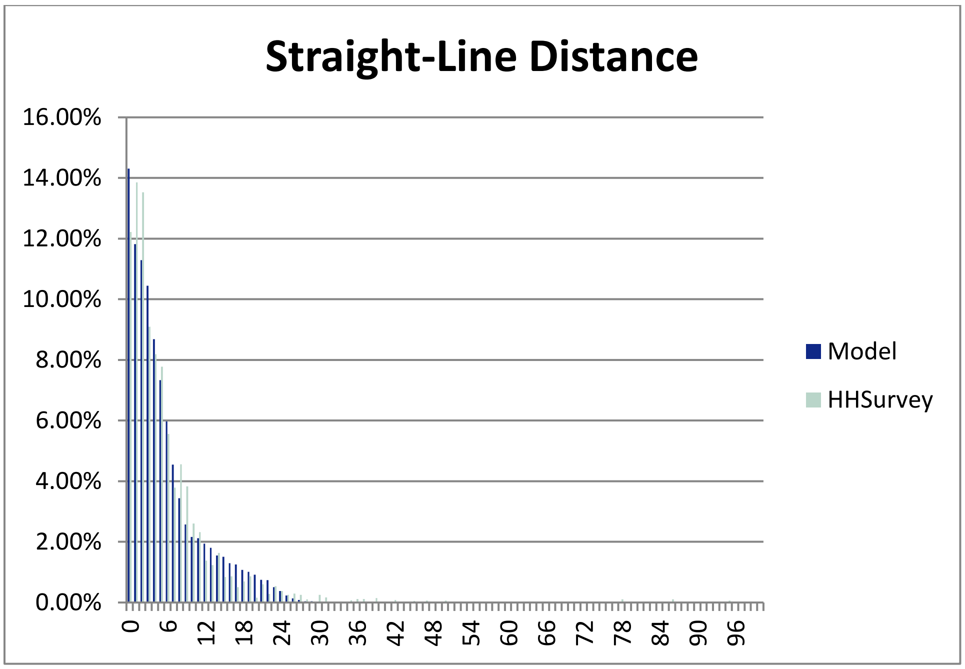
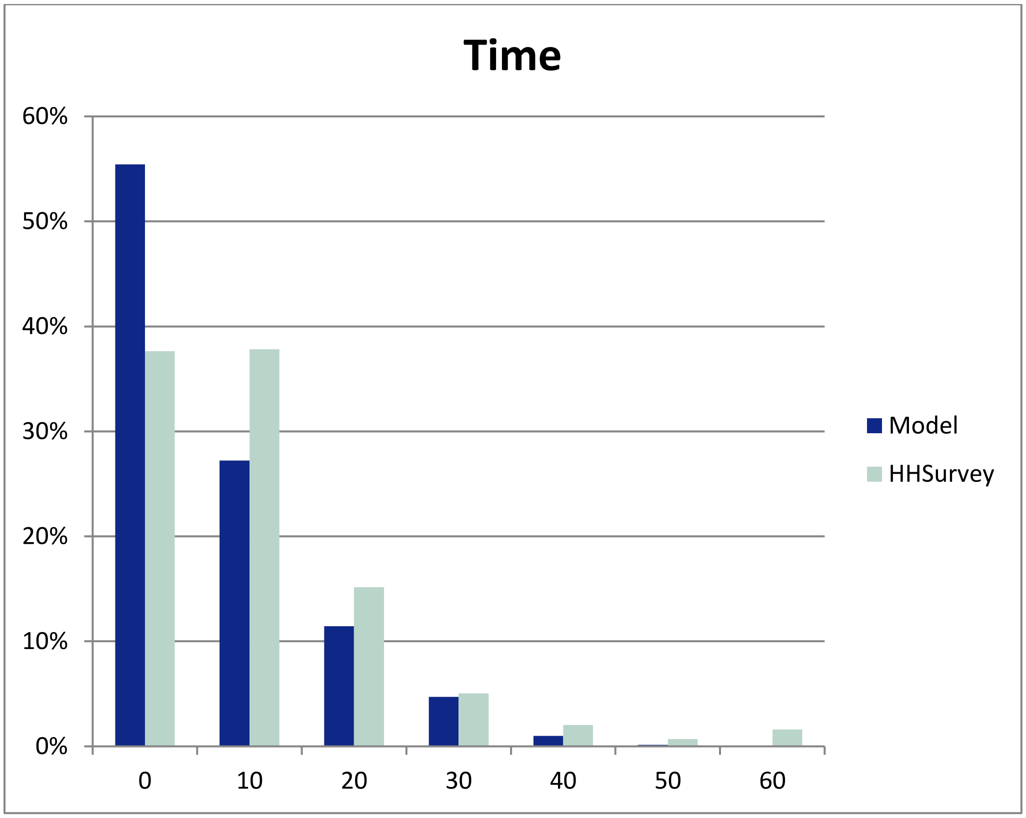


Figure 2.4. Home to School Tour Length Frequency Distribution (Time)



The more detailed comparisons in the Excel files show the following results:

- Both the survey data set and the model results show that children between ages 5 to 15 inclusive have shorter school trips than younger children, who have shorter trip lengths than students age 16 and older. This reflects that high school students often travel longer distances to school than younger children, and that pre-school children may travel farther to day care than the distance to elementary school.
- The model results show a slight increase in trip length to school as income increases. This is generally true in the survey data although the trend is not consistent (and seems illogical).
- The highest percentage of students who go to school in their zone of residence, is for students age 6 to 15, in both the survey data and model results. The overall percentage of students who attend school in their residence zone is 12 percent (survey) and 11 percent (model).

Transit Pass Ownership

The transit pass ownership model simulates whether each household in the synthetic population has a transit pass. The Excel file with the results of the transit pass ownership model is *Transit Pass Ownership.xlsm*.

Table 2.3 compares the modeled and observed transit pass ownership by county. The modeled percentage of households with transit passes matches the observed percentages well within the BMC region. The modeled percentages are low in the MWCOG region, especially in Washington, D.C.

Table 2.3. Comparison of Modeled and Observed Transit Pass Ownership by County

	Survey			Model Results			
County	Yes	No	Survey	Yes	No	Model	Difference
Baltimore City	24,120	228,088	10%	20,705	216,077	9%	-0.8%
Baltimore County	10,528	236,218	4%	14,516	295,706	5%	0.4%
Anne Arundel	8,717	164,813	5%	7,727	190,810	4%	-1.1%
Howard	6,456	119,521	5%	4,729	100,455	4%	-0.6%
Carroll	1,415	96,741	1%	2,021	60,317	3%	1.8%
Harford	1,515	122,941	1%	4,387	85,272	5%	3.7%
Montgomery/Prince George's/Frederick	111,908	665,605	14%	45,925	696,530	6%	-8.2%
D.C.	71,095	203,421	26%	26,310	234,828	10%	-15.8%
Total	**235,754**	**1,837,348**	**11%**	**126,320**	**1,879,995**	**6%**	**-5.1%**
BMC region	**52,751**	**968,322**	**5%**	**54,085**	**948,637**	**5%**	**0.2%**

E-ZPass Transponder Ownership

The E-ZPass transponder ownership model simulates whether each household in the synthetic population has a transponder. The Excel file with the results of this model is *E-ZPass Ownership.xlsm*.

It should be noted that the household survey data set did not include E-ZPass transponder ownership because the survey did not ask whether households owned transponders. The observed data for comparison therefore is obtained from an alternate source—a data set obtained by BMC from the Maryland Transportation Authority (MDTA) that provided the number of transponders owned by zip code. The number of "commercial" transponders (for example, the "Standard Business Plan") was removed from the totals prior to comparison.

The use of this alternate observed data source means that the observed data does not exactly correspond to the number of households with transponders. Most notably, the MDTA data set counts the *number of transponders*, not the *number of households with transponders*. If a household had more than one transponder, the MDTA data set would count multiple transponders. In addition, some households may own E-ZPass transponders obtained from agencies in other states. Furthermore, some commercial vehicles may have transponders that do not fall into the excluded categories while some personal vehicles may have transponders that are counted in the commercial categories. There are also some differences between the survey period (2007-2008) and the relatively recent MDTA data set.

Table 2.4 compares the modeled and observed transponder ownership by county. The model results show some noticeable differences from the observed data by county. While some model calibration was performed, it was decided not to adjust the model results too much given the different nature of the MDTA data set.

Table 2.4. Comparison of Modeled and Observed E-ZPass Transponder Ownership by County

	Observed			Modeled			
County	Households	Number of Passes	% Households with Passes	Households	Number of Passes	% Households with Passes	% Diff.
Baltimore City	252,208	66,654	26%	252,718	46,247	18%	-8%
Baltimore County	246,748	165,833	67%	318,820	151,812	48%	-20%
Anne Arundel	173,529	90,189	52%	202,188	148,250	73%	21%
Howard	125,976	45,981	36%	107,719	75,412	70%	34%
Carroll	98,156	9,816	10%	63,098	36,723	58%	48%
Harford	124,455	80,360	65%	91,762	68,410	75%	10%
Montgomery/Prince Georges/Frederick	777,512	177,348	23%	764,828	390,920	51%	28%
DC	274,517	23,852	9%	275,064	46,614	17%	8%
Total	2,073,100	660,033	32%	2,076,197	964,388	46%	15%
BMC Region	1,295,588	482,685	37%	1,311,369	573,468	44%	6%

2.2 Daily Activity Pattern and Related Models

Daily Activity Pattern Model

The daily activity pattern model simulates whether each person in the synthetic population has mandatory (work, university, or school) activities, has non-mandatory activities only, or makes no travel within the region (i.e., stays at home, is temporarily out of the model region, or has only external travel—travels only between home and locations outside the model region). If a mandatory activity pattern is chosen, the number of mandatory tours (zero, one, or two) is simulated, as well as whether any simulated work tours have stops.

Excel files summarizes the results of the daily activity pattern model for each person type:

- Senior - *DAP_Senior.xlsm*
- Full time worker - *DAP_FTW.xlsm*
- Part time worker - *DAP_PTW.xlsm*
- Adult (university) student - *DAP_Adult Student.xlsm*

- Non-working adult - *DAP_NWA.xlsm*
- Child age less than 5 - *DAP_Child1.xlsm*
- Child age 5-15 - *DAP_Child2.xlsm*
- Child age 16 or older - *DAP_Child3.xlsm*

Table 2.5 through Table 2.12 summarize the regional results of the calibrated daily activity pattern model for each person type.

The Excel files show the results segmented by various variables of interest, including county of residence, household size, income level, vehicle availability, and gender. These comparisons show only minor differences between the survey data and the model results (though in many cases, the large number of alternatives in the daily activity pattern model means that the survey data has few observations for several of the alternatives for many of the market segments).

Table 2.5. Regional Comparison of Daily Activity Patterns
Full Time Worker

Daily Activity Pattern Type	Expanded household survey data		Model Results	
	Count	Percentage	Count	Percentage
1 Work Tour, No Stops	986,563	42.6%	955,922	41.2%
1 Work Tour, With Stops	729,477	31.5%	783,134	33.8%
2 Work Tours, No Stops	47,491	2.0%	36,614	1.6%
2 Work Tours, Stops on One	36,882	1.6%	30,623	1.3%
2 Work Tours, Stops on Both	10,098	0.4%	9,168	0.4%
1 Univ. Tour/1 Work Tour, No Stops	5,966	0.3%	4,599	0.2%
1 Univ. Tour/1 Work Tour, Stops on Work Tour	3,892	0.2%	3,355	0.1%
1 School Tour/1 Work Tour, No Stops	0	0.0%	0	0.0%
1 School Tour/1 Work Tour, Stops on Work Tour	0	0.0%	0	0.0%
1 Univ. Tour	10,445	0.5%	10,477	0.5%
2 Univ. Tours	0	0.0%	0	0.0%
1 School Tour	0	0.0%	0	0.0%
2 School Tours	0	0.0%	0	0.0%
Non-Mandatory Travel Only	244,707	10.6%	267,483	11.5%
Stay at Home/Out of Area/ External Travel Only	241,912	10.4%	216,057	9.3%
Total	2,317,432	100%	2,317,432	100%

Table 2.6. Regional Comparison of Daily Activity Patterns
Part Time Worker

Daily Activity Pattern Type	Expanded household survey data		Model Results	
	Count	Percentage	Count	Percentage
1 Work Tour, No Stops	72,243	21.3%	70,730	20.9%
1 Work Tour, With Stops	62,267	18.4%	69,263	20.4%
2 Work Tours, No Stops	3,353	1.0%	2,187	0.6%
2 Work Tours, Stops on One	4,477	1.3%	3,047	0.9%
2 Work Tours, Stops on Both	2,081	0.6%	1,532	0.5%
1 Univ. Tour/1 Work Tour, No Stops	0	0.0%	1,724	0.5%
1 Univ. Tour/1 Work Tour, Stops on Work Tour	108	0.0%	99	0.0%
1 School Tour/1 Work Tour, No Stops	0	0.0%	0	0.0%
1 School Tour/1 Work Tour, Stops on Work Tour	0	0.0%	0	0.0%
1 Univ. Tour	277	0.1%	405	0.1%
2 Univ. Tours	0	0.0%	0	0.0%
1 School Tour	0	0.0%	0	0.0%
2 School Tours	0	0.0%	0	0.0%
Non-Mandatory Travel Only	136,425	40.2%	138,126	40.7%
Stay at Home/Out of Area/ External Travel Only	57,963	17.1%	52,080	15.4%
Total	339,193	100%	339,193	100%

Table 2.7. Regional Comparison of Daily Activity Patterns
Adult Student

Daily Activity Pattern Type	Expanded household survey data		Model Results	
	Count	Percentage	Count	Percentage
1 Work Tour, No Stops	19,694	7.6%	19,331	7.4%
1 Work Tour, With Stops	19,338	7.4%	19,091	7.3%
2 Work Tours, No Stops		0.0%	0	0.0%
2 Work Tours, Stops on One		0.0%	0	0.0%
2 Work Tours, Stops on Both	0	0.0%	0	0.0%
1 Univ. Tour/1 Work Tour, No Stops	4,111	1.6%	3,989	1.5%
1 Univ. Tour/1 Work Tour, Stops on Work Tour	2,076	0.8%	2,064	0.8%
1 School Tour/1 Work Tour, No Stops	0	0.0%	0	0.0%
1 School Tour/1 Work Tour, Stops on Work Tour	0	0.0%	0	0.0%
1 Univ. Tour	92,835	35.7%	91,869	35.2%
2 Univ. Tours	4,127	1.6%	4,131	1.6%
1 School Tour	0	0.0%	0	0.0%
2 School Tours	0	0.0%	0	0.0%
Non-Mandatory Travel Only	75,908	29.2%	76,026	29.1%
Stay at Home/Out of Area/ External Travel Only	41,699	16.1%	44,832	17.2%
Total	259,788	100%	261,333	100%

Table 2.8. Regional Comparison of Daily Activity Patterns
Senior

Daily Activity Pattern Type	Expanded household survey data		Model Results	
	Count	Percentage	Count	Percentage
1 Work Tour, No Stops	8,322	1.8%	8,452	1.8%
1 Work Tour, With Stops	6,859	1.5%	8,067	1.8%
2 Work Tours, No Stops	838	0.2%	0	0.0%
2 Work Tours, Stops on One	570	0.1%	0	0.0%
2 Work Tours, Stops on Both	0	0.0%	0	0.0%
1 Univ. Tour/1 Work Tour, No Stops	0	0.0%	0	0.0%
1 Univ. Tour/1 Work Tour, Stops on Work Tour	0	0.0%	0	0.0%
1 School Tour/1 Work Tour, No Stops	0	0.0%	0	0.0%
1 School Tour/1 Work Tour, Stops on Work Tour	0	0.0%	0	0.0%
1 Univ. Tour	1,775	0.4%	791	0.2%
2 Univ. Tours	0	0.0%	0	0.0%
1 School Tour	0	0.0%	0	0.0%
2 School Tours	0	0.0%	0	0.0%
Non-Mandatory Travel Only	272,942	59.7%	263,859	57.7%
Stay at Home/Out of Area/ External Travel Only	165,985	36.3%	176,122	38.5%
Total	457,291	100%	457,291	100%

Table 2.9. Regional Comparison of Daily Activity Patterns
Non-Working Adult

Daily Activity Pattern Type	Expanded household survey data		Model Results	
	Count	Percentage	Count	Percentage
1 Work Tour, No Stops	393	0.1%	467	0.1%
1 Work Tour, With Stops	357	0.1%	472	0.1%
2 Work Tours, No Stops	0	0.0%	0	0.0%
2 Work Tours, Stops on One	0	0.0%	0	0.0%
2 Work Tours, Stops on Both	0	0.0%	0	0.0%
1 Univ. Tour/1 Work Tour, No Stops	0	0.0%	0	0.0%
1 Univ. Tour/1 Work Tour, Stops on Work Tour	0	0.0%	0	0.0%
1 School Tour/1 Work Tour, No Stops	0	0.0%	0	0.0%
1 School Tour/1 Work Tour, Stops on Work Tour	0	0.0%	0	0.0%
1 Univ. Tour	587	0.1%	369	0.1%
2 Univ. Tours	0	0.0%	0	0.0%
1 School Tour	0	0.0%	0	0.0%
2 School Tours	0	0.0%	0	0.0%
Non-Mandatory Travel Only	398,552	68.4%	397,174	68.2%
Stay at Home/Out of Area/ External Travel Only	182,503	31.3%	183,910	31.6%
Total	582,392	100%	582,392	100%

Table 2.10. Regional Comparison of Daily Activity Patterns
Child Age Less than 5

Daily Activity Pattern Type	Expanded household survey data		Model Results	
	Count	Percentage	Count	Percentage
1 Work Tour, No Stops	0	0.0%	0	0.0%
1 Work Tour, With Stops	0	0.0%	0	0.0%
2 Work Tours, No Stops	0	0.0%	0	0.0%
2 Work Tours, Stops on One	0	0.0%	0	0.0%
2 Work Tours, Stops on Both	0	0.0%	0	0.0%
1 Univ. Tour/1 Work Tour, No Stops	0	0.0%	0	0.0%
1 Univ. Tour/1 Work Tour, Stops on Work Tour	0	0.0%	0	0.0%
1 School Tour/1 Work Tour, No Stops	0	0.0%	0	0.0%
1 School Tour/1 Work Tour, Stops on Work Tour	0	0.0%	0	0.0%
1 Univ. Tour	0	0.0%	0	0.0%
2 Univ. Tours	0	0.0%	0	0.0%
1 School Tour	125,930	37.3%	133,788	39.6%
2 School Tours	456	0.1%	0	0.0%
Non-Mandatory Travel Only	126,069	37.3%	132,190	39.1%
Stay at Home/Out of Area/ External Travel Only	85,476	25.3%	71,953	21.3%
Total	337,931	100%	337,931	100%

Table 2.11. Regional Comparison of Daily Activity Patterns
Child Age 5-15

Daily Activity Pattern Type	Expanded household survey data		Model Results	
	Count	Percentage	Count	Percentage
1 Work Tour, No Stops	365	0.0%	0	0.0%
1 Work Tour, With Stops	167	0.0%	0	0.0%
2 Work Tours, No Stops	0	0.0%	0	0.0%
2 Work Tours, Stops on One	0	0.0%	0	0.0%
2 Work Tours, Stops on Both	0	0.0%	0	0.0%
1 Univ. Tour/1 Work Tour, No Stops	0	0.0%	0	0.0%
1 Univ. Tour/1 Work Tour, Stops on Work Tour	0	0.0%	0	0.0%
1 School Tour/1 Work Tour, No Stops	701	0.1%	0	0.0%
1 School Tour/1 Work Tour, Stops on Work Tour	457	0.1%	0	0.0%
1 Univ. Tour	0	0.0%	0	0.0%
2 Univ. Tours	0	0.0%	0	0.0%
1 School Tour	513,502	70.1%	531,673	72.6%
2 School Tours	10,047	1.4%	10,717	1.5%
Non-Mandatory Travel Only	125,639	17.2%	117,309	16.0%
Stay at Home/Out of Area/ External Travel Only	81,658	11.1%	72,837	9.9%
Total	732,536	100%	732,536	100%

Table 2.12. Regional Comparison of Daily Activity Patterns
Child Age 16-17

Daily Activity Pattern Type	Expanded household survey data		Model Results	
	Count	Percentage	Count	Percentage
1 Work Tour, No Stops	4,783	3.6%	5,042	3.8%
1 Work Tour, With Stops	1,123	0.8%	1,654	1.2%
2 Work Tours, No Stops	0	0.0%	0	0.0%
2 Work Tours, Stops on One	0	0.0%	0	0.0%
2 Work Tours, Stops on Both	0	0.0%	0	0.0%
1 Univ. Tour/1 Work Tour, No Stops	0	0.0%	0	0.0%
1 Univ. Tour/1 Work Tour, Stops on Work Tour	0	0.0%	0	0.0%
1 School Tour/1 Work Tour, No Stops	4,699	3.5%	5,789	4.3%
1 School Tour/1 Work Tour, Stops on Work Tour	924	0.7%	934	0.7%
1 Univ. Tour	0	0.0%	0	0.0%
2 Univ. Tours	0	0.0%	0	0.0%
1 School Tour	87,307	64.9%	86,685	64.5%
2 School Tours	3,080	2.3%	2,601	1.9%
Non-Mandatory Travel Only	17,482	13.0%	17,152	12.8%
Stay at Home/Out of Area/ External Travel Only	15,052	11.2%	14,592	10.9%
Total	134,449	100%	134,449	100%

School Escorting Model

For each child traveling to school, the school escorting model determines whether he or she is escorted by another household member to school or from school, and, if so, which household member does the escorting, and whether that household member escorts the student as part of a mandatory tour (for example, on the way to or from work). The Excel file that summarizes the results of the school escorting model is *SchoolEscort.xlsm*.

Table 2.13 presents a summary of the comparison of the percentage of school escorting alternatives from the survey data set and the model results, by child age group (0-4, 5-15, and 16+). In this table, the five alternatives for each student are:

- Outbound mandatory – Escorting to school as part of a mandatory tour
- Outbound stand alone – Escorting to school as part of a stand alone tour
- Return mandatory – Escorting from school as part of a mandatory tour
- Return stand alone – Escorting from school as part of a stand alone tour
- None – Student is not escorted.

Table 2.14 shows the comparison of escort person types between the survey data set and model results. Both Table 2.13 and Table 2.14 show relatively close agreement between the observed and model results.

The more detailed comparisons in the Excel files show the following results:

- The survey data show that very little school escorting occurs in zero car households. The model results reflect this unsurprising result.
- Both the survey data and model results show that most escorts are full time workers or non-working adults.
- The household survey data show that 72 percent of escorts are female; the model results show a lower percentage of female escorts (62 percent).
- Generally, fewer children from higher income households are escorted, especially for the youngest children.

Table 2.13. Regional Comparison of School Escorting Alternatives

Escort Type	Child Age	Expanded household survey data		Model Results		Percentage Point Difference (Model - Survey)
		Count	Percentage	Count	Percentage	
Outbound mandatory	< 5 Years	53,716	20.9%	54,958	20.5%	-0.4%
Outbound standalone	< 5 Years	39,172	15.2%	38,501	14.4%	-0.9%
Return mandatory	< 5 Years	49,848	19.4%	51,756	19.3%	-0.1%
Return standalone	< 5 Years	39,941	15.5%	41,492	15.5%	0.0%
None	< 5 Years	74,263	28.9%	80,869	30.2%	1.3%
Total	< 5 Years	256,940		267,576		
Outbound mandatory	5-15 Years	78,304	7.3%	115,881	10.5%	3.2%
Outbound standalone	5-15 Years	114,090	10.6%	84,261	7.6%	-3.0%
Return mandatory	5-15 Years	48,057	4.5%	78,485	7.1%	2.6%
Return standalone	5-15 Years	99,897	9.3%	75,770	6.8%	-2.4%
None	5-15 Years	734,989	68.3%	751,817	68.0%	-0.4%
Total	5-15 Years	1,075,337		1,106,214		
Outbound mandatory	16+ Years	8,528	4.3%	6,736	3.4%	-0.9%
Outbound standalone	16+ Years	11,927	6.0%	21,528	10.9%	4.9%
Return mandatory	16+ Years	3,840	1.9%	5,327	2.7%	0.8%
Return standalone	16+ Years	6,166	3.1%	3,982	2.0%	-1.1%
None	16+ Years	167,920	84.6%	159,647	80.9%	-3.7%
Total	16+ Years	198,381		197,220		
Outbound mandatory	All	140,548	9.2%	177,575	11.3%	2.1%
Outbound standalone	All	165,189	10.8%	144,290	9.2%	-1.6%
Return mandatory	All	101,746	6.6%	135,568	8.6%	2.0%
Return standalone	All	146,004	9.5%	121,244	7.7%	-1.8%
None	All	977,171	63.8%	992,333	63.2%	-0.7%
Total	**All**	**1,530,658**		**1,571,010**		

Table 2.14. Regional Comparison of School Escorting Types – Household Survey vs. Model Results

Escort Person Type	Expanded Household Survey Data		Model Results		Percentage Point Difference (Model - Survey)
	Count	Percentage	Count	Percentage	
Adult Student	22,542	5.0%	6,629	1.5%	-3.6%
Full Time Worker	274,394	61.4%	308,295	68.2%	6.8%
Part Time Worker	53,548	12.0%	65,243	14.4%	2.5%
Non Working Adult	90,952	20.3%	67,654	15.0%	-5.4%
Senior	5,603	1.3%	4,347	1.0%	-0.3%
Total	447,038		452,168		

Joint Travel Model

The fully joint tour models include a **generation** model, which simulates the number (zero, one, or two) and purposes (meal, shopping, personal business, or social-recreation) of fully joint tours made by each household, and a **participation** model, which determines which household members participate in each simulated joint tour. The Excel file that summarizes the results of the fully joint tour models is *JointTour Gen & Part.xlsm*. The household survey data set shows an average of 0.255 fully joint tours per household while the model results show 0.262 joint tours per household.

The more detailed comparisons in the Excel files show the following results:

- The survey data set shows varying rates of joint tours per household by county, with the lowest rates in Baltimore City and Washington, D.C. This is not surprising since average household size is lower in these cities than in the rest of the model region. These two counties also have the lowest joint tour rates in the model results though the model somewhat overestimates the joint tour rate in Baltimore City.
- Among households making joint tours, there is no discernable pattern of the number of joint tours made by income level. The model somewhat overestimates the number of joint tours for the lowest income group
- Among households making joint tours, zero vehicle households make fewer joint tours though the model somewhat overestimates the joint tour rate for these households. The model also underestimates the joint tour rate for households with three or more vehicles.
- The distributions of joint tours by purpose and by party size (2, 3, or 3+) are similar for the survey data set and the model results. The cross-classifications of tour purpose by party size also match well, with the largest differences appearing for the combinations with the lowest incidence in the survey data set (generally, the 3+ person tours).

Individual Non-Mandatory Tour Generation Model

The individual non-mandatory tour generation model simulates the number (zero, one, two, or three) and purposes (meal, shopping, personal business, escorting, or social-recreation) of non-mandatory tours made by each person in the synthetic population for whom a mandatory or non-mandatory daily activity pattern has been simulated. (At least one non-mandatory tour must be simulated for persons with non-mandatory patterns). The Excel file that summarizes the results of the non-mandatory tour generation model is *INMTourGeneration.xlsm*. The number of modeled non-mandatory tours per person is slightly lower (about 4 percent) than the number of such tours in the expanded household survey data set.

The more detailed comparisons in the Excel files show the following results:

- The modeled percentages of non-mandatory tours by purpose match the percentages from the survey data set almost exactly.
- Compared to the survey data set, the model slightly overestimates the number of non-mandatory tours for seniors and slightly underestimates for children, adult students, and adult non-workers. The model percentages of non-mandatory tours by purpose for each person type also match the percentages from the survey data set almost exactly.
- Most of the underestimation of non-mandatory tours by the model is for males. The expanded show very similar percentages of tours by purpose for males and females. The slight differences between genders in the data (for example, slightly higher percentages of shopping and escort tours for females) are reflected in the model.
- There are a few relatively minor differences in the model results by income level, household size, and vehicle availability compared to the survey data set. Perhaps most notable is that the model does not pick up the differences by household size for individual meal tours—the survey data show that the larger the household, the lower the incidence of individual meal tours.

Work-Based Subtour Generation Model

The work based subtour generation model simulates the number (zero, one, or two) and purposes (work, meal, shopping, personal business, escorting, or social-recreation) of work based subtours made by persons making work tours. The Excel file that summarizes the results of the work based subtour generation model is *WBTourGeneration.xlsm*. The number of modeled work based subtours per work tour is about the same as the number of such subtours in the expanded household survey data set (0.154 observed versus 0.155 modeled).

The more detailed comparisons in the Excel files show the following results:

- The modeled percentages of work based subtours by purpose match the percentages from the survey data set well.
- The model results show that those who take non-auto modes to work make fewer subtours than those who take auto modes, with those who walk or bike to work making fewer subtours than those who took transit. This seems to make sense in that these people usually would not have access to cars for making work based subtours. However, the survey data set generally shows the opposite pattern. The model results slightly overestimate the number of subtours by workers who use auto modes to work and slightly underestimate the number of subtours by workers who use non-auto modes to travel to work.
- The survey data set shows that males make more work based subtours than females, and the model results match this result.

- The household survey data show that the rate of making work based subtours increases with income level. The model data show this pattern for all travelers, but at a much more moderate rate of increase.

2.3 TOUR LEVEL CHOICE MODELS

Tour Destination Choice Models

The tour destination choice models simulate the location of the primary activity of each tour. There are Excel files with detailed results for various aggregate activity purposes:

- Work (not to regular workplace) – *Tour Dest Work.xlsm*
- University - *Tour Dest Uni.xlsm*
- Fully joint – *Tour Dest Joint.xlsm*
- Individual non-mandatory (except escort tours) - *Tour Dest INM.xlsm*
- Work based subtours – *WB Tour Dest.xlsm*

Each spreadsheet file includes histograms comparing the tour length frequency distributions, by both time and distance, for the corresponding activity purpose. Table 2.15 summarizes the coincidence ratios for these comparisons.

Table 2.15. Coincidence Ratios for Tour Length Frequency Distributions

	Coincidence Ratio	
Tour Purpose	**Time**	**Distance**
Work (including tours to regular workplace)	86%	80%
University	91%	76%
Joint	90%	85%
Individual non-mandatory	89%	89%
Work based subtours	98%	77%

For each tour purpose, the following comparisons between the observed (expanded household survey) data and model results are included in the Excel files:

- Average tour length (time and distance) by:
  - Tour activity (meal, shop, personal business, or social-recreation) - *for non-mandatory tours only*
  - Income level
  - Area type at home (or workplace for work based subtours) and at the primary activity location

  - Person type – *except joint tours*
  - Number of household vehicles – *except work based subtours*
  - Parent tour mode –*work based subtours only*
- Percentage of intrazonal tours (primary activity location zone is the same as the home zone (or work zone for work based subtours)) by:
  - Area type
  - Person type – *work tours only*
  - Number of household vehicles – *except work based subtours*
  - Parent tour mode –*work based subtours only*

Generally, both the average tour lengths (see Table 2.16) and intrazonal percentages (see Table 2.17) from the model matched those from the survey data well. In the model results, the average tour lengths show a logical progression with tour lengths increasing as income increases; the survey data do not show this pattern for all tour purposes. Another difference is that the model shows more intrazonal tours for less dense areas while the survey data do not show this pattern.

Table 2.16. Average Trip Length Comparisons by Tour Purpose

	Observed		Model	
Tour Purpose	**Time (min)**	**Distance (miles)**	**Time (min)**	**Distance (miles)**
Work	23.0	12.0	23.1	11.3
University	17.2	9.0	17.2	8.3
Joint	12.8	7.1	14.4	7.2
Individual non-mandatory	11.0	5.7	11.9	5.6
Work based subtours	5.7	3.3	6.0	2.5

Table 2.17. Comparison of Intrazonal Percentages

Tour Purpose	Time	Distance
Work (including tours to regular workplace)	2%	3%
University	3%	4%
Joint	7%	8%
Individual non-mandatory	11%	13%
Work based subtours	18%	18%

Tour Time of Day Choice Models

The tour time of day choice models simulate the start and end times, in half hour increments, of the primary activity of each tour. There are Excel files with detailed results for various aggregate activity purposes:

- Mandatory (work, school and university) - *TOD_Mand.xlsm*
- Joint - *TOD_Joint.xlsm*
- Individual non-mandatory - *TOD_NM.xlsm*
- Work based subtours - *TOD_WB.xlsm*

Each spreadsheet presents histograms comparing the distributions of activity arrival and departures, for the corresponding activity purpose. Table 2.18 summarizes the coincidence ratios for these comparisons.

Table 2.18. Coincidence Ratios for Time of Day Distributions

	Coincidence Ratio	
Tour Purpose	**Arrival**	**Departure**
Work	85%	83%
School	81%	86%
University	61%	51%
Joint	83%	78%
Individual non-mandatory	83%	83%
Work based subtours	90%	91%

Table 2.19 presents the activity durations by purpose for the survey data set and the model results. These figures match well.

Table 2.19. Modeled and Observed Activity Durations by Purpose

	Duration (hours)	
Tour Purpose	**Survey**	**Model**
Work	7.1	7.4
School	7.0	7.2
University	4.5	5.0
Joint	1.9	1.7
Meal	0.9	1.5
Shopping	0.9	1.0
Personal Business	1.8	1.4
Social-recreation	1.0	1.8
Escort	0.1	0.2
Work based subtours	0.8	0.7

Each spreadsheet also compares the average activity duration in hours by the following segmentations:

- Income level
- Person type – *except joint tours*
- Gender – *except joint tours*
- Specific activity purpose (e.g., meal, shopping) – *joint, non-mandatory, and work based*

In most cases, the modeled and survey activity durations are within 10 percent or within 10 minutes of one another, when there are sufficient observations in the segment. Some exceptions include the following:

- Modeled activity durations for work tours are about 15 percent high for part time workers and about 25 percent high for adult students. Modeled activity durations for work tours are about 15 percent high for the $15,000 to $30,000 income group and about 10 percent high for the $30,000 to $50,000 income group.
- Modeled activity durations for non-mandatory tours are high for most segments since the average activity duration is high by about 15 minutes.
- Several of the university tour segments have greater differences between the observed data and model results; this is due to the relatively low numbers of these tours.

Tour Mode Choice Models

The tour mode choice models simulate the main mode of each tour. There are Excel files with detailed validation results for various aggregate activity purposes:

- Work - *TourModeChoice_Work.xlsm*
- School - *TourModeChoice_Sch.xlsm*
- University - *TourModeChoice_Uni.xlsm*
- Joint - *TourModeChoice_Joint.xlsm*
- Individual non-mandatory (except escort tours) - *TourModeChoice_INM.xlsm*
- Escort - *TourModeChoice_Escort.xlsm*
- Work based subtours - *TourModeChoice_WB.xlsm*

Table 2.20 compares the regional observed and modeled mode shares by tour purpose.

Table 2.20. Regional Modeled and Observed Tour Mode Shares by Purpose

	Work		School		University		Individual Non-Mandatory	
Tour Mode	**Survey**	**Model**	**Survey**	**Model**	**Survey**	**Model**	**Survey**	**Model**
Drive Alone	59.0%	58.6%	2.0%	1.9%	50.9%	49.5%	46.9%	47.4%
Shared Ride 2	14.4%	14.9%	19.5%	7.1%	11.6%	11.5%	24.3%	23.5%
Shared Ride 3+	7.7%	8.2%	38.0%	53.3%	11.4%	11.3%	12.2%	11.7%
Transit-Walk Access	9.1%	8.6%	4.5%	4.4%	13.3%	14.3%	6.0%	5.8%
Transit-Auto Access	6.6%	6.4%	0.3%	0.3%	3.9%	3.9%	0.9%	0.9%
Walk	2.3%	2.5%	7.7%	6.3%	6.3%	7.6%	8.9%	10.1%
Bike	0.8%	0.8%	0.4%	0.4%	1.7%	1.9%	0.6%	0.6%
School Bus			27.7%	26.3%			0.2%	

	Escort		Joint		Work-Based Subtours		ALL TRIPS	
Tour Mode	**Survey**	**Model**	**Survey**	**Model**	**Survey**	**Model**	**Survey**	**Model**
Drive Alone					44.5%	46.1%	38.9%	38.4%
Shared Ride 2	45.7%	46.9%	46.7%	47.2%	12.9%	12.7%	22.4%	20.9%
Shared Ride 3+	42.7%	40.5%	43.0%	43.5%	7.2%	7.0%	17.9%	20.1%
Transit-Walk Access			2.9%	2.6%	2.0%	2.2%	6.1%	5.9%
Transit-Auto Access			0.4%	0.0%	0.2%	0.0%	2.8%	2.7%
Walk	11.7%	12.5%	6.7%	6.4%	32.8%	31.7%	7.8%	8.0%
Bike			0.3%	0.3%	0.2%		0.6%	0.6%
School Bus					0.2%		3.5%	3.5%

For each tour purpose, the spreadsheet files show the following comparisons between the survey and modeled tour mode shares:

- Area type at home (or workplace for work based subtours) and at the primary activity location
- Distance range
- Transit in-vehicle time ranges (walk and auto access)
- Household size and income level
- Vehicles less than, equal to, or greater than number of workers/drivers
- Age and gender

In nearly all cases, the mode shares from the model matched those from the survey data well. Some of the key results, which are true for both the observed and model data, include the following:

- Not surprisingly, transit and non-motorized mode shares increase as the area becomes more densely developed while auto mode shares decrease. This trend noted in the expanded survey data is also seen in the model although the rate of changes among area types is more moderate in the model. (It should be noted that except for work and individual non-mandatory tours, the number of survey observations is fairly small for the most urban area types.)
- Transit-walk access mode shares decrease with increased distance; the opposite holds for transit-auto access shares (nearly all transit-auto access tours are for work or university purposes). The model captures these trends better for the walk access tours. Non-motorized trips, naturally, are nearly all short distance, and the model results reflect this.
- Transit mode shares to all counties are low—from zero to two percent—for all tour purposes, with the exception of the three Maryland Counties in the MWCOG region, where the transit shares are a bit higher. Transit shares to the cities of Baltimore and Washington are substantially higher. The model results reflect these trends.
- Transit-walk access shares decrease with increasing income levels for all tour purposes, and the model results accurately reflect this trend. For work tours, transit-auto access shares increase with increasing income levels, and the model results accurate reflect this as well.
- Generally, transit shares decrease with increasing household size, and the model accurately reflects this trend.
- Not surprisingly, transit and non-motorized mode shares are much higher in households with fewer vehicles than workers, or fewer vehicles than drivers, and are even higher in households with zero vehicles. The model reflects these trends accurately.
- Auto shares, especially drive alone, decrease while transit shares decrease with increasing age.
- For work tours, transit and shared ride mode shares are higher for females; drive alone and bike mode shares are higher for males.

Stop Generation Models

The stop generation models simulate the number and purposes of stops made on each tour. Separate models were estimated for each tour purpose. There are Excel files with detailed results for various aggregate activity purposes:

- Mandatory (work, school and university) - *Stops_Mand.xlsm*
- Joint - *Stops_Joint.xlsm*
- Individual non-mandatory - *Stops_INM.xlsm*
- Work based subtours - *Stops_WB.xlsm*

Table 2.21 compares the number of observed and modeled number of half tours with stops by tour purpose. Table 2.22 presents the observed and modeled daily stops per half tour in each direction by tour purpose. As these tables show, the model results are close to the observed results from the expanded household survey data set.

Table 2.21. Regional Modeled and Observed Shares of Half Tours by Number of Stops by Purpose

	Work		School/ University		Individual Non-Mandatory	
Stops	**Survey**	**Model**	**Survey**	**Model**	**Survey**	**Model**
0 stops	50%	48%	78%	80%	55%	60%
1 stop	35%	37%	15%	13%	30%	27%
2 stops	10%	9%	5%	5%	9%	8%
3 stops	6%	7%	2%	2%	6%	5%
	Joint		**Work-Based Subtours**		**All Half Tours**	
Stops	**Survey**	**Model**	**Survey**	**Model**	**Survey**	**Model**
0 stops	51%	58%	80%	86%	57%	60%
1 stop	34%	30%	17%	13%	29%	28%
2 stops	10%	9%	3%	2%	9%	8%
3 stops	4%	3%	0%	0%	5%	5%

**Note: Model is constrained to produce only 1 or 2 stops per half tour on work based subtours.

Table 2.22. Observed and Modeled Average Number of Stops per Half Tour

	Outbound Half Tour		Return Half Tour	
Tour Purpose	**Survey**	**Model**	**Survey**	**Model**
Work	0.24	0.28	0.47	0.46
School/University	0.08	0.08	0.24	0.22
Individual Mon-Mandatory	0.30	0.26	0.37	0.32
Joint	0.32	0.24	0.36	0.34
Work Based Subtours	0.10	0.07	0.17	0.13
Total – All Tours	**0.21**	**0.25**	**0.33**	**0.34**

For each tour purpose, the spreadsheet files show the following comparisons between survey and modeled stops:

- Income level
- Person type – *except joint tours*
- Age and gender – *except joint tours*

The more detailed comparisons in the Excel files show some differences between the model results and the expanded survey data (some due to small sample sizes for certain segments), but overall the model results reflect the observed data fairly well.

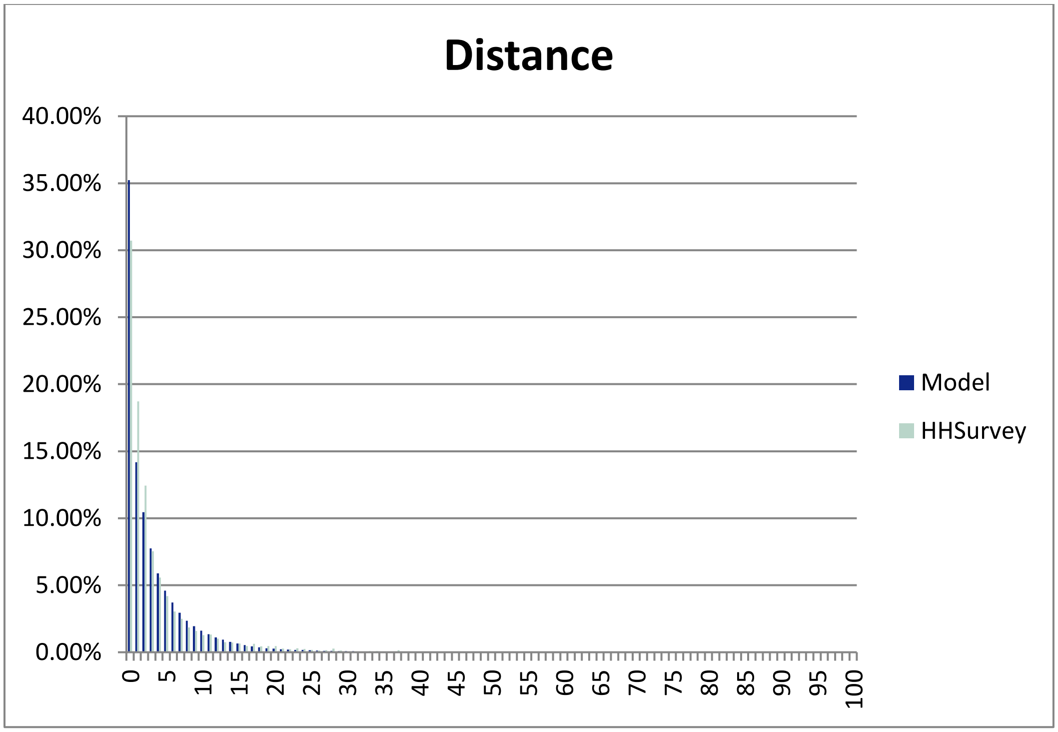
2.4 STOP/TRIP LEVEL CHOICE MODELS

Stop Destination Choice Models

The stop destination choice model simulates the locations of all intermediate stops between the home (or workplace, for work based subtours) and primary activity location on tours. The Excel file that summarizes the results of this model is *StopDestChoice.xlsm*.

Figure 2.5 presents a comparison between the observed (survey) and modeled trip length distance distributions. While there are some differences in the distributions, the fits are good; the coincidence ratio is 85 percent. The average trip distances are 4.1 miles (observed) and 4.4 miles (modeled).

Figure 2.5. Trip Length Frequency Distribution for Stops (miles)



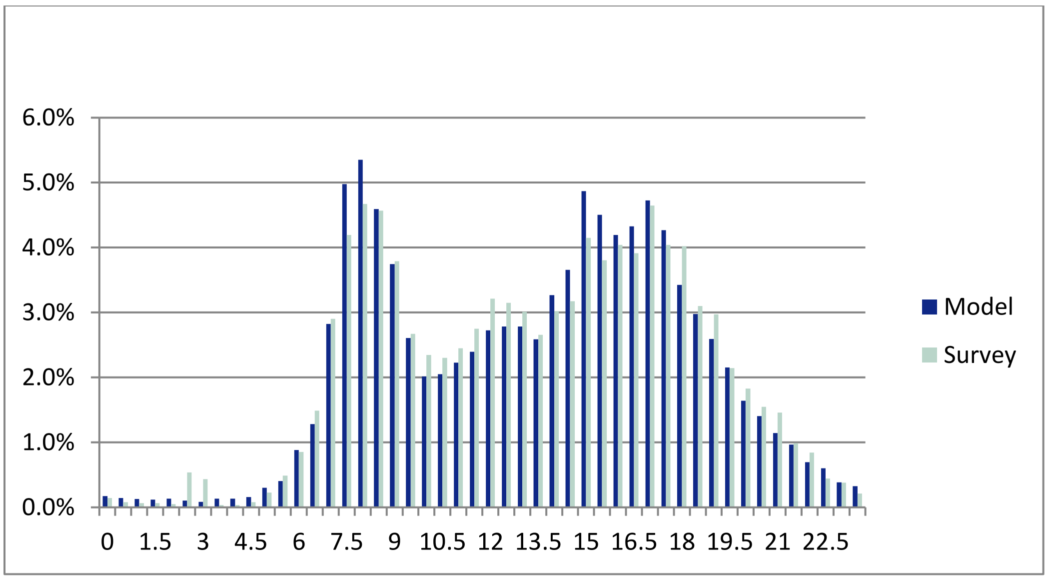
The spreadsheet file also provides comparisons between the observed data from the household survey and the model results for the average trip distances segmented by stop purpose, household income level, tour mode, area type at home and primary destination, and tour purpose. These comparisons show a good match, with 36 of the 54 segments having modeled trip lengths within one half mile of the observed trip length and 47 of the segments having modeled trip lengths within one mile of observed. The largest overestimates by the model are for two of the midrange area types and for school stops while the largest underestimates are for the rural area type and for work and university stops.

Stop Time of Day Choice Models

The stop time of day choice model simulates the times (at the half hour level) of all intermediate stops between the home (or workplace, for work based subtours) and primary activity location on tours. The Excel file that summarizes the results of this model (as well as the trip mode choice model, described in the next section) is *TripModeTODChoice.xlsm*.

Figure 2.6 presents a comparison between the observed (survey) and modeled stop time of day distributions. While there are some differences in the distributions, the fit is good. The spreadsheet file also compared the distributions by area type; these also show good fits.

Figure 2.6. Trip Length Frequency Distribution for Stops (miles)



Trip Mode Choice Model

The trip mode choice model simulates the mode for each trip that is part of a tour, conditional on the simulated tour mode. The Excel file *TripModeTODChoice.xlsm* also summarizes the results of the trip mode choice model. Following is a summary of trip mode shares by tour mode:

Drive alone:

- <u>Survey</u>: Drive alone – 99%, walk 1%
- <u>Model</u>: Drive alone – 98%, walk 2%

Tour mode shared ride 2:

- Survey: Drive alone – 30%, shared ride 2 – 68%, walk 2%
- Model: Drive alone – 31%, shared ride 2 – 67%, walk 2%

Tour mode shared ride 3+:

- Survey: Drive alone – 18%, shared ride 2 – 18%, shared ride 3+ – 62%, walk – 2%
- Model: Drive alone – 15%, shared ride 2 – 21%, shared ride 3+ – 63%, walk – 1%

Tour mode transit-walk access:

- Survey: Drive alone – 1%, shared ride 2 – 5%, shared ride 3+ – 3%, transit-walk access – 68%, walk – 23%, bike – 1%
- Model: Drive alone – 6%, shared ride 2 – 8%, shared ride 3+ – 4%, transit-walk access – 51%, walk – 29%, bike – 3%

Tour mode transit-auto access:

- Survey: Drive alone – 9%, shared ride 2 – 9%, shared ride 3+ – 5%, transit-walk access – 5%, transit-auto access – 65%, walk – 7%
- Model: Drive alone – 6%, shared ride 2 – 29%, shared ride 3+ – 18%, transit-walk access – 2%, transit-auto access – 39%, walk – 6%

Tour mode school bus:

- Survey: Shared ride 2 – 4%, shared ride 3+ – 6%, walk – 2%, school bus – 88%
- Model: Shared ride 2 – 5%, shared ride 3+ – 8%, walk – 3%, school bus – 84%

Note that by definition, all trips on walk and bicycle tours have the same trip mode as the tour mode.

The spreadsheet file also shows the following comparisons between survey and modeled trip mode shares:

- Area type at home (or workplace for work based subtours) and at the primary activity location
- Distance range
- Transit in-vehicle time ranges (walk access)
- Household size and income level
- Vehicles less than, equal to, or greater than number of workers/drivers
- Age and gender

In most cases, the mode shares from the model matched those from the survey data well.

3.0 Highway and Transit Assignment Validation

This chapter summarizes the validation checks of the highway and transit assignment components of the model. The assignment results presented in this chapter are based on a model application with three iterations of speed feedback.

3.1 HIGHWAY ASSIGNMENT

As noted earlier, the highway assignment procedures are essentially the same as those used by BMC in their previous trip based model. Validation checks previously used by BMC were therefore used for the validation of the highway assignment in the activity based model.

The highway assignment checks are as follows, with the table where each is summarized shown in parentheses. Generally, the model results compare well with the traffic counts.

- Comparisons of modeled and observed (from traffic counts) vehicle miles traveled (VMT) and volumes summarized by:
  - Roadway facility type (Table 3.1)
  - Area type (Table 3.2)
  - County (Table 3.3)

- Percentage root mean square error between model volumes and traffic counts summarized by:

Roadway facility type (
  - Table 3.4)
  - Volume level (Table 3.5)

- Comparisons of the sum of modeled volumes to the sum of traffic counts on screenlines and cutlines (Table 3.6)
- Comparisons of a.m. peak period modeled travel times and observed travel times from INRIX on major routes (Table 3.7)

There were various calibration changes associated with the highway network and assignment process. The major changes included the following:

- Capacity adjustments for surface street (facility type =3-5)
  - city fringe area (area type = 5): reduce capacity by 10%
  - center city (area type = 6,7): reduce capacity by 15%
  - core area (area type = 8,9) reduce capacity by 25%

- Free flow speed adjustment
    - o Surface street (facility type = 3-5): reduce free flow speed by 10%
    - o Freeway/expressway (facility type = 1,2): set free flow equal to speed limit + 7 mph

All of these changes were implemented in the Cube script file for highway assignment.

Table 3.1. Summary of Highway Assignment by Facility Type

Facility Type	Count VMT	Model VMT	% Diff.
Freeway	25,655,107	25,314,225	-1%
Primary Arterial	10,384,537	10,140,368	-2%
Minor Arterial	5,759,284	4,968,440	-14%
Collector	2,640,106	2,191,968	-17%
Other	530,916	508,105	-4%
All Links	44,969,950	43,123,105	-4%

Table 3.2. Summary of Highway Assignment by Area Type

Area Type	Count VMT	Model VMT	% Diff.
1	18,378,414	18,884,163	3%
2	13,121,387	11,933,541	-9%
3	10,630,732	9,738,524	-8%
4	3,259,251	3,003,833	-8%
5	846,451	845,260	0%
6	221,294	280,747	27%
7	371,774	391,593	5%
8	32,545	32,585	0%
9	71,672	81,490	14%
Total	46,933,520	45,191,736	-4%

Table 3.3. Summary of Highway Assignment by County

County	Count VMT	Model VMT	% Diff
Baltimore City	2,058,827	2,035,087	-1%
Baltimore County	8,710,124	8,174,492	-6%
Anne Arundel	5,801,220	5,387,089	-7%
Howard	3,747,683	3,652,752	-3%
Carroll	1,141,061	1,196,274	5%
Harford	1,616,272	1,432,657	-11%
Montgomery/Prince Georges/Frederick	22,173,958	21,400,605	-3%
D.C.	286,876	424,922	48%
Total	45,536,021	43,703,877	-4%

Table 3.4. Percentage Root Mean Square Error by Facility Type

Volume Group	% RMSE	R^2
Freeway	19.31	0.91
Primary Arterial	34.78	0.61
Minor Arterial	55.44	0.39
Collector	70.13	0.25
Other	78.24	0.37
All Links	38.34	

Table 3.5. Percentage Root Mean Square Error by Volume Group

Volume Group	% RMSE	R^2
0-5,000	111.75	0.07
5,000-10,000	49.95	0.07
10,000-25,000	34.11	0.34
25,000-50,000	26.02	0.44
50,000-100,000	15.06	0.75
>100,000	11.32	0.41
All Links	38.34	

Table 3.6. Screenline/Cutline Comparisons

Screenline	Sum of Counts	Sum of Model Volumes	Volume/ Count
1 - North CBD	173,714	184,192	1.06
2 - East CBD	228,350	290,188	1.27
3 - South CBD	224,937	262,354	1.17
4 - West CBD	155,371	145,673	0.94
5 - Patterson Park/East Baltimore	203,850	256,101	1.26
6 - North Of Liberty Heights Avenue	99,502	89,040	0.89
7 - East Of Jones Falls Expressway	223,419	247,499	1.11
8 - Harford Road	101,516	114,559	1.13
9 - South Of Monument	72,242	63,595	0.88
10 - North Baltimore City Line	341,157	293,625	0.86
11 - East Baltimore City Line	396,185	428,252	1.08
12 - South Baltimore City Line	545,816	557,657	1.02
13 - West Baltimore City Line	230,005	207,887	0.90
14 - Beltway (South)	415,663	376,877	0.91
15 - Beltway (Southwest)	488,223	519,402	1.06
16 - Beltway (Northwest)	363,001	330,152	0.91
17 - Beltway (North)	421,830	416,487	0.99
18 - Beltway (East)	497,201	483,649	0.97
19 - South Outer Cordon Line	289,247	276,681	0.96
20 - Southwest Outer Cordon Line	513,141	566,315	1.10
21 - West Outer Cordon Line	160,242	160,944	1.00
22 - Northwest Cordon Line	93,691	108,960	1.16
23 - North Outer Cordon Line	82,455	88,186	1.07
24 - Northeast Outer Cordon Line	261,828	273,799	1.05
25 - Towson Cordon	425,141	354,815	0.83
26 - Westminster Cordon	168,981	167,836	0.99
27 - Bel Air Cordon	252,350	210,988	0.84
28 - Columbia Cordon	525,201	479,098	0.91
29 - Mid-Howard County Screenline	518,171	491,970	0.95
30 - Annapolis Cordon	450,193	425,994	0.95
31 - MD 543-Harford County	189,828	178,973	0.94
32 - Anne Arundel Region Boundary	214,935	275,551	1.28
33 - Anne Arundel/Howard County Region Boundary	499,262	498,469	1.00
34 - Western Howard Region Boundary	32,344	61,600	1.90
35 - West Carroll Region Boundary	99,359	124,144	1.25
37 - North Frederick/Carroll Region Boundary	67,408	71,018	1.05
38 - North Baltimore County Region Boundary	61,424	63,359	1.03
39 - North Harford Region Boundary	24,752	25,941	1.05
40 - Northeast Region Boundary	118,640	121,290	1.02

Table 3.6. Screenline/Cutline Comparisons (continued)

Screenline	Sum of Counts	Sum of Model Volumes	Volume/ Count
41 - Annapolis Bay Bridge	73,412	75,551	1.03
42 - W of MD 3/I-97	312,871	277,322	0.89
43 - Howard/Anne Arundel County Line	402,540	413,707	1.03
44 - Howard/Carroll County Line	77,722	80,985	1.04
45 - Gwynns Falls West	316,437	340,834	1.08
46 - East of I-83/Baltimore County	394,821	304,076	0.77
47 - East of I-95/Baltimore County	265,284	231,561	0.87
48 - West of US 1/Harford County	123,740	108,406	0.88
49 - West of I-95/Harford County	182,551	164,209	0.90
50 - Harbor Crossings	240,248	176,284	0.73
51 - Expanded Region Boundary North Of I-495	137,568	140,743	1.02
52 - Potomac River Between Capital Beltway Crossings	828,900	833,474	1.01
53 - Expanded Region Boundary South of I-95	185,975	181,510	0.98
54 - East of MD 140/Baltimore County	300,573	271,051	0.90
55 - US 40 West Baltimore City	105,316	109,886	1.04
56 - Cold Spring Lane / Moravia Road	463,470	453,645	0.98
64 - Inner Washington	769,900	1,190,786	1.55
66 - Washington Beltway	1,638,065	1,720,779	1.05
68 - Outer Washington Region	1,617,919	1,518,148	0.94
72 - Rock Creek	489,417	530,320	1.08
75 - South of US 50	362,667	312,013	0.86
84 - East of I-95	474,027	492,226	1.04
85 - Montgomery/Frederick County Line	120,764	141,096	1.17

Table 3.7. Travel Time Comparisons (minutes) for A.M. Peak Period

			NB/EB/CW			SB/WB/CCW		
Roadway	**From/To**	**To/From**	**INRIX**	**Model**	**% Diff**	**INRIX**	**Model**	**% Diff**
I-83	PA Line	Shawan Rd (Hunt Valley)	15.9	14.2	-10.6%	19.6	23.3	18.5%
	Shawan Rd (in Hunt Valley)	I-695	5.7	7.1	25.5%	7.1	7.8	10.5%
	I-695	Downtown Baltimore (exit 1 Fayette St)	10.4	10.6	1.9%	11.5	12.3	7.3%
I-695	I-95 (in Rossville)	I-83	11.4	12.5	9.2%	15.8	15.6	-1.5%
	I-83	I-795	6.9	10.5	51.4%	6.5	9.2	42.5%
	I-795	I-70	5.2	7.3	40.2%	8.3	11.8	42.2%
	I-70	I-95	6.2	6.9	11.2%	7.8	9.9	27.1%
	I-95	I-97	12.1	6.6	-45.3%	11.8	5.4	-54.3%
	I-97	I-95 (Rossville)	20.9	25.7	23.0%	21.2	22.6	6.2%
I-795	MD 795 (in Reistertown)	MD 940 (Owings Mills)	4.5	4.6	3.3%	5.1	6.8	33.9%
	MD 940 (in Owings Mills)	I-695	3.6	3.5	-1.2%	4.8	5.5	14.1%
I-70	I-270 (in Frederick)	US 40	26.0	33.7	29.6%	25.0	24.4	-2.4%
	US 40	I-695 (Woodlawn)	11.2	13.7	22.2%	9.1	10.7	17.5%
I-95	Susquehanna River	I-695	23.4	24.7	5.6%	28.4	35.1	23.4%
	I-695	I-395	11.9	11.2	-5.6%	14.2	15.7	10.2%
	I-395	I-695 (Halethorpe)	3.5	4.4	24.6%	3.4	6.9	100.1%
	I-695 (in Halethorpe)	MD 32	9.9	13.2	33.2%	10.3	18.4	79.3%
	MD 32	I-495	12.0	17.7	47.4%	24.0	19.4	-19.3%
I-97	US 50	MD 32	6.1	13.4	120.1%	6.1	11.6	91.2%
	MD 32	I -695	9.5	14.3	50.7%	9.1	12.6	38.3%
I-195	Arbutus/I-95	BWI Airport	5.7	5.4	-5.0%	5.4	7.9	47.1%
I- 895	I-95/I-895 Split (Baltimore City)	I- 95 (Elkridge)	15.5	16.1	3.7%	16.2	21.3	31.3%
US 40	MD 24 (Edgewood)	I-695 (Rossville)	18.6	24.9	34.2%	17.8	28.5	60.3%
	I-695 (Rossville)	MD 2 (Downtown Baltimore)	15.3	11.8	-23.3%	14.5	15.5	7.6%
	MD 2 (Downtown Baltimore)	US 29 (Ellicott City)	19.5	28.3	44.9%	19.6	26.2	33.6%
US 1	MD 24 (Bel Air)	Honeygo Blvd	11.3	14.2	25.4%	11.2	15.0	34.1%
	Honeygo Blvd	I-695 (Overlea)	9.2	7.8	-15.6%	9.7	10.4	7.4%
	I-695 (Overlea)	I-83 (Downtown Baltimore)	17.2	17.2	0.1%	17.6	23.1	31.8%
	I-83 (Downtown Baltimore)	I-695 (Arbutus)	15.9	16.4	3.2%	13.2	18.4	39.3%
	I-695 (Arbutus)	MD 32	18.2	17.9	-1.7%	17.6	22.6	28.4%
MD 295	MLK Blvd (Downtown Baltimore)	I-695	6.3	6.7	6.7%	5.9	8.8	48.3%
	I-695	MD 32	9.8	11.2	14.8%	11.5	22.9	99.3%
	MD 32	I-95/I-495 (Greenbelt)	17.0	24.9	46.7%	16.0	18.1	12.9%
US 50	MD 2 (Annapolis)	I -97	5.3	2.3	-57.0%	4.9	2.6	-46.7%
	I -97	MD 3	7.0	8.6	23.5%	7.0	7.8	11.4%
	MD 3	I-95/I-495 (Greenbelt)	7.0	6.8	-3.4%	9.0	8.8	-1.7%

Table 3.7. Travel Time Comparisons (minutes) for A.M. Peak Period (continued)

			NB/EB/CW			SB/WB/CCW		
Roadway	**From/To**	**To/From**	**INRIX**	**Model**	**% Diff**	**INRIX**	**Model**	**% Diff**
MD 32	I -97/MD 3	I-95	15.0	20.4	36.0%	14.0	18.0	29.1%
	I-95	US 29	3.0	3.1	3.7%	3.9	4.4	11.0%
	US 29	MD 108	4.9	4.2	-13.5%	5.2	8.4	63.4%
	MD 108	I-70	10.0	13.3	16.0%	16.0	20.0	25.3%
	I-70	MD 26	10.0	11.6	16.4%	10.0	15.5	55.4%
MD 100	US 29	I -95	5.6	4.8	-13.8%	5.2	5.2	-1.1%
	I -95	I-97	8.0	12.4	55.4%	8.0	10.5	31.3%
	I-97	MD 177 (Annapolis)	8.6	9.5	10.9%	9.9	9.5	-3.7%
MD 10	MD 100	I-695	5.0	4.8	-3.9%	5.0	4.4	-11.3%
US 29	I -70	MD 175	6.3	5.0	-20.4%	6.2	10.2	65.3%
	MD 175	MD 216	5.8	9.6	63.5%	6.2	9.9	61.7%
	MD 216	I-95/I-495 (Greenbelt)	18.0	19.4	7.6%	32.0	27.1	-15.3%
MD 200	I-370	I-95	14.0	15.8	13.2%	15.0	16.5	9.9%
MD-129	Garrison Forest Rd (Owings Mills)	Northern Pkwy	17.4	18.9	8.7%	17.7	19.8	12.3%
	Northern Pkwy	MLK Blvd (Downtown Baltimore)	12.3	11.6	-5.4%	13.2	12.4	-5.9%
MD-26	MD-27 (Mt Airy)	I-695	28.1	23.0	-18.2%	30.0	28.2	-6.1%
	I-695	MD-140	11.4	13.8	21.2%	11.2	11.7	4.8%
MD-41	I-695	Cold Spring Ln (Baltimore)	6.6	8.3	25.0%	5.4	8.4	54.2%
MD-45	MD-138 (Monkton)	I-695	22.5	22.3	-1.1%	21.4	24.4	13.8%
	I-695	US 1 (Downtown Baltimore)	17.8	14.5	-18.3%	17.7	14.2	-20.0%
MD - 24	US 1	W. Ring Factory Road	3.0	3.5	16.2%	4.0	3.5	-12.3%
	W. Ring Factory Road	I-95	6.0	7.7	29.0%	6.0	8.6	43.2%
	I-95	US 40	3.0	2.5	-16.4%	3.0	3.0	-1.3%
MD - 140	Taneytown	MD 31	14.0	16.0	14.1%	14.0	18.9	34.7%
	MD 31	Malcolm Dr	5.0	5.0	-0.8%	4.0	4.8	19.6%
	Malcolm Dr	Reece Rd (Bethel Rd)	4.0	4.4	9.7%	4.0	4.4	10.7%
	Reece Rd	I-795	9.0	10.1	12.5%	9.0	13.6	51.1%

NB = northbound, EB = eastbound, CW= clockwise, SB = southbound, WB westbound, CCW = counterclockwise

3.2 TRANSIT ASSIGNMENT

As is the case with the highway assignment, the transit assignment process is the same with the new activity based model as it was with the previous trip based model, and so the validation checks are similar to those used in the trip based model validation. These checks are summarized in the Excel file *Transit_Assignment.xlsx*.

For the most part, the model results compare well with the ridership counts. While there are some notable differences, particularly for the Maryland Area Regional Commuter (MARC) rail service, the model results are closer to the counts than the previous trip based model. Some calibration changes were made to the mode choice model and the transit network, including a factor to reduce the attractiveness of high density areas for workplace location and some additional transit links added in the MWCOG region.

Transit boarding counts were available for 2011 and 2014 (the model base year is 2012). The 2014 counts take advantage of automatic passenger counter (APC) technology. There are some significant differences between the 2011 and 2014 data; it is unknown what portion of the difference is attributable to the change in passenger counting technology, as opposed to changes in the transit service provided, fares, auto operating costs, and demand patterns.

Another data source for transit assignment validation is the "2007 On Board Transit Survey - BMC Analysis." The on-board survey provides information on the number of transfers for transit trips and the access modes (walk or auto). The five year period between the on-board survey and the model base year means that there are unknown changes in transit rider behavior during that period that are not reflected in the model. These could be attributable to changes in the transit service provided, fares, auto operating costs, and demand patterns.

Table 3.8 shows the comparison of modeled transit boardings and observed boarding counts by service type. Comparisons to both the 2014 and 2011 boardings are shown (note that observed data for some categories are unavailable for some service types). Total modeled boardings over all services are within a few percent of the observed although there are larger differences by service types. Bus ridership is overestimated by the model (more so when the lower 2014 counts are used as the basis for comparison). Modeled MARC ridership is low, as is WMATA ridership. This may be partly due to the focus on the BMC region, since these services are used in large part by residents of the MWCOG region.

Table 3.8. Comparison of Modeled Boardings to Counts

	Modeled Boardings (2012)	2014 Counts	Difference	% Difference	%RMSE
All Bus	361,077	257,335	103,743	40%	66%
Total MTA Bus	299,356	242,304	57,052	24%	62%
MTA Radial Bus	157,250	142,882	14,368	10%	47%
MTA Circumferential Bus	81,322	57,741	23,581	41%	66%
MTA Feeder Bus	40,190	20,692	19,498	94%	156%
MTA Circulator	1,813	2,147	-333	-16%	40%
MTA Quick Bus	18,780	18,842	-62	0%	15%
Express Bus	10,400	1,180	9,220	782%	894%
MTA Rail	83,637	72,504	11,133	15%	21%
Baltimore MARC	12,207	28,563	-16,356	-57%	76%
Locally Operated Transit	51,322	13,851	37,470	271%	110%
WMATA	400,634	485,249	-84,615	-17%	77%
Total	**857,556**	**843,651**	**13,905**	**2%**	

	Modeled Boardings (2012)	2011 Counts	Difference	% Difference	%RMSE
Total MTA Bus	299,356	285,172	14,184	5%	62%
MTA Radial Bus	157,250	168,854	-11,604	-7%	51%
MTA Circumferential Bus	81,322	67,797	13,525	20%	59%
MTA Feeder Bus	40,190	24,648	15,542	63%	151%
MTA Circulator	1,813	2,393	-580	-24%	151%
MTA Quick Bus	18,780	21,480	-2,700	-13%	19%
Express Bus	10,400	1,490	8,910	598%	873%
MTA Rail	83,637	76,114	7,523	10%	17%
Baltimore MARC	12,207	25,468	-13,261	-52%	59%
Total	**405,600**	**388,244**	**17,356**	**4%**	

Table 3.9 shows the percentage of trips by number of transfers for three transit service types: MTA bus, rail (including light rail and Metro subway), and MARC commuter rail. In this table, the “target” percentages are derived from transit on-board survey data. The comparison shows a reasonably good match for bus and Rail, but the model overestimates the transfers for MARC.

Table 3.10 shows the percentage of linked transit trips and unlinked trips (boardings) by access mode and time of day for these same three service types. Overall, the modeled bus trips compare reasonably well to the survey targets. The rail comparison is a little off with too many linked trips and boardings, especially for walk access, in the peak period.

Table 3.9. Percentage of Transit Trips by Number of Transfers

% Trips by Number of Transfers	MTA Bus				Rail (LRT & Metro Subway)			
	Target	Model	Diff.	% Diff.	Target	Model	Diff.	% Diff.
0	66%	60%	-6%	-10%	44%	49%	5%	11%
1	28%	34%	5%	19%	36%	32%	-3%	-9%
2	5%	6%	1%	30%	16%	16%	-1%	-4%
3+	1%	0%	0%	-50%	4%	3%	-1%	-17%
Total	100%	100%	0%	0%	100%	100%	0%	0%
Transfer Ratio	1.40	1.47	0.07	5%	1.80	1.74	-0.07	-4%

% Trips by Number of Transfers	Commuter Rail (MARC)				Total			
	Target	Model	Diff.	% Diff.	Target	Model	Diff.	% Diff.
0	59%	16%	-43%	-72%	59%	55%	-4%	-7%
1	29%	36%	6%	21%	31%	34%	3%	10%
2	10%	28%	18%	172%	9%	9%	1%	10%
3+	1%	20%	19%	1311%	2%	2%	0%	14%
Total	100%	100%	0%	0%	100%	100%	0%	0%
Transfer Ratio	1.54	2.52	0.98	64%	1.53	1.59	0.05	4%

Table 3.10. Percentage of Boardings by Service Type by Time of Day and Access Mode

Time of Day	Access Mode		MTA Bus Target	MTA Bus Model	MTA Bus Diff	Rail (LRT & Metro Subway) Target	Rail (LRT & Metro Subway) Model	Rail (LRT & Metro Subway) Diff
Peak	Walk	Linked	39%	41%	2%	27%	36%	9%
		Boardings	39%	46%	7%	29%	39%	10%
		Transfer Ratio						
	Drive	Linked	11%	13%	2%	20%	20%	0%
		Boardings	10%	10%	0%	14%	17%	3%
		Transfer Ratio						
	Total	Linked	50%	54%	4%	46%	56%	10%
		Boardings	48%	55%	7%	43%	56%	13%
		Transfer Ratio						
Off-Peak	Walk	Linked	44%	38%	-7%	36%	30%	-7%
		Boardings	46%	39%	-7%	41%	31%	-10%
		Transfer Ratio						
	Drive	Linked	5%	8%	3%	17%	15%	-3%
		Boardings	5%	6%	0%	15%	12%	-3%
		Transfer Ratio						
	Total	Linked	50%	46%	-4%	54%	44%	-10%
		Boardings	52%	45%	-7%	57%	44%	-13%
		Transfer Ratio						
Total	Walk	Linked	84%	79%	-5%	63%	65%	2%
		Boardings	85%	85%	0%	70%	70%	0%
		Transfer Ratio						
	Drive	Linked	16%	21%	5%	37%	35%	-2%
		Boardings	15%	15%	0%	30%	30%	0%
		Transfer Ratio						
	Total	Linked	100%	100%	0%	100%	100%	0%
		Boardings	100%	100%	0%	100%	100%	0%
		Transfer Ratio						

Table 3.10. Percentage of Boardings by Service Type by Time of Day and Access Mode (continued)

Time of Day	Access Mode		MARC Commuter Rail			Total Transit		
			Target	Model	Diff	Target	Model	Diff
Peak	Walk	Linked	10%	24%	14%	33%	0	6%
		Boardings	11%	25%	14%	33%	0	10%
		Transfer Ratio				1.54	1.68	14%
	Drive	Linked	41%	50%	10%	16%	0	1%
		Boardings	38%	50%	12%	13%	0	-1%
		Transfer Ratio				1.30	1.15	-16%
	Total	Linked	51%	75%	24%	49%	1	6%
		Boardings	49%	75%	26%	47%	1	9%
		Transfer Ratio				1.46	1.52	6%
Off-Peak	Walk	Linked	13%	14%	1%	40%	0	-5%
		Boardings	17%	14%	-2%	42%	0	-6%
		Transfer Ratio				1.63	1.58	-5%
	Drive	Linked	36%	11%	-25%	11%	0	-1%
		Boardings	35%	11%	-24%	11%	0	-4%
		Transfer Ratio				1.55	1.13	-42%
	Total	Linked	49%	25%	-24%	51%	0	-6%
		Boardings	51%	25%	-26%	53%	0	-9%
		Transfer Ratio				1.61	1.48	-14%
Total	Walk	Linked	23%	39%	16%	73%	1	1%
		Boardings	27%	39%	12%	76%	1	5%
		Transfer Ratio				1.59	1.63	4%
	Drive	Linked	77%	61%	-16%	27%	0	-1%
		Boardings	73%	61%	-12%	24%	0	-5%
		Transfer Ratio				1.41	1.14	-26%
	Total	Linked	100%	100%	0%	100%	1	0%
		Boardings	100%	100%	0%	100%	1	0%
		Transfer Ratio				1.54	1.50	-4%

4.0 Sensitivity Testing and Temporal Validation

This chapter describes the results of the sensitivity testing and temporal validation that was performed for InSITE. This process consisted of three sensitivity tests and a "backcast" of the model from the base year of 2012 to a scenario representing the year 2000.

Sensitivity testing involves adjusting input variables in the model and observing the effects on forecasted travel. The following sensitivity tests were performed:

1. Aging Population
2. Brownfield Development
3. Capacity Increase

4.1 Aging Population Sensitivity Test

The assumption for this test was a 30 percent increase in one and two person households having at least one person in retirement age (65 or older). In effect, this was to reflect the impact of retiring post-war baby boomers on activities, travel, and mode usage. An implicit assumption in this test was that "70 is not the new 65," at least in terms of persons delaying retirement until 70. At the same time, since retirees can work, there will be work tours made by retired persons. Total regional population and employment were held at the same levels as the base conditions in order to investigate the sensitivity of various model components to the aging of the population.

The test was accomplished by revising the 2012 base year synthetic population to reflect the assumed change. Table 4.1 shows the distribution of population by age and person type for the validated base year scenario, and Table 4.2 shows the same distribution for the Aging Population scenario. Table 4.3 shows the percentage changes in population by age group and person type for the Aging Population scenario compared to the base scenario. As shown in Table 4.3, the 30 percent increase in one and two person households with at least one person in retirement age resulted in a 256,864, or 42 percent, increase in population in the 65 or older age category. There is a decrease in the number of workers, mainly full-time workers, of about seven percent.

Table 4.1. 2012 Base Scenario Population by Person Type and Age

	Age Range								
Person Type	**0-4**	**5-15**	**16-17**	**18-19**	**20-24**	**25-40**	**41-64**	**65+**	**Total**
Child age 0-4	338,642	0	0	0	0	0	0	0	338,642
Child age 5-15	0	733,350	0	0	0	0	0	0	733,350
Child age 16-17	0	0	113,420	37,553	0	0	0	0	150,973
Adult Student	0	0	0	64,269	154,052	53,842	14,158	3,795	290,116
Full Time Worker	0	0	0	28,768	154,552	926,336	1,120,351	91,163	2,321,170
Part Time Worker	0	0	0	43,516	58,143	75,458	119,935	45,434	342,486
Non-working Adult	0	0	0	16,704	19,953	137,265	435,853	0	609,775
Senior	0	0	0	0	0	0	0	469,125	469,125
Total	338,642	733,350	113,420	190,810	386,700	1,192,901	1,690,297	609,517	5,255,637

Table 4.2. Aging Population Scenario Population by Person Type and Age

	Age Range								
Person Type	**0-4**	**5-15**	**16-17**	**18-19**	**20-24**	**25-40**	**41-64**	**65+**	**Total**
Child age 0-4	339,902	0	0	0	0	0	0	0	339,902
Child age 5-15	0	732,338	0	0	0	0	0	0	732,338
Child age 16-17	0	0	110,772	40,160	0	0	0	0	150,932
Adult Student	0	0	0	67,905	151,638	52,618	11,733	5,469	289,363
Full Time Worker	0	0	0	30,037	158,677	917,797	931,498	114,783	2,152,792
Part Time Worker	0	0	0	42,788	57,898	73,858	105,622	58,417	338,583
Non-working Adult	0	0	0	17,501	19,577	135,749	390,098	0	562,925
Senior	0	0	0	0	0	0	0	687,712	687,712
Total	339,902	732,338	110,772	198,391	387,790	1,180,022	1,438,951	866,381	5,254,547

Table 4.3. Percent Change in Population by Person Type and Age – Aging Population vs. Base Scenario

	Age Range								
Person Type	**0-4**	**5-15**	**16-17**	**18-19**	**20-24**	**25-40**	**41-64**	**65+**	**Total**
Child age 0-4	0%	–	–	–	–	–	–	–	0%
Child age 5-15	–	0%	–	–	–	–	–	–	0%
Child age 16-17	–	–	-2%	7%	–	–	–	–	0%
Adult Student	–	–	–	6%	-2%	-2%	-17%	44%	0%
Full Time Worker	–	–	–	4%	3%	-1%	-17%	26%	-7%
Part Time Worker	–	–	–	-2%	0%	-2%	-12%	29%	-1%
Non-working Adult	–	–	–	5%	-2%	-1%	-10%	–	-8%
Senior	–	–	–	–	–	–	–	47%	47%
Total	0%	0%	-2%	4%	0%	-1%	-15%	42%	0%

Only 85 percent of the increase in the age 65 or older population was modeled to be in the senior (not employed) person type category; nine percent of the population increase remained as full-time workers, and five percent remained as part-time workers. Table 1.4 shows the distributions of the age 65 or older population and the total population by person type for the base and the Aging Population scenarios.

Table 4.4. Distributions of Age 65 or Older and Total Population by Person Type and Age

	Base Scenario		Aging Population	
Person Type	**65+**	**Total**	**65+**	**Total**
Child 1	0%	6%	0%	6%
Child 2	0%	14%	0%	14%
Child 3	0%	3%	0%	3%
Adult Student	1%	6%	1%	6%
Full Time Worker	15%	44%	13%	41%
Part Time Worker	7%	7%	7%	6%
Non-working Adult	0%	12%	0%	11%
Senior	77%	9%	79%	13%
Total	100%	100%	100%	100%

Regular Workplace

The changes in numbers of workers with and without regular workplaces appear to be logical for the aging population scenario. Overall, the numbers of workers with regular workplaces suggest that jobs (at employer locations) will be unfulfilled. This should show up in the numbers of work tours per employee.

There are only very small differences in the time and distance frequency distributions between home and regular workplaces between the base and Aging Population scenarios. This is illustrated at a gross level by the differences in the average times and distances to the regular workplace, as shown in Table 4.5. This is as expected since the number of people moving into 65+ age range is relatively small in comparison to total workers. While the number of full-time and part-time workers in the 65+ age range increases by about 27 percent, there is a net loss of only about 138,000 full-time and part-time workers, representing about 7 percent of the base work force. While the workplace location choices of workers by age range have not been summarized, it is doubtful that the distribution of regular places of work for seniors could be so different from other aged workers to cause a shift in the overall average times and distances.

Table 4.5. Average Times and Distances to Regular Workplaces, Base and Aging Population Scenarios

	Base Scenario			Aging Population			Percent Difference [(Aging-Model) /Model]	
Person Type	**Average Time**	**Average Distance**	**Workers with Usual Workplace**	**Average Time**	**Average Distance**	**Workers with Usual Workplace**	**Time**	**Distance**
Full Time Worker	22.7	12.6	2,145,440	22.7	12.6	1,990,052	-0.1%	0.0%
Part Time Worker	21.0	11.5	269,590	20.9	11.4	265,081	-0.2%	-0.3%
Total	22.5	12.4	2,415,030	22.5	12.4	2,255,133	-0.1%	-0.1%

While there are fewer full-time workers in the Aging Population scenario, the proportion without a regular workplace remains constant with that for the base scenario at 7.6 percent (see Table 4.6). For part-time workers, the proportion of workers without a regular workplace increases from 21.3 percent for the base scenario to 21.7 percent for the Aging Population scenario. Such a change appears to be logical and consistent with the increase in the proportion of part-time workers in the 65+ age range (the proportion increases from 13 percent for the base scenario to 17 percent for the Aging Population scenario).

Table 4.6. Workers with No Regular Workplace, Base and Aging Population Scenarios

	Base Scenario				Aging Population			
Person Type	No Regular Workplace	Have Regular Workplace	Total	Percent with No Regular Workplace	No Regular Workplace	Have Regular Workplace	Total	Percent with No Regular Workplace
Full Time Worker	175,730	2,145,440	2,321,170	7.6%	162,740	1,990,052	2,152,792	7.6%
Part Time Worker	72,896	269,590	342,486	21.3%	73,502	264,081	338,583	21.7%
Total	248,626	2,415,030	2,663,656	9.3%	236,242	2,255,133	2,491,375	9.5%

Since the regional employment in the Aging Population scenario was unchanged from the base scenario, the number of full-time and part-time workers per employee also decreases by the same percentage (about seven percent) as the overall number of workers, suggesting the following possibilities:

- Jobs going unfulfilled
- Workers working multiple jobs (as be measured, somewhat, by work tours/employee)
- Work tours by other person types (adult students or older children)
- Jobs being filled by casual employees (non-working adults and seniors not working on a regular full-time or part-time basis; these may be thought of as volunteer workers or irregular workers, say, working for a temporary agency)

Daily Activity Patterns

The overall changes in numbers of persons by person type making each type of daily activity pattern appear to be logical for the aging population scenario. In general, the percentages of daily activity patterns involving work decrease, and the numbers of travel patterns involving non-mandatory travel or stay at home activity patterns increase. At a more disaggregate level, some changes in daily activity patterns do not have a readily logical explanation. However, the illogical changes affect relatively few people/activity patterns.

Table 4.7 shows the distribution of daily activity patterns by person type for the base scenario. The distributions for the Aging Population scenario were almost identical to those for the base scenario.

Table 4.7. Proportions of Population by Daily Activity Pattern Type and Person Type – Base Scenario

Daily Activity Pattern Type	Percentage of Patterns by Person								
	Full-Time Worker	Part-Time Worker	Adult Student	Non-Working Adult	Senior	Child 1	Child 2	Child 3	Total
One Work Tour-No Stops	43%	22%	8%	0%	2%	0%	0%	3%	21%
One Work Tour-With Stops	33%	19%	6%	0%	2%	0%	0%	1%	16%
Two Work Tours-No Stops	2%	1%	0%	0%	0%	0%	0%	0%	1%
Two Work Tours, Stops On One	1%	1%	0%	0%	0%	0%	0%	0%	1%
Two Work Tours, Stops On Both	0%	0%	0%	0%	0%	0%	0%	0%	0%
One University & One Work Tour, No Stops	0%	1%	2%	0%	0%	0%	0%	0%	0%
One University & One Work Tour, Stops On Work Tour	0%	0%	1%	0%	0%	0%	0%	0%	0%
One School & One Work Tour, No Stops	0%	0%	0%	0%	0%	0%	0%	3%	0%
One School & One Work Tour, Stops On Work Tour	0%	0%	0%	0%	0%	0%	0%	0%	0%
One University Tour	0%	0%	37%	0%	0%	0%	0%	0%	2%
Two University Tours	0%	0%	2%	0%	0%	0%	0%	0%	0%
One School Tour	0%	0%	0%	0%	0%	41%	73%	69%	15%
Two School Tours	0%	0%	0%	0%	0%	0%	1%	1%	0%
Non-Mandatory Travel	11%	41%	28%	68%	57%	37%	16%	12%	27%
Stay At Home	9%	15%	17%	31%	39%	22%	10%	10%	16%
Total for All Patterns	100%	100%	100%	100%	100%	100%	100%	100%	100%

Table 4.8 shows the distribution by daily activity pattern for the total populations for the two scenarios for the BMC planning region, the MWCOG planning region, and the entire model region. The Aging Population scenario shows slight decreases in the proportions of persons with daily activity patterns including one work tour and slight increases in the population proportions with non-mandatory and stay at home daily activity patterns. This is as expected for an aging population.

Table 4.8. Proportions of Total Populations by Daily Activity Pattern Type by Region

Daily Activity Pattern Type	BMC Region		MWCOG Region		Model Region	
	Base	Aging Population	Base	Aging Population	Base	Aging Population
One Work Tour-No Stops	21%	20%	21%	20%	21%	20%
One Work Tour-With Stops	16%	15%	16%	15%	16%	15%
Two Work Tours-No Stops	1%	1%	1%	1%	1%	1%
Two Work Tours-Stops On One	1%	1%	1%	1%	1%	1%
Two Work Tours-Stops On Both	0%	0%	0%	0%	0%	0%
One University & One Work Tour-No Stops	0%	0%	0%	0%	0%	0%
One University & One Work Tour-Stops On Work Tour	0%	0%	0%	0%	0%	0%
One School & One Work Tour-No Stops	0%	0%	0%	0%	0%	0%
One School & One Work Tour- Stops On Work Tour	0%	0%	0%	0%	0%	0%
One University Tour	2%	2%	2%	2%	2%	2%
Two University Tours	0%	0%	0%	0%	0%	0%
One School Tour	15%	15%	15%	15%	15%	15%
Two School Tours	0%	0%	0%	0%	0%	0%
Non-Mandatory Travel	28%	29%	27%	28%	27%	29%
Stay At Home	16%	17%	16%	17%	16%	17%
Total	100%	100%	100%	100%	100%	100%

Table 4.9 shows the percent changes in numbers of people by person type making each type of daily activity pattern. The total line in Table 4.9 shows the percent changes in numbers of people by person type for the two scenarios in order to provide a basis for the changes in population by type of daily activity pattern. The changes in persons by modeled daily activity pattern type are not constant over daily activity pattern types. This is as expected since other socioeconomic and demographic characteristics affect the types of daily activity patterns made by the population. Overall, there is a six to seven percent decrease in the number of daily activity patterns that include work tours. While there are large increases in the number of daily activity patterns with work tours by seniors, work tours made by seniors are for volunteer or "casual" work, not regular full- or part-time work.

Table 4.9. Percent Change in Numbers of Persons Making Daily Activity Patterns

Daily Activity Pattern Type	Percent Change [(Aging-Validation)/Validation]								
	Full-Time Worker	Part-Time Worker	Adult Student	Non-Working Adult	Senior	Child 1	Child 2	Child 3	Total
One Work Tour, No Stops	-6.8%	-2.1%	0.9%	-8.1%	49.1%			2.0%	-5.8%
One Work Tour, With Stops	-7.6%	-1.0%	-0.4%	0.7%	51.4%			3.2%	-6.4%
Two Work Tours, No Stops	-6.7%	-1.1%							-6.4%
Two Work Tours, Stops On One	-7.2%	0.2%							-6.6%
Two Work Tours, Stops On Both	-7.2%	-7.7%							-7.3%
One University & One Work Tour, No Stops	-1.3%	-1.0%	-0.1%						-0.7%
One University & One Work Tour, Stops On Work Tour	-3.2%	-12.0%	-1.6%						-2.8%
One School & One Work Tour, No Stops								0.5%	0.5%
One School & One Work Tour, Stops On Work Tour								-11.1%	-11.1%
One University Tour	-2.2%	9.1%	0.1%	7.6%	50.1%				0.2%
Two University Tours			-0.3%						-0.3%
One School Tour						-0.7%	0.1%	0.0%	0.0%
Two School Tours							4.2%	3.1%	4.0%
Non-Mandatory Travel	-8.3%	-0.7%	-0.6%	-7.6%	48.9%	1.9%	-0.3%	-2.2%	5.5%
Stay At Home	-7.3%	-1.2%	-0.9%	-7.9%	42.8%	-0.2%	-2.3%	1.1%	5.2%
Total Population Change	-7.3%	-1.1%	-0.3%	-7.7%	46.6%	0.37%	-0.14%	-0.03%	-0.02%

Table 4.10 shows the relative changes in daily activity patterns by person type. The values in Table 4.10 effectively divide the percent changes in daily activity patterns by type within each person type shown in Table 4.9 by the change in the numbers of persons by type. Only results for full-time workers, part-time workers, non-working adults and seniors are shown since those person types had the greatest changes due to the aging population.

Many of the changes in Table 4.10 seem logical. Values in the range of, say, 0.9 to 1.1 show modest responses to the changes caused by the aging population. Although they generally affected only small numbers of daily activity patterns by type (see Table 4.6), some of the changes suggested overly large or illogical sensitivities to the aging population. For example:

- Each one percent change in part-time workers resulted in a 6.75 percent change in two work tours with stops on both tours.
- Each one percent change in part-time workers resulted in an 8.01 percent change in one university tour daily activity patterns, in the *opposite direction*.

Table 4.10. Ratio of Changes in Daily Activity Patterns by Type to Changes in Person Types

Daily Activity Pattern Type	Ratios of Changes (Percent Change in Daily Activity Patterns by Person Type / Percent Change in Persons by Person Type)[1]			
	Full-Time Worker	Part-Time Worker	Non-Working Adult	Senior
One Work Tour, No Stops	0.94	1.87	1.05	1.05
One Work Tour, With Stops	1.05	0.85	-0.09	1.10
Two Work Tours, No Stops	0.93	1.00	–	–
Two Work Tours, Stops On One	1.00	-0.15	–	–
Two Work Tours, Stops On Both	1.00	6.75	–	–
One University & One Work Tour, No Stops	0.17	0.88	–	–
One University & One Work Tour, Stops On Work Tour	0.45	10.53	–	–
One School & One Work Tour, No Stops	–	–	–	–
One School & One Work Tour, Stops On Work Tour	–	–	–	–
One University Tour	0.31	-8.01	-0.99	1.07
Two University Tours	–	–	–	–
One School Tour	–	–	–	–
Two School Tours	–	–	–	–
Non-Mandatory Travel	1.14	0.59	0.99	1.05
Stay At Home	1.01	1.04	1.02	0.92

[1] Highlighted cells show daily activity patterns with more than two percent or more of the population for that person type.

Tour Destination Choice

It is useful to review the process used to get to work tour destination choice prior to reviewing these results. The first step in the process, regular workplace, determines whether a worker has a regular work location. This determination is made only for full- and part-time workers. Other types of persons (non-working adults, seniors, adult students, and child type 3) can, in fact, work, but have no regular work locations. The regular workplace model also uses a choice model to assign regular work locations for full- and part-time workers with regular work locations.

The daily activity pattern model determines whether a person makes one or more work tours on the travel day. These choices are made for all person types who may, in fact, work on a given day: full- and part-time workers, non-working adults, seniors, adult students, and child type 3.

Finally, the work tour destination choice model determines the actual destination location for each home-based work tour. For full- and part-time workers, the work tour destinations are likely to be the regular places of work for those workers with a regular places of work, but the destinations may be to locations other than the regular work locations.

Summaries of individual non-mandatory tours are also summarized in this section since the population moved into the senior category makes those types of tours.

The overall changes in the numbers of work tours by person type and the average work tour durations and distances for the Aging Population scenario are reasonable in comparison to the base scenario. The results suggest that some employment in the region is filled by casual (and volunteer) employees rather than full- or part-time workers. However, the results also suggest that slightly over five percent of the jobs in the BMC region will not be filled by workers.

Likewise, the changes in numbers, durations, and distances of individual non-mandatory tours for the Aging Population scenario are reasonable in comparison to the base scenario and suggest that overall vehicle-miles of travel in the region for the Aging Population scenario should decrease slightly from the base scenario.

Table 4.11 summarizes the numbers of work tours by person type for the base and Aging Population scenarios and Table 4.12 summarizes the individual non-mandatory tours by person type. The changes shown in Table 4.11 and Table 4.12 are reflective of the changes in population for the population in the full-time worker, part-time worker, and senior person type categories. The changes in work tours for non-working adults (albeit, very few actual tours), adult students, and child 3 reflect a propensity for populations those person types to have higher probabilities of making work tours as household characteristics change with the Aging Population scenario. The change in individual non-mandatory tours for non-working adults reflects the change in population for that person type.

Table 4.11. Work Tours by Person Type

	Percentage Change in Population	Number of Work Tours			Percentage of Work Tours	
Person Type	**(Aging vs. Base)**	**Base**	**Aging Population**	**Percentage Difference**	**Base**	**Aging Population**
Full-Time Worker	-7.3%	1,902,170	1,769,696	-7.0%	89.6%	88.2%
Part-Time Worker	-1.1%	153,595	152,467	-0.7%	7.2%	7.6%
Senior	46.6%	16,582	25,394	53.1%	0.8%	1.3%
Non-Working Adult	-7.7%	911	963	5.7%	0.0%	0.0%
Adult Student	-0.3%	40,251	47,126	17.1%	1.9%	2.3%
Child 3	0.0%	10,125	11,234	11.0%	0.5%	0.6%
Child 2	-0.1%	–	–	–	–	–
Child 1	0.4%	–	–	–	–	–
Total	0.0%	2,123,634	2,006,880	-5.5%	100.0%	100.0%

Table 4.12. Individual Non-Mandatory Tours by Person Type

Person Type	Percentage Change in Population (Aging vs. Base)	Individual Non-Mandatory Tours: Base	Individual Non-Mandatory Tours: Aging Population	Individual Non-Mandatory Tours: Percentage Difference	Percentage of INM Tours: Base	Percentage of INM Tours: Aging Population
Full-Time Worker	-7.3%	706,777	654,824	-7.4%	34.2%	30.6%
Part-Time Worker	-1.1%	218,669	215,502	-1.4%	10.6%	10.1%
Senior	46.6%	349,098	513,909	47.2%	16.9%	24.0%
Non-Working Adult	-7.7%	438,194	402,409	-8.2%	21.2%	18.8%
Adult Student	-0.3%	127,305	126,946	-0.3%	6.2%	5.9%
Child 3	0.0%	34,343	34,538	0.6%	1.7%	1.6%
Child 2	-0.1%	109,552	109,981	0.4%	5.3%	5.1%
Child 1	0.4%	82,846	83,058	0.3%	4.0%	3.9%
Total	0.0%	2,066,784	2,141,167	3.6%	100.0%	100.0%

Work tour length frequency distributions for the Aging Population scenario are almost identical to those for the base scenario. The coincidence ratios for the differences between the distributions for the two scenarios for all work tours were 1.0 for time and 0.99 for distance. The individual non-mandatory tour length frequency distributions for the Aging Population scenario are also almost identical to those for the base scenario, with coincidence ratios of 0.99 for both time and distance.

Table 4.13 summarizes the average work tour trip durations and distances (from home to work location) for the different person types. InSITE shows very little change in average durations and distances between the two scenarios for full- and part-time workers. That result should be expected since those person types are modeled to have regular work locations. Conversely, average durations and distances change more substantially for other person types with the average durations and distances in the Aging Population scenario increasing over those for the base scenario for seniors and decreasing for the other person types (the large decrease in the averages for the non-working adults is probably impacted by the low number of people in that category actually making work tours). Overall, the changes in durations and distances for the non-worker person types offset so that there is a three percent decrease in duration and four percent decrease in distance.

The changes in average durations and distances for seniors suggest that they have to travel slightly farther for work if they are casual workers or volunteers. In the Aging Population scenario, some of the additional 65 or older population was assumed to continue to be full- or part-time workers. Changes in their average work tour durations and distances would be expected to mirror those shown for all full- and part-time workers in Table 4.13.

Table 4.13. Average Work Tour Times and Distances

	Average Time			Average Distance		
Person Type	**Base**	**Aging Population**	**Percentage Difference**	**Base**	**Aging Population**	**Percentage Difference**
Full-Time Worker	20.8	20.7	0.0%	11.1	11.0	-0.2%
Part-Time Worker	17.2	17.2	-0.3%	8.8	8.7	-0.5%
Senior	15.3	15.7	2.7%	7.3	7.5	2.9%
Non-Working Adult	15.4	13.8	-10.4%	7.3	6.3	-14.5%
Adult Student	15.6	14.7	-5.4%	7.1	6.6	-7.1%
Child 3	17.8	17.3	-2.9%	8.8	8.4	-4.3%
Child 2	–	–	–	–	–	–
Child 1	–	–	–	–	–	–
Total	20.3	20.2	-0.5%	10.8	10.7	-0.7%

Table 4.14 summarizes the average individual non-mandatory tour trip durations and distances for the different person types. InSITE shows very little change in average durations and distances for all person types except seniors, who show increases in average durations and distances of almost three percent for the Aging Population scenario. The increase in the average durations and distances for seniors is probably reflective of the home locations for the additional senior population.

Table 4.14. Average Individual Non-Mandatory Tour Times and Distances

	Average Time			Average Distance		
Person Type	**Base**	**Aging Population**	**Percentage Difference**	**Base**	**Aging Population**	**Percentage Difference**
Full-Time Worker	11.9	12.0	0.5%	5.6	5.6	0.5%
Part-Time Worker	11.8	11.9	0.5%	5.6	5.6	0.7%
Senior	12.3	12.7	2.8%	5.9	6.1	2.7%
Non-Working Adult	12.5	12.4	-0.3%	5.8	5.8	-0.3%
Adult Student	11.4	11.4	0.0%	5.1	5.1	-0.5%
Child 3	10.0	9.9	-1.0%	4.5	4.5	-0.7%
Child 2	10.2	10.2	-0.2%	4.6	4.7	0.0%
Child 1	10.1	10.1	0.0%	4.5	4.5	0.2%
Total	11.9	12.0	1.0%	5.5	5.6	1.2%

As shown in Table 4.13 and Table 4.14, overall durations and distances decrease for work tours and increase for individual non-mandatory tours. The offsetting changes in distances results in an overall decrease of about 295,000 one-way person-miles (home to non-home location) for the Aging Population scenario compared to the base scenario. This combined decrease is about 0.6 percent of the combined 2012 person-miles for the two purposes.

A key concern regarding the Aging Population scenario results is the decrease in workers available to fill jobs. As shown in Table 4.15, the Aging Population scenario shows a 5.5 percent decrease in the numbers of work tours per employee, suggesting a deficit in the numbers of workers and work tours to fill the jobs available. Based on Table 4.13, work tours made by full- and part-time workers decreased from 2,055,765 in the base scenario to 1,922,163 in the Aging Population scenario. This 6.5 percent decrease in full- and part-time work tours was only partially offset by additional work tours made by senior, non-working adult, adult student, and child 3 populations.

Decreases in work tours are larger outlying counties than in Baltimore City and Baltimore County. This suggests that the outlying counties may "suffer" more in their attempts to fill available jobs. The number of work tours per employee is extremely low in Washington, D.C. This is due to the model region's boundary being the Potomac River, meaning that workers from Virginia who also fill jobs in Washington are not considered.

Table 4.15. Work Tours per Employee by County of Employment

	Work Tours				Work Tours per Employee	
Destination County	**Base**	**Aging Population**	**Percentage Change**	**Employment**	**Base**	**Aging Population**
Baltimore City	228,891	221,204	-3.4%	348,098	0.66	0.64
Baltimore County	337,759	322,710	-4.5%	453,658	0.74	0.71
Anne Arundel County	224,311	210,057	-6.4%	330,686	0.68	0.64
Howard County	137,025	127,584	-6.9%	187,341	0.73	0.68
Carroll County	44,197	41,382	-6.4%	71,688	0.62	0.58
Harford County	78,951	72,905	-7.7%	109,122	0.72	0.67
Total BMC Region	1,051,134	995,842	-5.3%	1,500,593	0.70	0.66
Montgomery/Prince George's/Frederick Counties	751,693	705,707	-6.1%	969,243	0.78	0.73
Washington, D.C.	320,807	305,331	-4.8%	718,184	0.45	0.43
Total	2,123,634	2,006,880	-5.5%	3,188,020	0.67	0.63

Tour Time of Day

While there are fewer work tours, the overall arrival times at workplaces and departure times from workplaces and the average durations spent at workplaces for the Aging Population scenario are very similar to those for the base scenario. However, the increase in population aged 65 or over in the Aging Population scenario produces some substantial changes both in the absolute and relative distributions of non-mandatory tours by time of day. More arrivals and departures at the non-mandatory destination occur during the mid-a.m. to late p.m. time periods (7:30 a.m. to 7:00 p.m.) for the Aging Population scenario than for the base scenario while there are fewer arrivals and departure at the non-mandatory destinations during the other time periods. The increases in non-mandatory travel are greatest in the midday time period (9:30 a.m. to 3:00 p.m.).

The impact of the aging population on work and non-mandatory travel and activities by time of day are as expected.

Impact on work tour arrivals and departures by time-of-day

Figure 4.1 shows diurnal distributions of work tours by arrival time at the workplace. As expected, the numbers of work tours by time period for the Aging Population scenario are less than for the base scenario for all time periods. The percentage distributions of total daily trips arriving at the workplace by time period for the Aging Population scenario and the base scenario are almost identical.

Figure 4.1. Trip Length Frequency Distribution for Stops (miles)

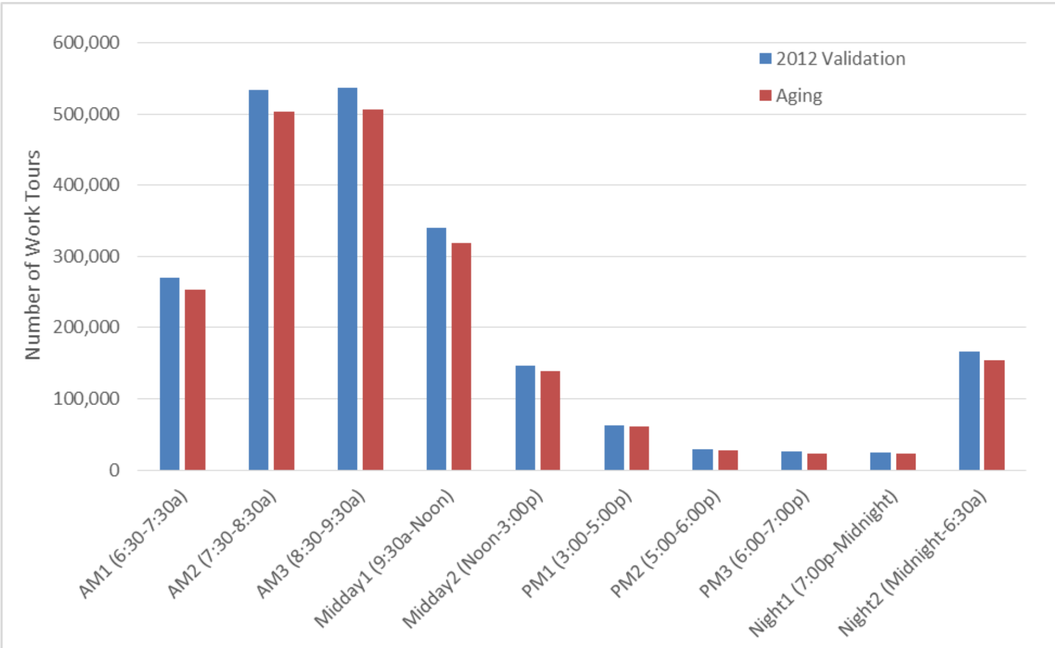


Figure 4.2 shows the percent changes of the Aging Population scenario work tours from the base scenario by arrival time period (i.e. [(Aging Population – base scenario)/base scenario]). The change in work tours for the entire day, -6.1 percent, is also shown for reference. Values above the -6.1 percent reference line mean that relatively more arrivals occurred during the time period for the Aging Population scenario than for the base scenario. This figure, in effect, magnifies the differences in the diurnal distributions. Nevertheless, the major differences occur for time periods where there were relatively few arrivals.

Figure 4.3 and Figure 4.4 show the same information as Figure 4.1 and Figure 4.2 except for work tour departure times from the workplace. The results of the departures parallel those for the arrivals:

Figure 4.2. Percent Change from Base Scenario by Arrival Time Period

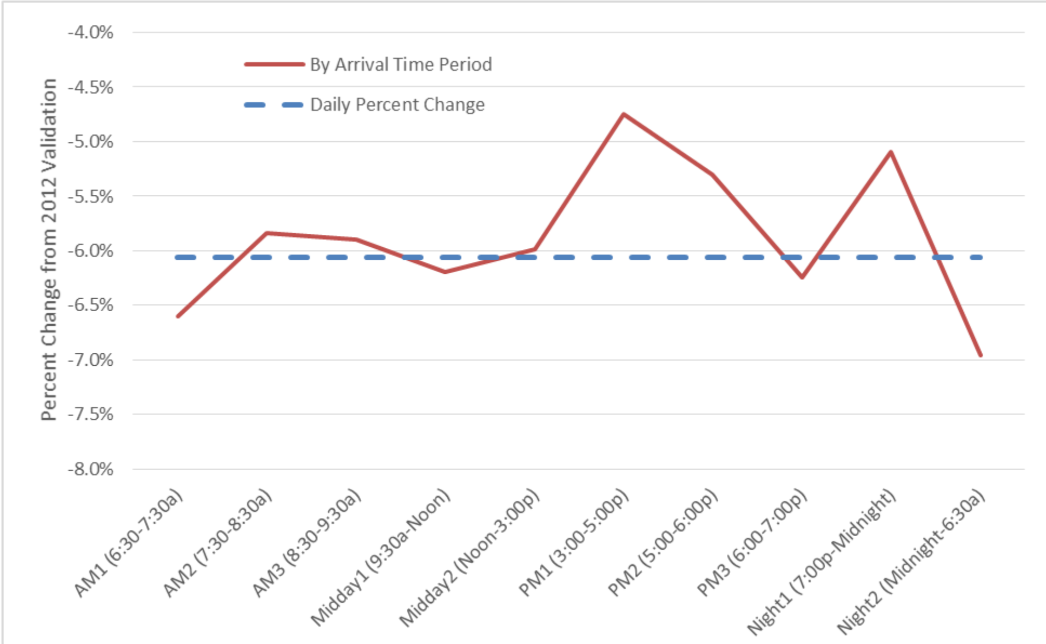


Figure 4.3. Work Tours by Departure Time from Workplace

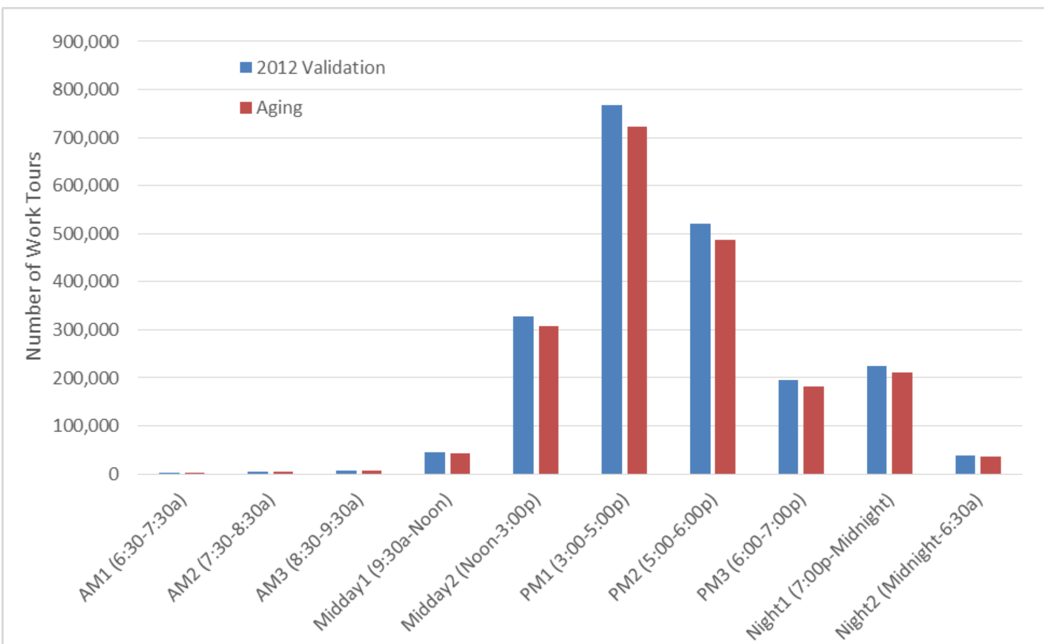
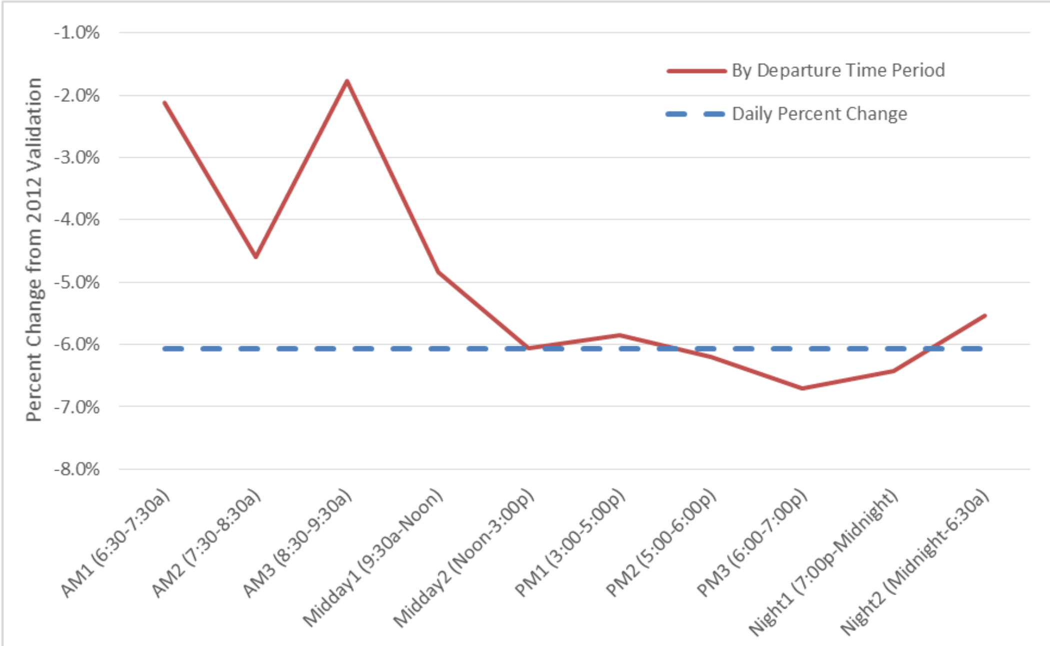


Figure 4.4. Percentage Change from Base Scenario by Departure Time Period



- The percentage distributions of total daily trips departing from the workplace by time period for the Aging Population scenario and the base scenario are almost identical.
- The major differences from the -6.1 percent daily decrease in work tours for the Aging Population scenario occur for time periods where there were relatively few departures.

Overall, there is little change in the diurnal distributions of work tour arrivals or departures for the Aging Population scenario in comparison to the base scenario.

While there is little change in the diurnal distributions of work tour arrivals or departures for the Aging Population scenario in comparison to the base scenario, durations of time at work can vary. Table 4.16 shows the numbers of work tours and their average work durations by person type. Overall, there is very little change in average work durations for any of the person types except for non-working adults. The non-working adults comprise a very small portion of the persons making work tours; the relatively large difference in duration has very little impact on overall average hours worked.

Table 4.16. Work Duration by Person Type

Person Type	Base Average Duration (Hours)	Base Count	Aging Population Average Duration (Hours)	Aging Population Count	Percent Difference Aging Population - Base
Full-Time Worker	7.64	1,905,311	7.64	1,769,696	0.0%
Part-Time Worker	6.00	154,963	5.99	152,467	-0.2%
Senior	5.79	16,918	5.78	25,394	-0.3%
Adult Student	6.11	47,009	6.11	47,126	0.0%
Non-Working Adult	1.77	1,005	2.02	963	14.2%
Child 3	4.90	11,147	4.97	11,234	1.4%
Child 2	–	–	–	–	–
Child 1	–	–	–	–	–
Total	7.46	2,136,353	7.44	2,006,880	-0.2%

Figure 4.5 shows diurnal distributions of non-mandatory tours by arrival time at the destination location for the non-mandatory tour. The numbers of non-mandatory tours by time period for the Aging Population scenario are greater than for the base scenario for the AM2 through PM2 time periods. For the early morning, late evening, and night time periods, non-mandatory tour arrivals are lower for the Aging Population scenario than for the base scenario. These patterns are as might be expected with an aging population.

Figure 4.6 shows the percent changes of the Aging Population scenario non-mandatory tours from the base scenario by arrival time period (i.e. [(Aging Population – base scenario)/base scenario]). The change in non-mandatory tours for the entire day, 3.6 percent, is also shown for reference. Values above the 3.6 percent reference line mean that relatively more arrivals occurred during the time period for the Aging Population scenario than for the base scenario. This figure, in effect, magnifies the differences in the diurnal distributions. The major differences occur for time periods where there are substantial arrivals suggesting an increase in travel in the late morning through early evening time periods.

Figure 4.5. Non-Mandatory Tours by Arrival Time at Destination

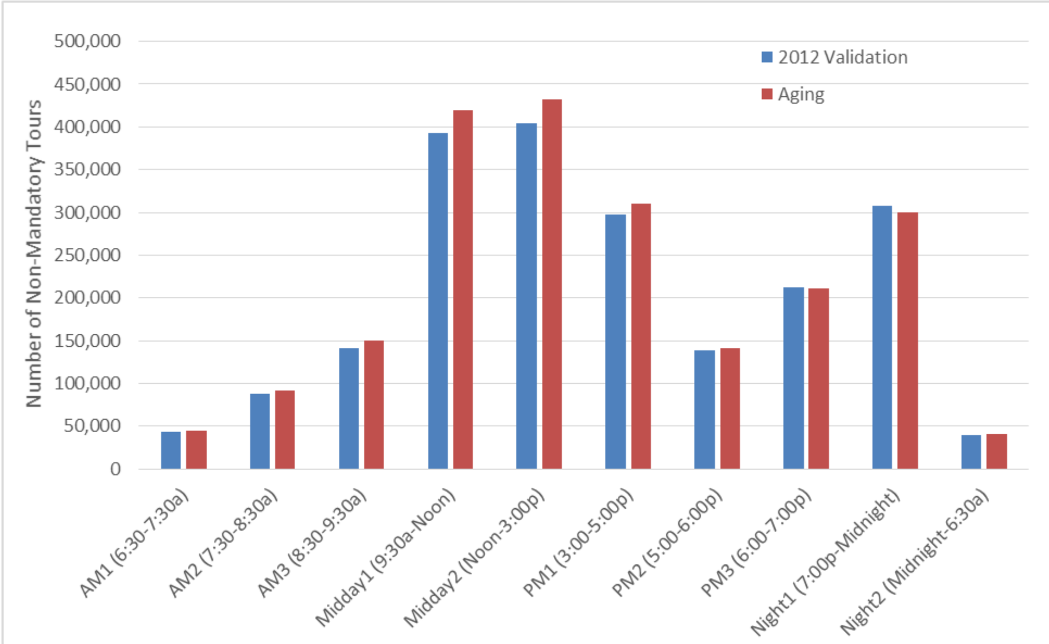


Figure 4.6. Percent Change from Base Scenario by Arrival Time Period

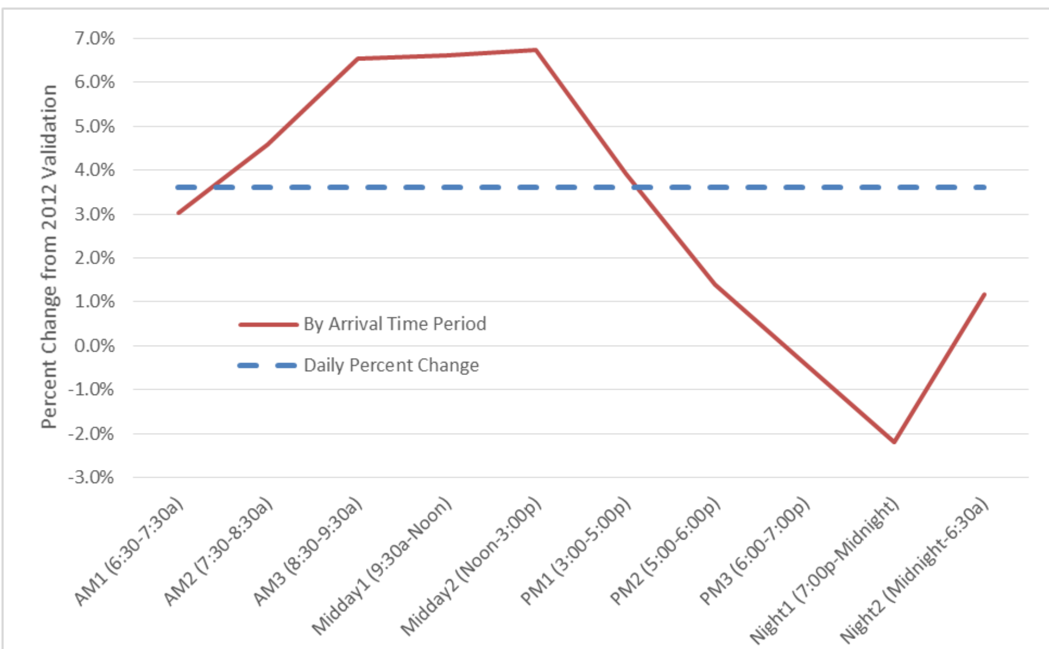


Figure 4.7 and Figure 4.8 show the same information as Figure 4.5 and Figure 4.6 except for non-mandatory tour departure times from the non-mandatory tour destination. The results of the departures parallel those for the arrivals:

- The percentage distributions of total daily trips departing from the non-mandatory destination by time period for the Aging Population scenario are greater than for the base scenario for the mid morning through late evening time periods, and lower for the early morning and night time periods.
- The major differences from the 3.6 percent daily increase in non-mandatory tours for the Aging Population scenario occur for time periods where there are substantial numbers of departures.

Overall, the Aging Population scenario has a substantial impact on the diurnal distributions of non-mandatory tours by time of day.

Figure 4.7. Non-Mandatory Tours by Departure Time from Destination

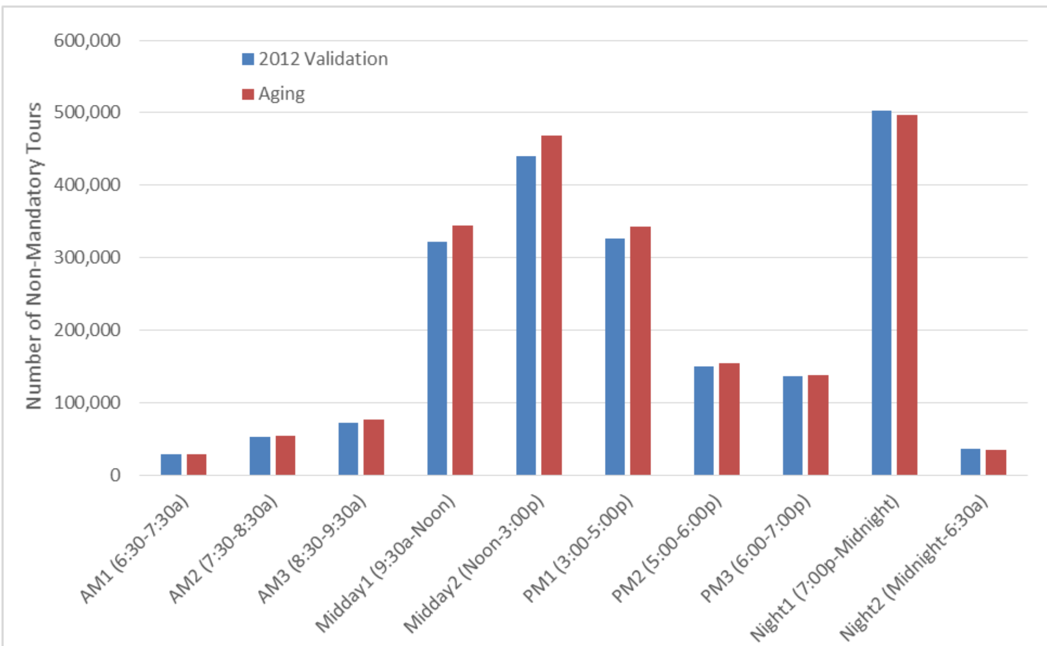
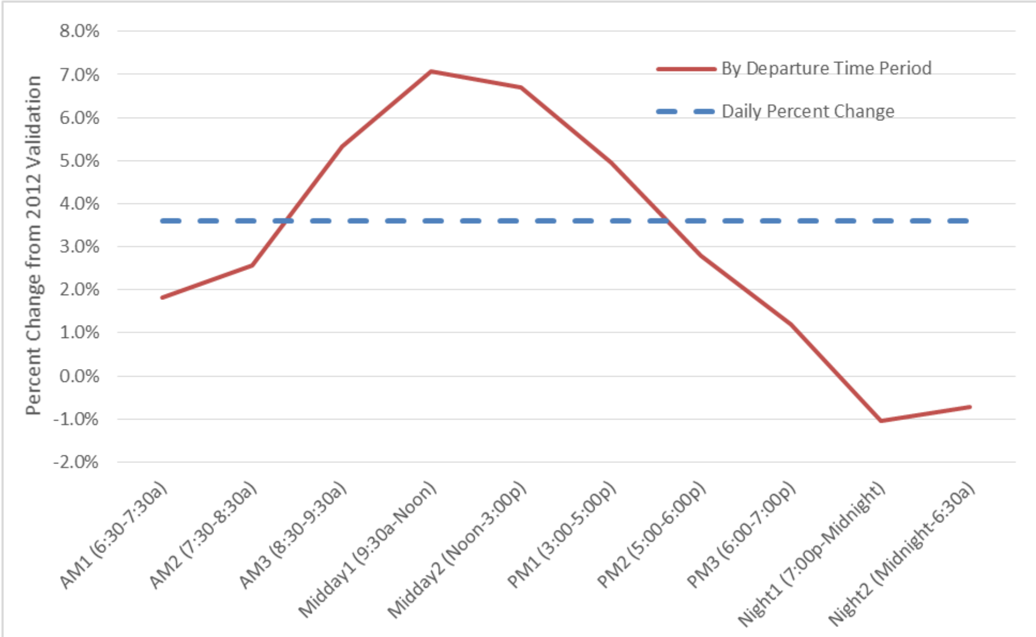


Figure 4.8. Percent Change from Base Scenario by Departure Time Period



While there are some substantial changes in the diurnal distributions of non-mandatory tour arrivals and departures for the Aging Population scenario in comparison to the base scenario, durations of time at the non-mandatory destination remain relatively stable by person type. Table 4.17 shows the numbers of non-mandatory tours and their average durations by person type. Overall, there is very little change in average durations for any of the person types except for Child Type 3. However, the absolute change is a decrease of 0.02 hours, or 1.2 minutes, in the duration spent at the non-mandatory destination by Child Type 3.

Table 4.17. Activity Duration by Person Type

	Base		Aging Population		
Person Type	**Average Duration (Hours)**	**Count**	**Average Duration (Hours)**	**Count**	**Percent Difference in Aging Population Non-Mandatory Activity Duration from Base**
Full-Time Worker	1.03	706,777	1.03	654,824	-0.1%
Part-Time Worker	1.06	218,669	1.06	215,502	0.3%
Senior	1.28	349,098	1.27	513,909	-0.7%
Adult Student	1.51	127,305	1.52	126,946	0.7%
Non-Working Adult	1.35	438,194	1.34	402,409	-0.8%
Child 3	1.69	34,343	1.67	34,538	-1.6%
Child 2	1.65	109,552	1.65	109,981	–
Child 1	–	–	–	–	–
Total	1.23	1,983,938	1.23	2,058,109	0.2%

Tour Mode Choice

The increase in age 65 or older population had relatively little impact on tour mode shares. The increase in non-mandatory trips for the Aging Population scenario produced a small increase in non-mandatory transit tours. However, the increase in non-mandatory transit tours for the Aging Population scenario did not offset the loss in work transit tours resulting from the increase in age 65 or older population. Thus, while transit tours decreased for the Aging Population scenario, the differential changes in work and non-mandatory tours by transit could prompt a review of peak and off-peak transit service levels offered for the Aging Population scenario.

The increase in the population age 65 and older in the Aging Population scenario had very little impact on tour mode shares. As shown in Table 4.18, tour mode shares for work tours are almost identical for the base scenario and for the Aging Population scenario. Tour mode shares for non-mandatory tours for the two scenarios vary a little more for non-mandatory tours but are still within 0.5 percent for each tour mode. The hypothesis that increased population in the 65 or older age category would lead to increased transit use was not reflected in the Aging Population scenario.

Table 4.18. Work and Non-Mandatory Tour Mode Shares

	Work Tours		Non-Mandatory Tours	
Tour Mode	Base	Aging Population	Base	Aging Population
Drive Alone	55.2%	55.0%	43.2%	43.7%
Shared Ride 2	14.5%	14.5%	23.0%	23.0%
Shared Ride 3+	8.5%	8.5%	11.6%	11.5%
Walk To Transit	8.9%	8.9%	7.8%	7.6%
Drive To Transit	9.0%	9.1%	2.2%	2.2%
Walk	3.0%	3.0%	11.6%	11.4%
Bike	0.9%	0.9%	0.7%	0.7%
School Bus	0.0%	0.0%	0.0%	0.0%

While tour mode shares are relatively unaffected by the Aging Population scenario, the numbers of tours by mode are greatly impacted. Table 4.19 summarizes the tours by tour mode for work tours, non-mandatory tours, and the sum of the two tour purposes for the base scenario and Aging Population scenario. Focusing on transit, the number of work tours by walk and drive to transit for the Aging Population scenario decreases about 19,000 from the base scenario. That loss in transit tours is partially offset by the 3,400 additional non-mandatory transit tours in the Aging Population scenario. Since work tours have a higher tendency to occur during peak periods and non-mandatory tours are more concentrated during the midday, the impacts on the transit system vary. The transit system was unchanged for the Aging Population scenario (in comparison to the base scenario). However, with the increase in population aged 65 or older and the commensurate increase in midday period, non-mandatory tours, adjustment of midday transit service to serve increasing numbers of senior members on the population might be considered.

Table 4.19. Work and Non-Mandatory Tours by Tour Mode

	Work Tours		Non-Mandatory Tours		Total Work & Non-Mandatory Tours	
Tour Mode	Base	Aging Population	Base	Aging Population	Base	Aging Population
Drive Alone	1,180,018	1,103,045	773,666	814,967	1,953,684	1,918,012
Shared Ride 2	310,406	291,050	411,185	429,098	721,591	720,148
Shared Ride 3	181,152	171,563	206,778	213,538	387,930	385,101
Transit-Walk	189,233	179,061	139,984	142,205	329,217	321,266
Transit-Auto	192,005	183,106	38,917	40,105	230,922	223,211
Walk	64,007	60,768	207,441	212,544	271,448	273,312
Bike	19,532	18,287	12,218	12,250	31,750	30,537
School Bus	0	0	0	0	0	0
Total	2,136,353	2,006,880	1,790,189	1,864,707	3,926,542	3,871,587

Highway Assignment

Table 4.20 summarizes the change in modeled VMT for the Aging Population scenario from the base scenario as a percent of the base scenario VMT. As might be expected for a scenario where the 65 or older population increases by 30 percent, a.m. peak, p.m. peak, and night VMT decreases while midday VMT generally stays the same or increases from the base scenario. The decreases in a.m. peak and p.m. peak VMT results from the overall decrease of workers making work tours. The decrease in night VMT probably results from seniors showing a higher propensity to avoid night time tours than the general public. The stable nature of the midday VMT for the Aging Population scenario in comparison to the base scenario VMT is probably a result of the increase in age 65 or older population and their propensity to make non-mandatory, midday travel.

Overall, the changes in outputs from individual model components and changes in VMT by time of day appear to be reasonable for the Aging Population scenario in comparison to the base scenario.

Table 4.20. Percent Change in VMT as Percent of Base Scenario VMT

	Percentage Change in VMT as Percentage of Base Scenario VMT				
Geographic Area	**AM**	**Midday**	**PM**	**Night**	**Total**
Baltimore City	-3%	0%	-2%	-3%	-2%
Anne Arundel County	-4%	0%	-3%	-4%	-3%
Baltimore County	-3%	0%	-3%	-4%	-3%
Carroll County	-5%	0%	-4%	-4%	-3%
Harford County	-5%	-2%	-4%	-6%	-4%
Howard County	-4%	-1%	-4%	-6%	-3%
Baltimore Region	-4%	0%	-3%	-4%	-3%
Washington D.C.	-4%	1%	-2%	-4%	-2%
Montgomery County	-4%	1%	-4%	-4%	-3%
Prince George's Co.	-5%	1%	-3%	-4%	-3%
Frederick County	-6%	0%	-5%	-7%	-4%
Washington Region	-4%	1%	-3%	-4%	-3%
Total	-4%	0%	-3%	-4%	-3%

Transit Assignment

Table 4.21 through Table 4.24 compare the changes in linked trips and estimated boardings MTA Buses, LRT and Metro, MARC, and the total of these three segments for the Aging Population scenario with those from the base scenario. The results for the Aging Population scenario are very similar to those for the base scenario with only a slight reduction in total linked trips and boardings. The slight reduction in linked trips and boardings is consistent with the findings for the tour mode choice model (see Table 4.18 and Table 4.19).

Table 8.2 shows the shares of linked trips and boardings by time-of-day for walk access, drive access, and total for the base scenario and the Aging Population scenario. The results are consistent with what has been shown previously – relative peak transit travel generally decreases while relative off-peak transit travel generally increases. Also, use of auto access in the Aging Population scenario shows a relative decrease from the base scenario.

Table 4.21. Base and Aging Population Linked Trips and Estimated Boardings – MTA Buses

Trips by Number of Transfers	Base	Aging Population	Difference	Percent Difference
0	111,755	110,765	-990	-1%
1	63,500	64,005	505	1%
2	11,436	11,343	-93	-1%
3+	800	814	14	2%
Total	187,491	186,927	-564	0%
Estimated Boardings*	276,263	276,060	-203	0%
Estimated Boardings Per Linked Trip	1.47	1.48	0.00	0%

* Boardings by mode have been estimated by the assigned number of linked trips on the mode multiplied by the number of boardings (i.e. transfers + 1) on any mode required on the transit path for the interchange. Linked trips by mode are determined by highest mode used (from the mode hierarchy list) on the transit path for the interchange.

Table 4.22. Base and Aging Population Linked Trips and Estimated Boardings – LRT & Metro

Trips by Number of Transfers	Base	Aging Population	Difference	Percent Difference
0	30,919	30,049	-870	-3%
1	20,571	20,157	-414	-2%
2	10,028	9,786	-242	-2%
3+	2,098	1,898	-200	-10%
Total	63,616	61,890	-1,726	-3%
Estimated Boardings*	110,537	107,313	-3,224	-3%
Estimated Boardings Per Linked Trip	1.74	1.73	0.00	0%

* Boardings by mode have been estimated by the assigned number of linked trips on the mode multiplied by the number of boardings (i.e. transfers + 1) on any mode required on the transit path for the interchange. Linked trips by mode are determined by highest mode used (from the mode hierarchy list) on the transit path for the interchange.

Table 4.23. Base and Aging Population Linked Trips and Estimated Boardings – MARC

Trips by Number of Transfers	Base	Aging Population	Difference	Percent Difference
0	2,025	1,937	-88	-4%
1	4,438	4,262	-176	-4%
2	3,470	3,357	-113	-3%
3+	2,535	2,404	-131	-5%
Total	12,468	11,960	-508	-4%
Estimated Boardings*	31,451	30,148	-1,303	-4%
Estimated Boardings Per Linked Trip	2.52	2.52	0.00	0%

* Boardings by mode have been estimated by the assigned number of linked trips on the mode multiplied by the number of boardings (i.e. transfers + 1) on any mode required on the transit path for the interchange. Linked trips by mode are determined by highest mode used (from the mode hierarchy list) on the transit path for the interchange.

Table 4.24. Base and Aging Population Linked Trips and Estimated Boardings – Total MTA Buses, LRT/Metro, and MARC

Trips by Number of Transfers	Base	Aging Population	Difference	Percent Difference
0	144,699	142,751	-1,948	-1%
1	88,509	88,424	-85	0%
2	24,934	24,486	-448	-2%
3+	5,433	5,116	-317	-6%
Total	263,575	260,777	-2,798	-1%
Estimated Boardings*	418,251	413,521	-4,730	-1%
Estimated Boardings Per Linked Trip	1.59	1.59	0.00	0%

* Boardings by mode have been estimated by the assigned number of linked trips on the mode multiplied by the number of boardings (i.e. transfers + 1) on any mode required on the transit path for the interchange. Linked trips by mode are determined by highest mode used (from the mode hierarchy list) on the transit path for the interchange.

Table 4.25. Base and Aging Population Shares of Linked Trips and Estimated Boardings by Time-of-Day – Total MTA Buses, LRT/Metro, and MARC

Access Mode	Time of Day	Total Linked Trips Base	Total Linked Trips Aging Population	Total Linked Trips Difference	Total Boardings Base	Total Boardings Aging Population	Total Boardings Difference
Walk	Peak	39.1%	39.1%	0.0%	43.7%	43.5%	-0.2%
	Off-Peak	34.6%	35.0%	0.4%	36.4%	36.9%	0.5%
	Daily	73.8%	74.2%	0.4%	80.1%	80.4%	0.3%
Drive	Peak	16.4%	16.0%	-0.4%	12.5%	12.2%	-0.3%
	Off-Peak	9.9%	9.8%	0.0%	7.4%	7.4%	0.0%
	Daily	26.2%	25.8%	-0.4%	19.9%	19.6%	-0.3%
Total	Peak	55.5%	55.1%	-0.4%	56.2%	55.7%	-0.5%
	Off-Peak	44.5%	44.9%	0.4%	43.8%	44.3%	0.5%
	Daily	100.0%	100.0%	0.0%	100.0%	100.0%	0.0%

4.2 Brownfield Development Sensitivity Test

The intent of this test is to measure the impact of a substantial new development or redevelopment of a brownfield site into a major employment center. Under Armour has recently announced plans over the next 20 years to develop about 50 acres south of Cromwell Street as its Port Covington headquarters (http://www.baltimoresun.com/business/real-estate/bs-bz-under-armour-plans-20160128-story.html). Under Armour expects to eventually house more than 10,000 employees at the new campus. The master plan calls for three high-rise office buildings with 3.9 million square feet with about three-quarters of the space being office space.

The actual sensitivity test "moved" 13,695 employees to the new site, increasing the total employment in the two TAZs representing the site (TAZs 308 and 313) from 1,643 in the base scenario data set to 15,338 for the sensitivity test. In addition, 4,714 households with 12,000 residents and 79 residents in group quarters were modeled for the site.

The original sensitivity test plans called for several changes to be made to the transportation network to serve the redevelopment:

- Extend local bus route 27 from its current terminus just north of the Hanover Street Bridge into the development using East Cromwell Street to Port Covington Drive and looping back to East Cromwell Street using West Peninsula Drive,
- Add a stop for local bus route 64 and express route 64x at Hanover Street and East Cromwell Street, and

- Assume the requested TIGER grant for a full interchange between State Highway 2 (Hanover Street) and I-95 has been has been received and a full interchange is in place.

The network changes were not implemented in the sensitivity test. Thus, the current sensitivity test will show how much the existing transportation network will be stressed by the redevelopment of the site. This will allow the test to be rerun, if desired, to test the efficacy of the network changes.

Zonal Employment Changes

Table 4.26 shows the distribution of employment by type for the base scenario, and Table 4.27 shows the same distribution for the Brownfield scenario. Table 4.28 shows the absolute changes for the Brownfield scenario in comparison to the base scenario for the various strata.

Reallocating the employment to the brownfield site resulted in some small differences in Baltimore region control totals by employment type. Employment was moved to the site from non-brownfield locations within Baltimore City and the five surrounding counties. The employment moves from the surrounding counties resulted in a net increase in employment within Baltimore City. Employment in Montgomery, Prince George's, and Frederick Counties and in Washington, D.C. was not changed for the Brownfield scenario.

Table 4.26. Base Scenario Employment by Type

	2012 Model Validation Employment							
County	**Retail**	**Office**	**Industrial**	**Education**	**Health**	**Food Service**	**Other**	**Total**
Baltimore City Non-Brownfield	19,499	103,559	57,435	50,492	84,392	20,554	46,276	382,207
Brownfield TAZ (308)	*31*	*16*	*328*	*0*	*0*	*117*	*289*	*781*
Brownfield TAZ (313)	*276*	*0*	*534*	*0*	*0*	*26*	*26*	*862*
Total Brownfield	*307*	*16*	*862*	*0*	*0*	*143*	*315*	*1,643*
Total Baltimore City	19,806	103,575	58,297	50,492	84,392	20,697	46,591	383,850
Anne Arundel County	38,735	90,516	68,618	28,946	36,739	28,554	38,578	330,686
Baltimore County	56,166	126,555	76,162	42,657	73,651	29,770	48,697	453,658
Carroll County	9,836	12,430	18,484	7,493	9,016	5,918	8,511	71,688
Harford County	13,608	38,959	18,719	9,262	11,421	7,460	9,693	109,122
Howard County	20,201	55,852	41,020	17,618	16,139	11,651	24,863	187,344
Total	**158,352**	**427,887**	**281,300**	**156,468**	**231,358**	**104,050**	**176,933**	**1,536,348**

Table 4.27. Brownfield Scenario Employment by Type

County	Brownfield Scenario Employment							
	Retail	Office	Industrial	Education	Health	Food Service	Other	Total
Baltimore City Non-Brownfield	19,464	103,414	57,331	50,492	84,180	20,536	46,186	381,603
Brownfield TAZ (308)	*750*	*3,464*	*570*	*0*	*1,000*	*601*	*750*	*7,135*
Brownfield TAZ (313)	*950*	*4,294*	*656*	*0*	*500*	*603*	*1,200*	*8,203*
Total Brownfield	*1,700*	*7,758*	*1,226*	*0*	*1,500*	*1,204*	*1,950*	*15,338*
Total Baltimore City	21,164	111,172	58,557	50,492	85,680	21,740	48,136	396,941
Anne Arundel County	38,257	88,351	68,286	28,946	36,378	28,164	38,042	326,424
Baltimore County	55,573	123,927	75,814	42,657	73,138	29,400	48,064	448,573
Carroll County	9,710	12,098	18,395	7,493	8,917	5,830	8,380	70,823
Harford County	13,433	37,935	18,639	9,262	11,297	7,343	9,544	107,453
Howard County	19,942	54,415	40,822	17,618	16,003	11,472	24,491	184,763
Total	**158,079**	**427,898**	**280,513**	**156,468**	**231,413**	**103,949**	**176,657**	**1,534,977**

Table 4.28. Absolute Difference between Brownfield Scenario and Base Scenario by Type

County	2012 Model Validation Employment							
	Retail	Office	Industrial	Education	Health	Food Service	Other	Total
Baltimore City Non-Brownfield	-35	-145	-104	0	-212	-18	-90	-604
Brownfield TAZ (308)	*719*	*3,448*	*242*	*0*	*1,000*	*484*	*461*	*6,354*
Brownfield TAZ (313)	*674*	*4,294*	*122*	*0*	*500*	*577*	*1,174*	*7,341*
Total Brownfield	*1,393*	*7,742*	*364*	*0*	*1,500*	*1,061*	*1,635*	*13,695*
Total Baltimore City	1,358	7,597	260	0	1,288	1,043	1,545	13,091
Anne Arundel County	-478	-2,165	-332	0	-361	-390	-536	-4,262
Baltimore County	-593	-2,628	-348	0	-513	-370	-633	-5,085
Carroll County	-126	-332	-89	0	-99	-88	-131	-865
Harford County	-175	-1,024	-80	0	-124	-117	-149	-1,669
Howard County	-259	-1,437	-198	0	-136	-179	-372	-2,581
Total	**-273**	**11**	**-787**	**0**	**55**	**-101**	**-276**	**-1,371**

Zonal Population and Household Changes

Based on the 2012 synthetic population, 4,709 households with 10,827 residents were moved from more rural areas in the Baltimore region to TAZ 308 bringing the total population of that TAZ to 12,000 in the Brownfield scenario. The households were randomly selected from TAZs in the rural area with each TAZ contributing to the increased population in TAZ 308.

Table 4.29 shows the distribution of population by person type and age for the BMC region for both the base and the Brownfield scenarios. Table 4.30 and Table 4.31 show the population distributions for Baltimore City for the base and Brownfield scenarios, respectively. The total population for the Brownfield scenario for Baltimore City is 10,578 more than for the base scenario. Table 4.32 ?/shows the population by person type and age information for TAZ 308. The total Brownfield scenario population for TAZ 308 is 11,924, or 1,346 more than the change in population in Baltimore City (10,578). This difference occurred since two TAZs contributing households and population to TAZ 308 were from Baltimore City. Note that there are 76 people in group quarters in TAZ 308, bringing the Brownfield scenario population to 12,000.

Table 4.29. Population by Person Type and Age for BMC Region – Base and Brownfield Scenarios

	Age Range								
Person Type	**0-4**	**5-15**	**16-17**	**18-19**	**20-24**	**25-40**	**41-64**	**65+**	**Total**
Child 1	167,341	0	0	0	0	0	0	0	167,341
Child 2	0	374,925	0	0	0	0	0	0	374,925
Child 3	0	0	56,955	17,484	0	0	0	0	74,439
Adult Student	0	0	0	29,970	73,218	24,601	7,081	2,027	136,897
Full Time Worker	0	0	0	16,100	79,316	438,443	571,202	46,476	1,151,537
Part Time Worker	0	0	0	21,781	26,916	35,749	64,330	23,724	172,500
Non-working Adult	0	0	0	9,486	9,960	64,619	226,526	0	310,591
Senior	0	0	0	0	0	0	0	252,903	252,903
Total	167,341	374,925	56,955	94,821	189,410	563,412	869,139	325,130	2,641,133

Table 4.30. Base Scenario Population by Person Type and Age for Baltimore City

	Age Range								
Person Type	**0-4**	**5-15**	**16-17**	**18-19**	**20-24**	**25-40**	**41-64**	**65+**	**Total**
Child 1	42,117								42,117
Child 2		77,968							77,968
Child 3			12,117	5,394					17,511
Adult Student				9,211	30,571	7,698	2,044	429	49,953
Full Time Worker				2,947	14,691	107,650	101,981	7,635	234,904
Part Time Worker				5,639	8,957	9,817	12,846	4,537	41,796
Non-working Adult				2,262	1,657	22,826	60,382		87,127
Senior								56,398	56,398
Total	42,117	77,968	12,117	25,453	55,876	147,991	177,253	68,999	607,774

Table 4.31. Brownfield Scenario Population by Person Type and Age for Baltimore City

	Age Range								
Person Type	**0-4**	**5-15**	**16-17**	**18-19**	**20-24**	**25-40**	**41-64**	**65+**	**Total**
Child 1	43,011								43,011
Child 2		78,778							78,778
Child 3			12,334	5,433					17,767
Adult Student				9,283	30,707	7,764	2,077	440	50,271
Full Time Worker				2,982	15,272	109,539	104,237	7,879	239,909
Part Time Worker				5,749	8,998	9,926	13,070	4,657	42,400
Non-working Adult				2,273	1,853	23,070	61,397		88,593
Senior								57,623	57,623
Total	43,011	78,778	12,334	25,720	56,830	150,299	180,781	70,599	618,352

Table 4.32. Brownfield Scenario Population by Person Type and Age for TAZ 308

Person Type	Age Range 0-4	5-15	16-17	18-19	20-24	25-40	41-64	65+	Total
Child 1	987								987
Child 2		1,011							1,011
Child 3			239	41					280
Adult Student				84	170	83	40	12	389
Full Time Worker				38	600	2,127	2,541	261	5,567
Part Time Worker				120	50	134	244	127	675
Non-working Adult				14	201	292	1,131		1,638
Senior								1,377	1,377
Total	987	1,011	239	297	1,021	2,636	3,956	1,777	11,924

Regular Workplace

The changes in the regular place of work model resulting from the Brownfield scenario in comparison to the base scenario are, for the most part, minimal. However, the number of workers choosing the two brownfield TAZs, 308 and 313, as the location of their regular workplace exceeds the total employment in those two TAZs. While this is an illogical result, it is probably an anomaly since the overall ratio of regular workplaces to employee for Baltimore City is 0.65 for the base scenario and 0.69 for the Brownfield scenario.

Since the workplace location choice model is not doubly constrained, the fact that the regular workplace to employee ratio exceeds 1.0 for the two brownfield TAZs provides some information regarding the location. In short, it is a very desirable work location due to its location. The results also suggests that, due to its location, the brownfield site could "support" even more employment, although additional employment would also increase the numbers of workers choosing the location for a regular work location.

Based on the structure of the model, one method for correcting this situation would be to artificially reduce the amount of employment in the brownfield TAZs. Thus, if a ratio of regular workplaces to employment of 0.69 was deemed to be more reasonable, the brownfield employment could be factored downward by that amount for input to the regular workplace location choice model. In subsequent models, the full employment should be used.

At an aggregate level, there was no change in the home to work time and distance tour length frequency distributions. Coincidence ratios were 1.0. Average times and distances were the same; the absolute change in the average times to the regular workplace for full- and part-time workers was less than 1 second. These findings held for both full-time and part-time workers.

Table 4.33 summarizes the numbers of workers with regular workplaces in TAZs 308 and 313 for the base and Brownfield scenarios. The numbers of workers reporting a regular workplace in the brownfield TAZs increased from 1,060 in the base scenario to 16,512 in the Brownfield scenario. The proportions of workers in the brownfield who reside in Baltimore City or Anne Arundel County increased in the Brownfield scenario. This is as might be expected given the increase in population in TAZ 308 and the proximity of Baltimore City and Anne Arundel County to the brownfield site.

Table 4.33. Workers with Regular Workplace in the Brownfield TAZs

	Base Scenario				Brownfield Scenario			
Home TAZ	**Full-Time Workers**	**Part-Time Workers**	**Total Workers**	**Percent by County/ Region**	**Full-Time Workers**	**Part-Time Workers**	**Total Workers**	**Percent by County/ Region**
Baltimore City	358	48	406	38%	7,451	1,051	8,502	51%
Anne Arundel County	117	9	126	12%	2,300	223	2,523	15%
Baltimore County	313	31	344	32%	3,528	417	3,945	24%
Carroll County	9	0	9	1%	96	14	110	1%
Harford County	47	6	53	5%	397	33	430	3%
Howard County	47	2	49	5%	378	29	407	2%
Washington, D.C.	1	0	1	0%	28	3	31	0%
Montgomery County	16	2	18	2%	157	10	167	1%
Prince George's County	43	6	49	5%	314	37	351	2%
Frederick County	5	0	5	0%	43	3	46	0%
BMC Region	891	96	987	93%	14,150	1,767	15,917	96%
Washington Region	65	8	73	7%	542	53	595	4%
Total	**956**	**104**	**1,060**		**14,692**	**1,820**	**16,512**	

One concern with the regular workplace location results is the numbers of workers reporting regular workplaces in the two brownfield TAZs. In the base scenario, there were 1,643 employees for the 1,060 workers reporting that they had a regular workplace in one of the two TAZs. This gives a ratio of regular workplaces per employee of 0.65. For the Brownfield scenario, there were only 15,338 employees for the 16,512 workers reporting that their regular workplace was in one of the two brownfield TAZs, producing a ratio of regular workplaces per employee of 1.08.

The fact that number of workers reporting a regular workplace in the brownfield TAZs exceeds the employment in the TAZs is illogical. Unlike doubly constrained trip distribution models, there are no constraints in the workplace location choice model to prevent such an occurrence. It is assumed that this is a rare occurrence. Table 4.34 shows the numbers of workers naming each county as the location of their regular workplace along with the employment in the county. All of the counties have more employment than workers naming regular workplaces, with the overall average rate in the BMC region being 0.77. The overall rate for Baltimore City for the base scenario, 0.59, is lower than the overall modeled rate for the BMC region. For the Brownfield scenario, the overall workplaces per employee for Baltimore City increases slightly to 0.60.

Table 4.34. Workers with Regular Workplaces and Employment by County

	Base Scenario			Brownfield Scenario		
County	Usual Workplaces	Total Employment	Workplaces/ Employee	Usual Workplaces	Total Employment	Workplaces/ Employee
Baltimore City	226,043	383,850	0.59	239,999	396,941	0.60
Anne Arundel County	263,649	330,686	0.80	259,693	326,424	0.80
Baltimore County	380,895	453,658	0.84	375,267	448,573	0.84
Carroll County	52,779	71,688	0.74	51,837	70,823	0.73
Harford County	93,045	109,122	0.85	91,266	107,453	0.85
Howard County	168,060	187,344	0.90	165,522	184,763	0.90
Washington, D.C.	326,161	718,184	0.45	326,167	718,184	0.45
MO/PG/FR	904,398	969,257	0.93	905,341	969,257	0.93
BMC Region	1,184,471	1,536,348	0.77	1,183,584	1,534,977	0.77
Washington Region	1,230,559	1,687,441	0.73	1,231,508	1,687,441	0.73
Total	2,415,030	3,223,789	0.75	2,415,092	3,222,418	0.75

Tour Destination Choice

As expected, little change in average tour times and distances between the base and Brownfield scenarios was noted. Larger differences in destination choice as measure by average tour times and distances to and from the brownfield TAZs were noted, also as expected. An issue with the implementation of the Brownfield scenario resulting from the decision to allocate all new population and employment to parcels that existed in the base scenario was discovered in the analysis. It is likely that this decision affected intrazonal and intra-brownfield tours.

As shown in Table 4.35, at an aggregate level, there was virtually no change in home-based work tour destination choice for all workers. The trip length frequency distribution coincidence ratios were 1.0 for both time and distance. Average times and distances were almost identical; the absolute change in the average work tour times to the destination for full- and part-time workers was 0.01 minutes, or less than 1 second.

The comparisons of the base scenario results to Brownfield scenario results for workers with and without regular workplace locations mirrored those for all workers. Results were the most different for workers without a regular workplace with the average tour duration changing by 0.09 minutes (5.4 seconds) and average trip distance changing by 0.08 miles.

Table 4.35. Average Home-Based Work Tour Times and Distances

	Average Time (Minutes)			Average Distance (Miles)		
Worker Type	Base Scenario	Brownfield Scenario	Coincidence Ratio	Base Scenario	Brownfield Scenario	Coincidence Ratio
Regular Workplace Workers	20.26	20.23	1.00	10.87	10.85	1.00
Non-Regular Workplace Workers	20.35	20.44	0.99	10.21	10.29	0.99
All Workers	20.28	20.27	1.00	10.73	10.74	1.00

Table 4.36 summarizes the average home-based tour times and distances for all tour types sent to TAZs 308 and 313 for the base and Brownfield scenarios. Table 4.37 shows the average home-based tour times and distances for all tour types sent from TAZs 308 to all other TAZs. The average tour times and distances vary for the tours sent to and the tours sent from the TAZs, demonstrating sensitivity to the mix of employment opportunities and access to the TAZs (due to the changes in travel time resulting from increased traffic) for the Brownfield scenario. The Brownfield scenario average tour times and distances for tours sent from TAZ 308 (the only TAZ with population) are more volatile in comparison to the base scenario than the trips sent to the two TAZs. This is largely due to the relatively small number of persons in TAZ 308 in the base scenario (1,173) compared to the population for the Brownfield scenario (12,000).

The Brownfield scenario tour times and distances sent from TAZ 308 are lower than those for those for the base scenario for all tour purposes except joint tours. With the exception of home-based university tours, this could reflect the increased opportunities provided by the development in the two brownfield TAZs. Overall, the number of intrazonal (TAZ 308) home-based tours per population increased from 0.02 intrazonal tours per person for the base scenario to 0.12 intrazonal tours per person for the Brownfield scenario. If tours from TAZ 308 to TAZ 313 are added, the number of intra-brownfield tours increased to 0.15 tours per person.

Table 4.36. Average Home-Based Tour Times and Distances Sent to TAZs 308 and 313

	Average Time (Minutes)			Average Distance (Miles)		
Tour Type	**Base Scenario**	**Brownfield Scenario**	**Coincidence Ratio**	**Base Scenario**	**Brownfield Scenario**	**Coincidence Ratio**
Regular Workplace Workers	16.91	16.84	0.93	9.95	10.00	0.82
Non-Regular Workplace Workers	16.55	15.74	0.80	9.60	9.62	0.45
All work (Regular and Non-Regular)	16.89	16.77	0.92	9.92	9.98	0.83
Individual Non-Mandatory	12.98	11.24	0.81	7.35	6.25	0.73
University	16.82	17.94	0.91	10.05	11.24	0.66
Joint	14.07	14.59	0.66	8.09	8.76	0.42

Table 4.37. Average Home-Based Tour Times and Distances Sent from TAZ 308

	Average Time (Minutes)			Average Distance (Miles)		
Tour Type	**Base Scenario**	**Brownfield Scenario**	**Coincidence Ratio**	**Base Scenario**	**Brownfield Scenario**	**Coincidence Ratio**
Regular Workplace Workers	14.02	12.27	0.79	8.61	7.54	0.70
Non-Regular Workplace Workers	11.64	7.84	0.83	6.27	4.08	0.45
All work (Regular and Non-Regular)	13.82	11.97	0.81	8.41	7.31	0.69
Individual Non-Mandatory	8.78	7.42	0.91	4.41	3.56	0.67
University	11.97	9.33	0.79	6.64	4.76	0.52
Joint	7.32	8.23	0.92	3.34	4.06	0.75

An issue with the implementation of the sensitivity test was uncovered in the analysis of the Brownfield scenario. Figure 4.9 shows the locations of parcels in TAZs 308 and 313 for the base scenario. TAZ 308 is basically the area north of I-95 and west of Hanover Street south of I-95. TAZ 313 is basically the area east of Hanover Street and south of I-95 (with a small portion north of I-95 at the eastern edge of the area). For expediency, the increased population and employment for the Brownfield scenario was added to the existing parcels. This approach probably skewed the numbers of intrazonal tours and tours between the two TAZs.

Table 4.38 summarizes the numbers of work tours per employee by county. For the BMC region, there are about 0.68 home-based work tours per employee for the base scenario and 0.69 for the Brownfield scenario. These rates are lower than the average number of regular workplaces per employee for the BMC region, 0.77, reflecting the fact that less than 88 percent of workers with regular work places go to their regular places of work on an average day. The percentage is less than 88 percent since work tours include tours made by workers without a regular place of work.

The exception to the "88 percent" rule is Baltimore City where there are slightly more home-based work tour per employee than regular workplaces per employee. This difference from the norm might reflect increased amounts of casual workers without regular places of work making work tours to Baltimore City.

Figure 4.9. Port Covington Parcels

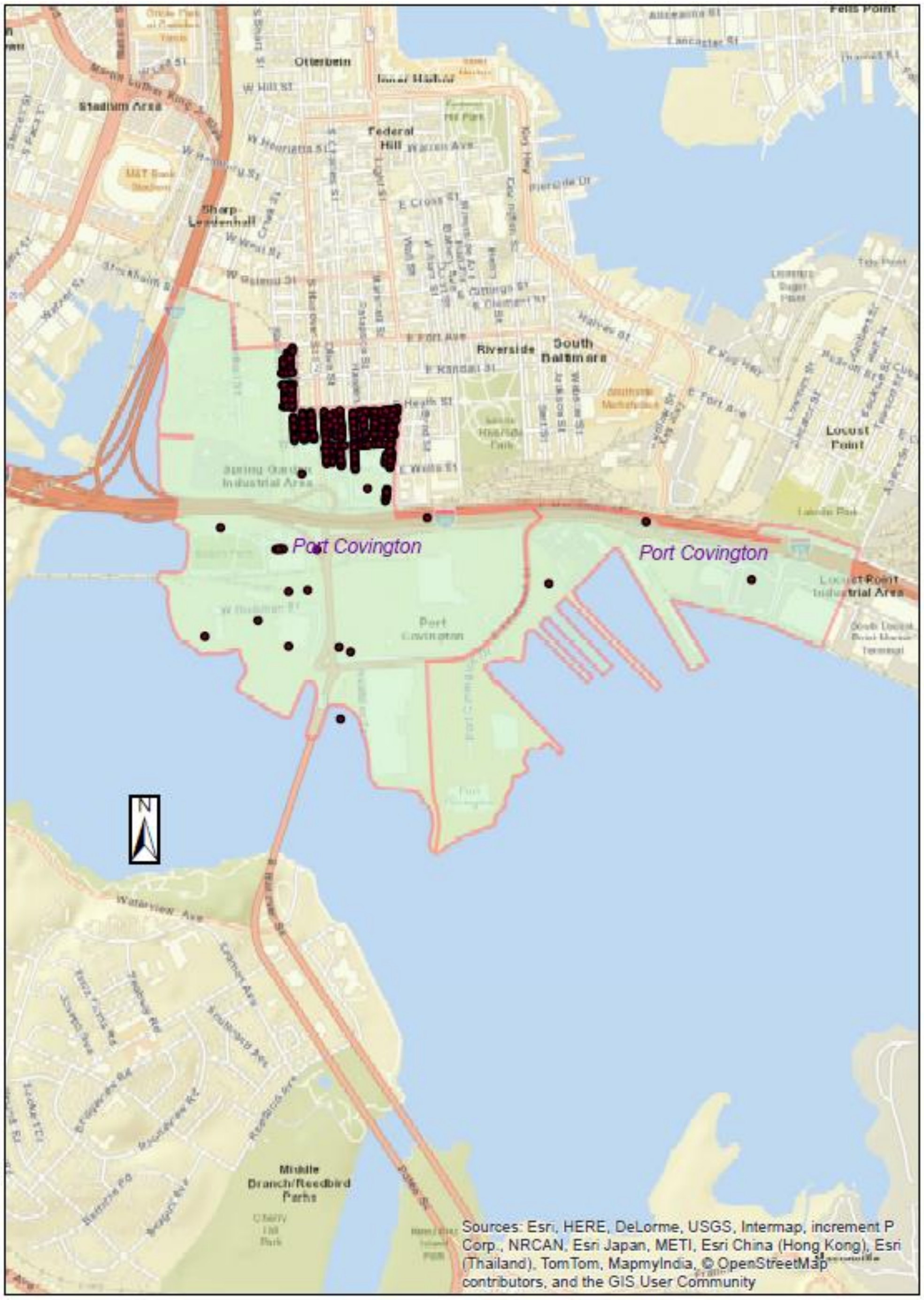


Table 4.38. Home-Based Work Tours per Employee

County	Base Scenario			Brownfield Scenario		
	Work Tours	Total Employment	Work Tours/ Employee	Work Tours	Total Employment	Work Tours/ Employee
Baltimore City	228,891	383,850	0.60	244,766	396,941	0.62
Anne Arundel County	224,311	330,686	0.68	221,462	326,424	0.68
Baltimore County	337,759	453,658	0.74	334,630	448,573	0.75
Carroll County	44,197	71,688	0.62	43,544	70,823	0.61
Harford County	78,951	109,122	0.72	77,588	107,453	0.72
Howard County	137,025	187,344	0.73	135,004	184,763	0.73
Washington, D.C.	320,807	718,184	0.45	324,262	718,184	0.45
MO/PG/FR	751,693	969,257	0.78	754,915	969,257	0.78
BMC Region	1,051,134	1,536,348	0.68	1,056,994	1,534,977	0.69
Washington Region	1,072,500	1,687,441	0.64	1,079,177	1,687,441	0.64
Total	2,123,634	3,223,789	0.66	2,136,171	3,222,418	0.66
TAZs 308 and 313		1,643	0.00		15,388	0.00

Work-Based Sub-tours

The Brownfield scenario produces very little change in overall work-based sub-tour generation and destination choice in comparison to the base scenario. Total work-based sub-tours by only about 200 for the Brownfield scenario, and the sub-tour destination choice trip length frequency distributions were almost identical.

Tour Mode Choice

Table 4.39 shows the work tour and non-mandatory tour mode shares for the base and Brownfield scenarios. As might be expected, the Brownfield scenario produced almost no change in regional mode shares.

Table 4.39. Work and Non-Mandatory Tour Mode Shares

Tour Mode	Work Tours		Non-Mandatory Tours	
	Base Scenario	Brownfield Scenario	Base Scenario	Brownfield Scenario
Drive Alone	55.2%	55.2%	43.2%	43.2%
Shared Ride 2	14.5%	14.5%	23.0%	23.0%
Shared Ride 3	8.5%	8.5%	11.6%	11.6%
Walk To Transit	8.9%	8.8%	7.8%	7.8%
Drive To Transit	9.0%	9.0%	2.2%	2.2%
Walk	3.0%	3.0%	11.6%	11.6%
Bike	0.9%	0.9%	0.7%	0.7%
School Bus	0.0%	0.0%	0.0%	0.0%

Transit Assignment

Table 4.40 shows the linked transit trips and estimated boardings by mode for the base and Brownfield scenarios. Overall, there is very little change in transit use in the region.

Table 4.40. Linked Transit Trips and Boardings

Mode	Linked Trips				Boardings*			
	Base Scenario	Brownfield Scenario	Difference	Percent Difference	Base Scenario	Brownfield Scenario	Difference	Percent Difference
MTA Bus	187,491	188,459	968	1%	276,263	278,860	2,597	1%
LRT/Metro	63,616	63,427	-189	0%	110,537	110,671	134	0%
MARC	12,468	12,594	126	1%	31,451	31,929	478	2%
Total	263,575	264,480	905	0%	418,251	421,460	3,209	1%

* Boardings by mode have been estimated by the assigned number of linked trips on the mode multiplied by the number of boardings (i.e. transfers + 1) on any mode required on the transit path for the interchange. Linked trips by mode are determined by highest mode used (from the mode hierarchy list) on the transit path for the interchange.

The Brownfield scenario, however, produce some localized impacts on transit ridership. Figure 4.10 shows the transit routes in the brownfield area and Table 7.2 shows the ridership by line and boardings at the Hamburg Street station. As noted in Table 4.40, total MTA bus boardings for the Brownfield scenario increased by 2,597 over the base scenario. The total increase on the MTA buses serving the area was 3,985, suggesting that the primary reason for the increase was the development of the brownfield. The increase in boardings at the Hamburg Street station was probably due to its proximity to the brownfield site.

Figure 4.10. MTA Bus Lines and LRT Station Serving Brownfield Site

Table 4.41. Transit Boardings for MTA Bus Lines and LRT Station Serving Brownfield Site

Route/Station	Color in Figure 4.10	Base Scenario	Brownfield Scenario	Difference	Percent Difference
1		2,568	3,174	606	24%
27		4,393	4,478	85	2%
64/64x		5,581	9,124	3,543	63%
120/160		3,367	3,204	-163	-5%
310/320		644	571	-72	-11%
410/411/420		1,241	1,227	-14	-1%
Hamburg Street		860	941	81	9%

Highway Assignment

For the most part, the highway assignment results are very similar between the base and Brownfield scenarios. The percentage root mean square error difference between the two assignments is 1.75 percent. The modeled VMT is 0.2 percent higher for the Brownfield scenario. Most of the differences are in the vicinity of the brownfield development. The only county with a VMT difference of greater than one percent between the two scenarios is Baltimore City, where the development is located.

Since the aggregate summaries are so similar, it makes sense to focus on the volume differences between the two scenarios at the link level. Figure 4.11 shows the p.m. peak period traffic assignment results for the area around TAZs 308 and 313 for the base scenario and Figure 4.12 shows the results for the Brownfield scenario. The links are color coded by level of service:

- Green=LOS A & B
- Yellow=LOS C & D
- Orange=LOS E & F
- Red=Over capacity

The addition of the population and employment for the Brownfield scenario resulted in very little change in level of service on the links serving the brownfield site. In fact, the increases in traffic on arterials adjacent to TAZ connector links show relatively increase due to the brownfield development.

Figure 4.11. Base Scenario P.M. Peak Period Assignment for Links near TAZs 308 and 313

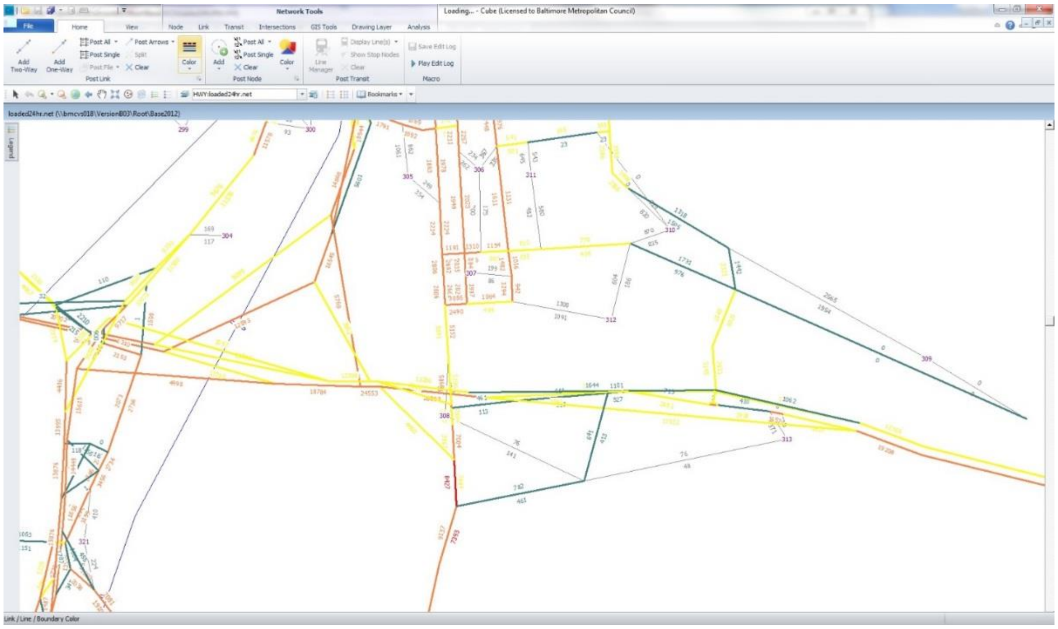
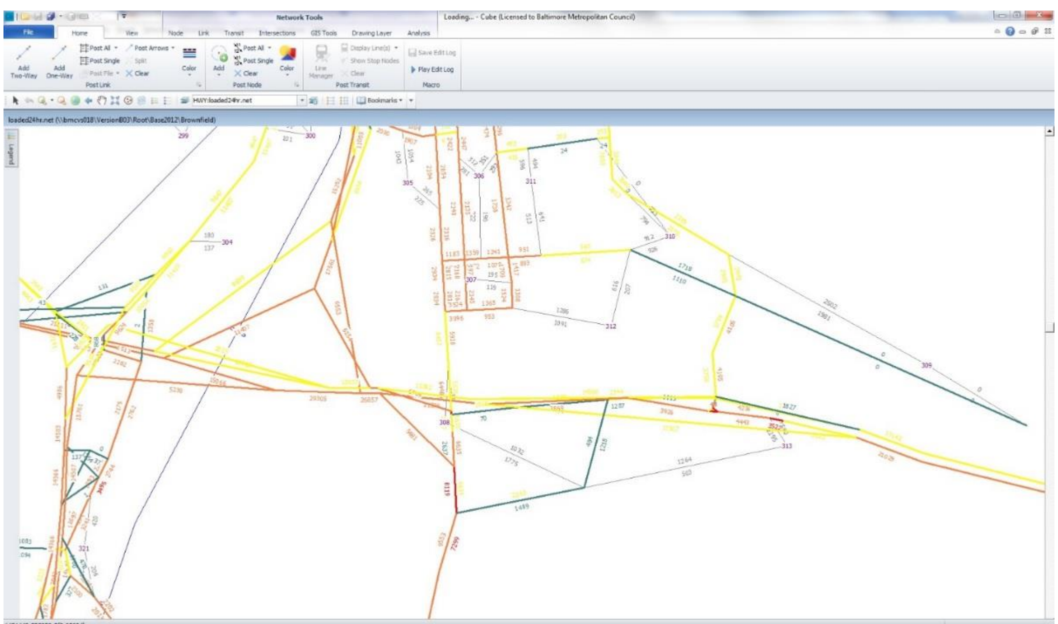


Figure 4.12. Brownfield Scenario P.M. Peak Period Assignment for Links near TAZs 308 and 313



4.3 CAPACITY INCREASE SENSITIVITY TEST

The intent of this test was to measure the impact of congestion on time-of-day of travel. While this might have been inferred from a future forecast, such an approach would have resulted from increased population and employment which would impact the entire model. This test was more focused on the effects of the highway network change.

New technology such as automated and connected vehicles has been touted to provide more efficient highway travel as a result of less congestion and higher vehicle travel speeds. Based on information from the region's performance monitoring reports, an unreliable segment of the Baltimore Beltway between Harrisburg Expressway and I-95 was identified. Modeled highway network links for this segment were modified to increase per lane capacity by 10 percent. PopGen and other socioeconomic input data remain unchanged from the base scenario.

While the change in capacity on the segment could affect all components of the InSITE model (after PopGen) due to feedback loops, the impacts were expected to be greatest on tour mode choice and subsequent model components. Results for the following model components were analyzed:

- Regular workplace;
- Work tour destination choice;
- Tour mode choice;
- Tour time-of-day;
- Local transit volumes; and
- Local highway volumes.

Regular Workplace

As expected, the changes in the regular place of work model resulting from the freeway segment Capacity Increase scenario in comparison to the base scenario were virtually indistinguishable. At an aggregate level, there was no change in the home to work tour length frequency distributions for distance and time; coincidence ratios were 1.0. Average times and distances were the same; the absolute change in the average times to the regular workplace for full- and part-time workers was less than half a second, and the change in average distances was less than 60 feet. These results hold for both full-time and part-time workers.

Tour Destination Choice

Changes in tour destination choice as measured by changes in time and distance frequency distributions, as well as average tour durations and distances, resulting from the Capacity Increase scenario in comparison to the base scenario were indistinguishable for all tour purposes. At an aggregate level, there were virtually no changes in time or distance frequency distributions for any of the tour purposes. Coincidence ratios were all 0.99 or 1.0, and average times and distances were almost identical for each tour purpose when compared across the two scenarios.

Tour Mode Choice

The change in Beltway capacity resulted in little difference in work tour mode shares. Since the Beltway is a circumferential route and most transit routes are more radial in nature, no large changes in auto versus transit shares were expected.

Some changes in drive alone versus shared ride mode shares would be reasonable, with a shift to higher drive alone shares in the increased Capacity Scenario. Those changes should be greatest for the work tour purpose since they are most likely to occur in congested peak periods. Table 4.42, Table 4.43, and Table 4.44 show the differences between county-to-county tours for drive alone, shared ride 2, and shared ride 3+ tours, respectively. While the tables show that there are, indeed, differences in tours by the three auto modes, no discernable patterns are obvious. Since the random seeds in the InSITE modeling were kept constant for both the base and Capacity Increase scenarios, the differences can largely be attributed to "random noise" introduced to the static equilibrium assignment process by the capacity changes.

Table 4.42. Differences and Percentage Differences in County-to-County Home-Based Work Tours – Drive Alone

	Difference, Capacity Increase - Base								Percent Difference, Capacity Increase - Base							
	Ba Cy	Ba Co	AA Co	Ho Co	Ca Co	Ha Co	Mo/ PG/ Fr	DC	Ba Cy	Ba Co	AA Co	Ho Co	Ca Co	Ha Co	Mo/ PG/ Fr	DC
Ba Cy	38	15	12	75	1	-40	-20	12	*0%*	*0%*	*0%*	*1%*	*0%*	*-4%*	*-1%*	*5%*
Ba Co	89	-20	77	-36	-4	-151	62	7	*0%*	*0%*	*1%*	*0%*	*0%*	*-2%*	*1%*	*1%*
AA Co	57	-43	95	-14	-1	-15	8	-17	*1%*	*0%*	*0%*	*0%*	*-1%*	*-3%*	*0%*	*0%*
Ho Co	15	-35	76	-22	-12	-4	-137	26	*0%*	*0%*	*1%*	*0%*	*-1%*	*-5%*	*-1%*	*1%*
Ca Co	-12	-14	10	-50	-2	-29	56	40	*-1%*	*0%*	*1%*	*-1%*	*0%*	*-8%*	*1%*	*7%*
Ha Co	-26	124	-23	-2	-10	-39	-4	-25	*-1%*	*1%*	*-1%*	*0%*	*-5%*	*0%*	*0%*	*-4%*
Mo/PG/Fr	9	-34	68	37	5	-35	-501	320	*0%*	*-1%*	*0%*	*0%*	*0%*	*-22%*	*0%*	*0%*
DC	7	-8	5	13	0	-4	-157	82	*6%*	*-4%*	*0%*	*2%*	*0%*	*-80%*	*0%*	*0%*

Table 4.43. Differences and Percentage Differences in County-to-County Home-Based Work Tours – Shared Ride 2

	Difference, Capacity Increase - Base								Percent Difference, Capacity Increase - Base							
	Ba Cy	Ba Co	AA Co	Ho Co	Ca Co	Ha Co	Mo/ PG/ Fr	DC	Ba Cy	Ba Co	AA Co	Ho Co	Ca Co	Ha Co	Mo/ PG/ Fr	DC
Ba Cy	29	92	10	16	-8	-13	-6	-7	*0%*	*1%*	*0%*	*1%*	*-14%*	*-5%*	*-2%*	*-7%*
Ba Co	67	-56	3	-22	-23	13	-21	15	*1%*	*0%*	*0%*	*-1%*	*-3%*	*1%*	*-2%*	*5%*
AA Co	15	-48	69	18	7	-3	-25	11	*1%*	*-2%*	*0%*	*1%*	*14%*	*-2%*	*-1%*	*1%*
Ho Co	-27	-18	-4	-1	-7	-3	44	-6	*-3%*	*-1%*	*0%*	*0%*	*-4%*	*-10%*	*1%*	*-1%*
Ca Co	1	9	-1	-6	6	-1	-8	9	*0%*	*0%*	*0%*	*-1%*	*0%*	*-1%*	*0%*	*5%*
Ha Co	23	23	9	3	0	-54	-6	-28	*2%*	*1%*	*2%*	*1%*	*0%*	*-1%*	*-1%*	*-13%*
Mo/PG/Fr	3	-54	80	-40	-1	-2	27	-57	*0%*	*-3%*	*1%*	*-1%*	*0%*	*-4%*	*0%*	*0%*
DC	-3	-6	-3	5	0	0	-23	106	*-7%*	*-11%*	*-1%*	*3%*	*0%*	*0%*	*0%*	*1%*

Table 4.44. Differences and Percentage Differences in County-to-County Home-Based Work Tours – Shared Ride 3+

	Difference, Capacity Increase - Base								Percent Difference, Capacity Increase - Base							
	Ba Cy	Ba Co	AA Co	Ho Co	Ca Co	Ha Co	Mo/ PG/ Fr	DC	Ba Cy	Ba Co	AA Co	Ho Co	Ca Co	Ha Co	Mo/ PG/ Fr	DC
Ba Cy	-3	-53	-3	9	1	-15	1	-5	*0%*	*-1%*	*0%*	*1%*	*4%*	*-10%*	*0%*	*-9%*
Ba Co	-82	36	44	22	10	-43	15	-3	*-1%*	*0%*	*2%*	*1%*	*2%*	*-4%*	*2%*	*-1%*
AA Co	-4	-33	-96	5	7	8	0	-16	*0%*	*-2%*	*-1%*	*0%*	*23%*	*9%*	*0%*	*-2%*
Ho Co	21	-5	24	-41	9	-7	35	15	*3%*	*0%*	*1%*	*-1%*	*7%*	*-30%*	*1%*	*3%*
Ca Co	-3	-1	-10	5	10	8	1	3	*-1%*	*0%*	*-4%*	*1%*	*0%*	*15%*	*0%*	*3%*
Ha Co	10	5	6	-21	12	7	-4	6	*1%*	*0%*	*2%*	*-8%*	*55%*	*0%*	*-1%*	*4%*
Mo/PG/Fr	-20	-31	19	34	13	-1	-98	67	*-3%*	*-3%*	*0%*	*1%*	*3%*	*-3%*	*0%*	*0%*
DC	3	12	-2	-12	-1	1	17	-42	*23%*	*35%*	*-1%*	*-16%*	*-50%*	*100%*	*0%*	*-1%*

Key to Tables 4.42 through 4.44:

Ba Cy = Baltimore City
Ba Co = Baltimore County
AA Co = Anne Arundel County
Ho Co = Howard County
Ca Co = Carroll County
Ha Co = Harford County
Mo/PG/Fr = Montgomery/Prince George's/Frederick Counties
DC = Washington, D.C.

Tour Time-of-Day Choice

Figure 4.13 shows diurnal distributions of work tours by arrival time at the workplace and Figure 4.14 shows the diurnal distributions for departures from the workplace. Again, the change in capacity on the Beltway freeway segment had almost no change on the diurnal distributions of work tour arrival and departure times from the workplace.

Figure 4.13. Work Tours by Arrival Time at Workplace

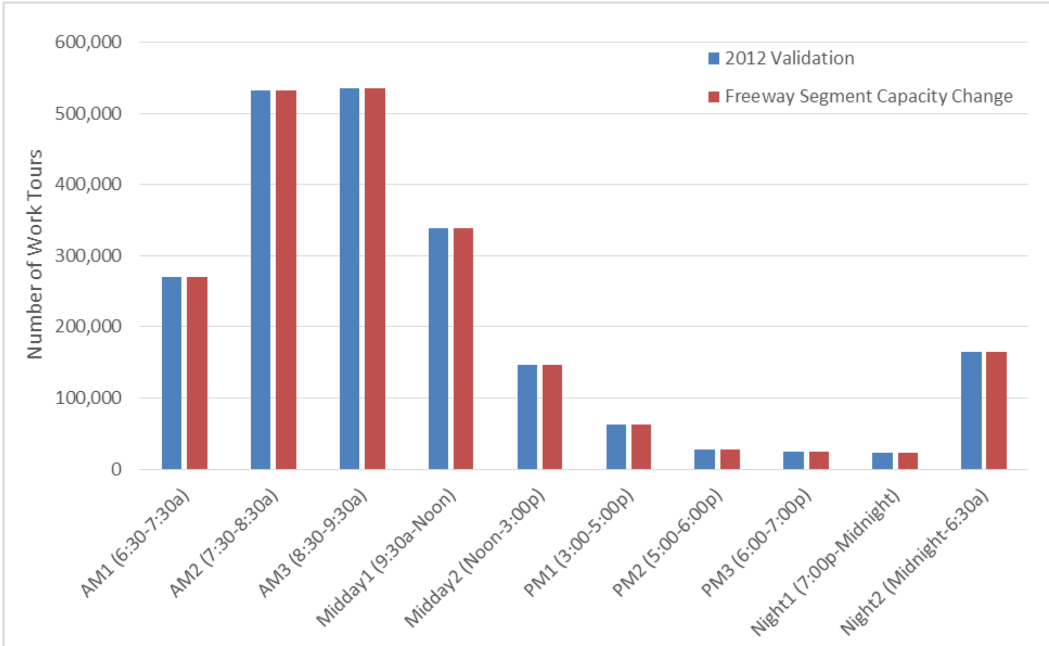
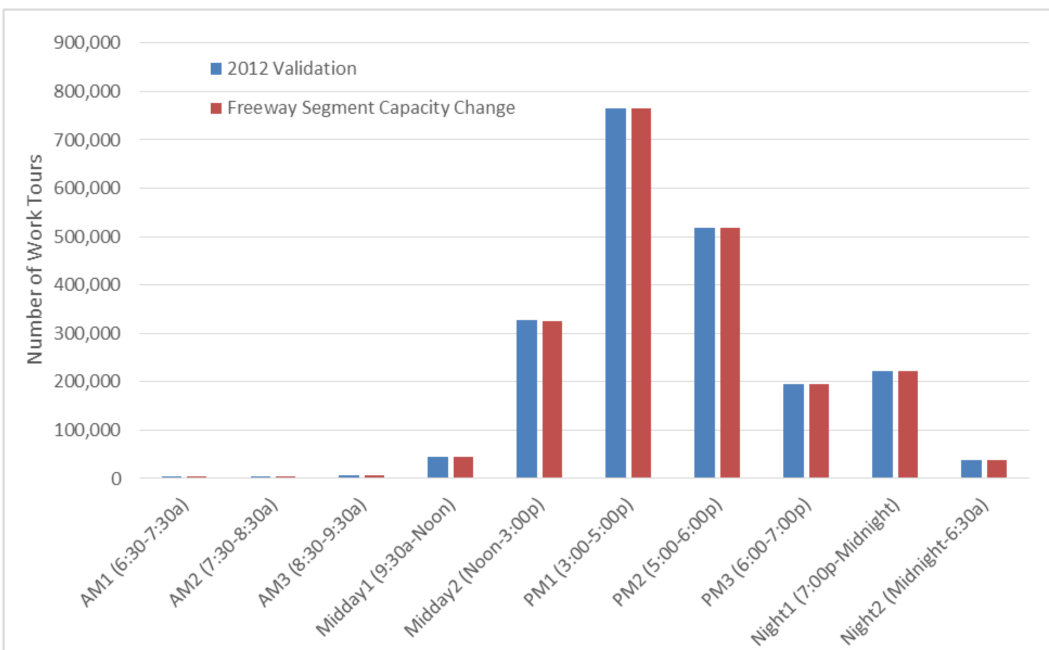


Figure 4.14. Work Tours by Departure Time from Workplace



Local Transit Volumes

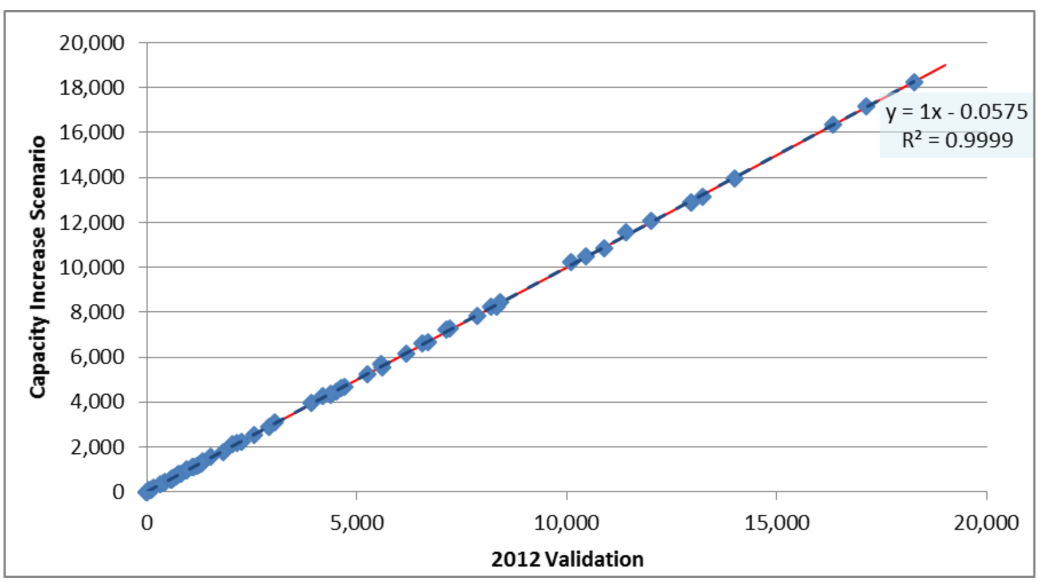
Bases on the lack of change in tour mode shares and the circumferential nature of the freeway segment capacity changes, little change should be expected in regional or localized transit volumes. Table 4.45 shows the linked transit trips and estimated boardings by mode for the base and Capacity Increase scenarios. Overall, there is very little change in transit use in the region. Figure 4.15 shows a scatterplot of the MTA bus boardings by line for the Capacity Increase scenario versus the bus boardings by line for the base scenario. As shown by the regression line and R^2, the boardings by line are almost identical for the two model runs.

Table 4.45. Linked Transit Trips and Boardings

	Linked Trips				Boardings*			
Mode	Base Scenario	Capacity Increase Scenario	Difference	Percentage Difference	Base Scenario	Capacity Increase Scenario	Difference	Percentage Difference
MTA Bus	187,491	187,343	-148	0%	276,263	275,832	-431	0%
LRT & Metro	63,616	63,491	-125	0%	110,537	110,358	-179	0%
MARC	263,575	263,552	-23	0%	31,451	32,101	650	2%
Total	263,575	263,552	-23	0%	418,251	418,291	40	0%

* Boardings by mode have been estimated by the assigned number of linked trips on the mode multiplied by the number of boardings (i.e. transfers + 1) on any mode required on the transit path for the interchange. Linked trips by mode are determined by highest mode used (from the mode hierarchy list) on the transit path for the interchange.

Figure 4.15. MTA Bus Boardings – Capacity Increase Scenario versus Base Scenario



Local Highway Volumes

In the aggregate, the highway assignment results are very similar between the base and Capacity Increase scenarios. The overall difference in VMT is less than one half percent for every facility type and in every county except for Baltimore City and Baltimore County, where the freeway segment is located. The VMT is about one percent higher in Baltimore County and just under one percent lower in Baltimore City, where some of the facilities from which volume is diverted to the improved segment are located. Overall, the percentage root mean square difference between the two assignments is less than three percent.

Figure 4.16 shows heat plots comparing the assigned PM peak period traffic volumes on the inner loop of the freeway segment from the base and Capacity Increase scenarios. The volumes from the four p.m. peak assignments are shown for each heat plot. Figure 4.17 shows similar heat plots, but for the outer loop. There is very little difference between the base and Capacity Increase scenario heat plots for either the inner or outer loops.

These results may be expected. Static user equilibrium (SUE) assignment procedures are used in InSITE. Based on the results shown in Figure 4.16 and Figure 4.17, there appear to be chokepoints at the northern end of the freeway segment and in the middle of the segment. Since SUE will allow the volume on a network link to exceed the capacity (i.e. the volume/capacity ratio can exceed 1.0), it is likely that the two chokepoints serve as weirs for the traffic on the segment. Thus, even with the 10 percent increase in capacity, the volume/capacity ratios at the chokepoints may be high enough that additional traffic cannot be "forced" through the segment.

Figure 4.16. P.M. Peak Traffic Heat Plot of Inner Loop of Beltway Segment – Capacity Increase Scenario versus Base Scenario

Base Scenario – Inner Loop Volumes **Capacity Increase Scenario – Inner Loop Volumes**

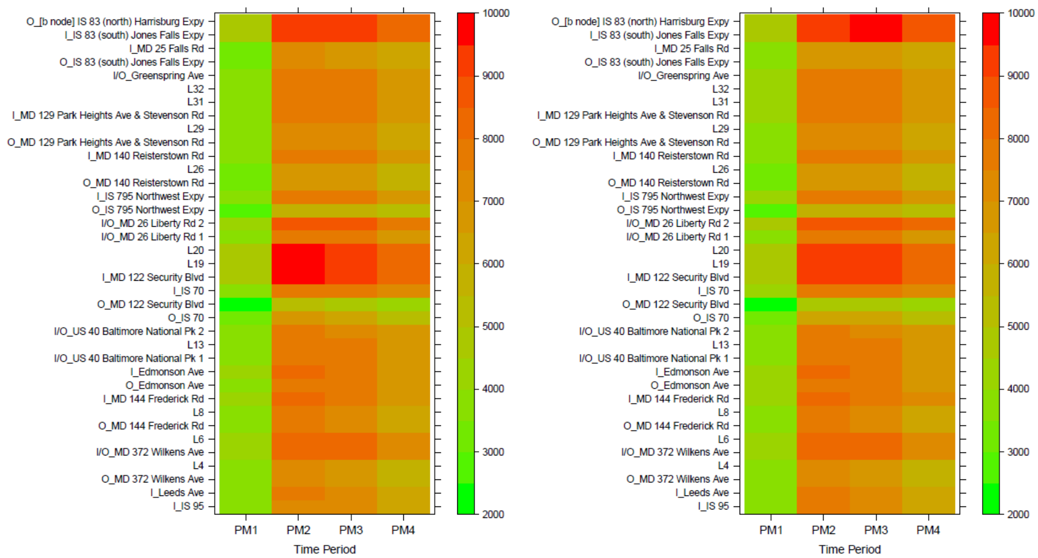
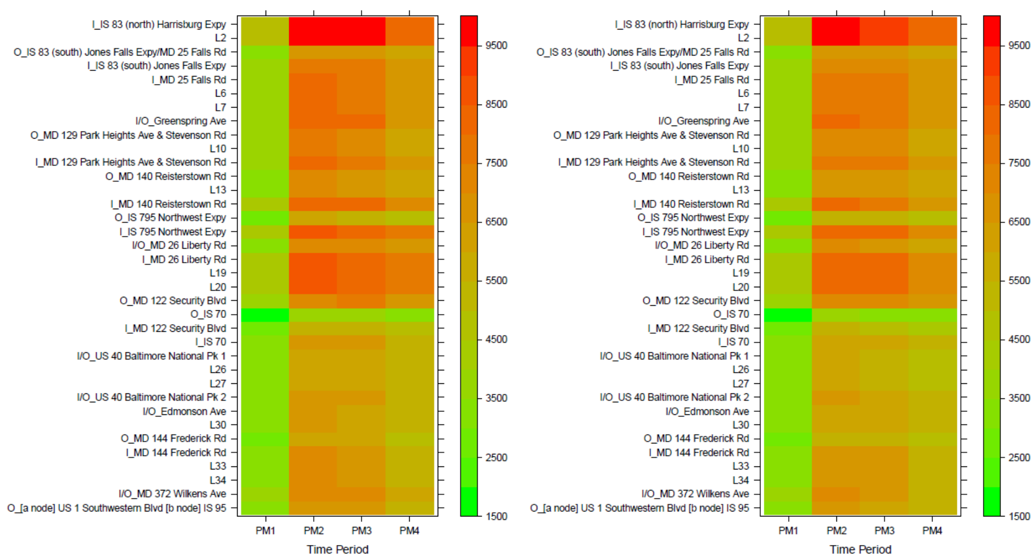


Figure 4.17. P.M. Peak Traffic Heat Plot of Outer Loop of Beltway Segment – Capacity Increase Scenario versus Base Scenario

Base Scenario – Outer Loop Volumes **Capacity Increase Scenario – Outer Loop Volumes**



4.4 YEAR 2000 BACKCAST

The backcast to 2000 is intended to demonstrate the impacts of changing demographic and networks on the model system. Substantial effort is required to fully understand the results of such a backcast validation. Three summaries should be made if data are available:

- 2000 backcast scenario versus 2012 base scenario
- 2000 survey data expanded to 2000 versus 2008 survey data expanded to 2012
- 2000 backcast scenario versus 2000 survey data expanded to 2000

The third point is the primary check and reason for the temporal validation. Based on a project for FHWA evaluating model runs from BMC's 2000 and 2008 trip based models, a conclusion was reached that results of two different scenarios using the same model showed much more similarity than results using different models for the two scenarios. An example of this finding was that the observed VMT difference between the 2000 and 2008 base scenarios was about 10 percent, but the VMT difference when forecasting 2008 using the BMC model estimated and calibrated to 2000 or backcasting 2000 using the BMC model estimated and calibrated to 2008 was only about five percent, or one half the actual change. Also, the home based work average trip durations were about 21 minutes for both 2000 and 2008 based on the 2000 model while they were about 25 minutes for both 2000 and 2008 based on the 2008 model. These findings were not surprising since various parameters and assumptions were changed between the 2000 and 2008 BMC models, and some of these changes were undoubtedly due to differences in the observed travel patterns for members of the household surveyed and used for the validations of the two models, as well as improvements made to the 2008 model when it was developed.

One of the goals for activity based models such as InSITE is that they model traveler behavior rather than travel patterns. Thus, it is hoped that the InSITE model produces backcasts that more closely reproduce observed 2000 travel patterns than the trip based models.

As this is being written, observed traffic and transit volumes are available for 2000, but not expanded household survey data. Thus, this memorandum focuses on the 2000 backcast scenario and how it compares to the validated 2012 base scenario results. When the 2000 survey data are expanded to 2000 demographic data, the comparisons listed in the second and third bullet points can be made.

Synthetic Population

PopGen was rerun with targets based on year 2000 demographic data. In addition, the source households for PopGen were from the 2000 Census PUMS data. The following section compares the 2012 PopGen results to the 2000 PopGen results.

Table 4.46 shows the distribution of population by age and person type for the 2012 base scenario, and Table 4.47 shows the same distribution for 2000. Table 4.48 shows the percent changes for the 2000 backcast in comparison to the 2012 base for the various strata. As shown in Table 4.48, there are about eight percent fewer people in the 2000 backcast scenario than in 2012. The percentage changes vary by person type, with the populations of adult students and non-working adults for 2000 most different (lower) from 2012; the total population of younger children (the sum of Child 1 and Child 2) changes least from 2012 in the 2000 backcast.

There are substantial changes in populations by age group. It is interesting to note that the age distribution for workers in 2000 was skewed much more to younger workers than in 2012. Of particular interest is the lower numbers of full time and part time workers and seniors in the 65+ age range. The relative differences in the 65+ age range population for 2000 compared to 2012 are basically the converse of those tested in the aging scenario sensitivity test.

Table 4.46. 2012 Base Scenario Population by Person Type and Age

	Age Range								
Person Type	**0-4**	**5-15**	**16-17**	**18-19**	**20-24**	**25-40**	**41-64**	**65+**	**Total**
Child 1	338,642	0	0	0	0	0	0	0	338,642
Child 2	0	733,350	0	0	0	0	0	0	733,350
Child 3	0	0	113,420	37,553	0	0	0	0	150,973
Adult Student	0	0	0	64,269	154,052	53,842	14,158	3,795	290,116
Full Time Worker	0	0	0	28,768	154,552	926,336	1,120,351	91,163	2,321,170
Part Time Worker	0	0	0	43,516	58,143	75,458	119,935	45,434	342,486
Non-working Adult	0	0	0	16,704	19,953	137,265	435,853	0	609,775
Senior	0	0	0	0	0	0	0	469,125	469,125
Total	338,642	733,350	113,420	190,810	386,700	1,192,901	1,690,297	609,517	5,255,637

Table 4.47. 2010 Backcast Scenario Population by Person Type and Age

	Age Range								
Person Type	**0-4**	**5-15**	**16-17**	**18-19**	**20-24**	**25-40**	**41-64**	**65+**	**Total**
Child 1	318,168	0	0	0	0	0	0	0	318,168
Child 2	0	752,122	0	0	0	0	0	0	752,122
Child 3	0	0	112,327	21,244	0	0	0	0	133,571
Adult Student	0	0	0	36,392	89,183	44,452	11,644	6,231	187,902
Full Time Worker	0	0	0	36,421	128,490	943,549	1,021,413	50,848	2,180,721
Part Time Worker	0	0	0	38,854	71,670	90,169	95,475	42,195	338,363
Non-working Adult	0	0	0	19,053	20,441	156,349	307,180	0	503,023
Senior	0	0	0	0	0	0	0	411,307	411,307
Total	318,168	752,122	112,327	151,964	309,784	1,234,519	1,435,712	510,581	4,825,177

Table 4.48. Percent Change in 2000 Backcast Population from 2012 by Person Type and Age

	Age Range								
Person Type	**0-4**	**5-15**	**16-17**	**18-19**	**20-24**	**25-40**	**41-64**	**65+**	**Total**
Child 1	-6.0%	–	–	–	–	–	–	–	-6.0%
Child 2	–	2.6%	–	–	–	–	–	–	2.6%
Child 3	–	–	-1.0%	-43.4%	–	–	–	–	-11.5%
Adult Student	–	–	–	-43.4%	-42.1%	-17.4%	-17.8%	64.2%	-35.2%
Full Time Worker	–	–	–	26.6%	-16.9%	1.9%	-8.8%	-44.2%	-6.1%
Part Time Worker	–	–	–	-10.7%	23.3%	19.5%	-20.4%	-7.1%	-1.2%
Non-working Adult	–	–	–	14.1%	2.4%	13.9%	-29.5%	–	-17.5%
Senior	–	–	–	–	–	–	–	-12.3%	-12.3%
Total	-6.0%	2.6%	-1.0%	-20.4%	-19.9%	3.5%	-15.1%	-16.2%	-8.2%

Table 4.49 shows the distribution of households by number of workers and income group for 2012, and Table 4.50 shows the same information for 2000. Table 4.51 and Table 4.52 show the percentage distributions for households by number of workers and income group. It should be noted that the same income breakpoints in real dollars were used for each forecast year for the PopGen runs. Based on the Baltimore/ Washington CPIs for 2000 and 2010, that would imply the following breakpoints for 2000 in 2000 dollars (Table 4.49 through Table 4.52 continue to show the income groupings in constant, 2010 dollars):

Breakpoints in 2010$	Breakpoints in 2000$
$15,000	$11,300
$30,000	$22,700
$50,000	$37,800
$100,000	$75,700

As shown in Table 4.49 and Table 4.50, there were fewer workers per household in 2012 than in 2000, possibly reflecting lingering effects of the Great Recession. Further, as shown in Table 4.51 and Table 4.52, there are relatively fewer households in the lowest income group in 2000 (8 percent) than in 2012 (10 percent) when the breakpoints used for each year are kept in constant dollars. Again, this might reflect the lingering impact of the Great Recession on household income in 2012.

The maintenance of income breakpoints in constant dollars is a departure from modeling procedures that keep the same percentile distributions of households by income group. Using percentiles to define income groups suggests that the actual buying power of household's money is not what is important to travel decisions, but, instead, a household's relative income to other households affects behavior. An underlying assumption regarding InSITE is that it forecasts activity and travel behavior; to this extent, a household's actual income rather than its relative income is assumed to affect travel behavior.

Table 4.49. Households by Number of Workers and Income Group – 2012 Base Scenario

		Income Group (2010 $)				
Workers in Household	**Total Households**	**< $15K**	**$15K - $30K**	**$30K - $50K**	**$50K- $100K**	**$100K+**
All households	**2,076,197**	**204,315**	**206,054**	**310,732**	**675,934**	**679,162**
0 workers	**415,879**	149,920	90,202	68,353	75,486	31,918
1 worker	**856,065**	49,590	100,401	186,543	329,789	189,742
2 workers	**652,493**	4,489	14,351	48,766	226,045	358,842
3+ workers	**151,760**	316	1,100	7,070	44,614	98,660
Avg. Workers/HH	***1.31***	***0.29***	***0.65***	***1.00***	***1.40***	***1.88***

Table 4.50. Households by Number of Workers and Income Group – 2000 Backcast

		Income Group (2010 $)				
Workers in Household	Total Households	< $15K	$15K - $30K	$30K - $50K	$50K-$100K	$100K+
All households	**1,890,968**	**152,960**	**180,295**	**291,068**	**634,455**	**632,190**
0 workers	**380,808**	105,197	78,445	74,765	80,141	42,260
1 worker	**724,130**	43,430	85,444	166,251	272,151	156,854
2 workers	**628,788**	4,087	14,747	44,248	240,184	325,522
3+ workers	**157,242**	246	1,659	5,804	41,979	107,554
Avg. Workers/HH	***1.44***	***0.34***	***0.68***	***0.97***	***1.50***	***2.08***

Table 4.51. Percentage of Households by Number of Workers and Income Group – 2012 Base Scenario

		Income Group (2010 $)				
Workers in Household	Total Households	< $15K	$15K - $30K	$30K - $50K	$50K-$100K	$100K+
All households	**100%**	**10%**	**10%**	**15%**	**33%**	**33%**
0 workers	**20%**	7%	4%	3%	4%	2%
1 worker	**41%**	2%	5%	9%	16%	9%
2 workers	**31%**	0%	1%	2%	11%	17%
3+ workers	**7%**	0%	0%	0%	2%	5%

Table 4.52. Percentage of Households by Number of Workers and Income Group – 2000 Backcast

		Income Group (2010 $)				
Workers in Household	Total Households	< $15K	$15K - $30K	$30K - $50K	$50K-$100K	$100K+
All households	**100%**	**8%**	**10%**	**15%**	**34%**	**33%**
0 workers	**20%**	6%	4%	4%	4%	2%
1 worker	**38%**	2%	5%	9%	14%	8%
2 workers	**33%**	0%	1%	2%	13%	17%
3+ workers	**8%**	0%	0%	0%	2%	6%

Regular Workplace

The numbers of workers with and without regular workplaces are about the same for the base and backcast scenarios. This seems reasonable.

The average trip lengths to work are slightly lower in the backcast scenario, as shown in Table 4.53. Average distances are about two percent lower while average travel times are about three percent lower. This reflects a slight decline in average speed, which would be consistent with an increase in congestion between 2000 and 2012. The time and distance frequency distributions reflect these differences.

Table 4.53. Average Times and Distances to Regular Workplace

Person Type	2012 Base Scenario			2010 Backcast Scenario			Percent Difference [(Backcast-Model)/ Model]	
	Average Time	Average Distance	Workers with Usual Workplace	Average Time	Average Distance	Workers with Usual Workplace	Time	Distance
Full Time Worker	22.7	12.6	2,145,440	22.1	12.3	2,015,106	-2.9%	-2.1%
Part Time Worker	21.0	11.5	269,590	20.5	11.2	269,046	-2.1%	-1.9%
Total	22.5	12.4	2,415,030	22.5	12.4	2,284,152	-2.8%	-2.1%

While there are fewer full-time workers in the backcast scenario, the proportion without a usual workplace remains constant with that for the 2012 base scenario at 7.6 percent (see Table 4.54). For part-time workers, the proportion of workers without a usual workplace decreases from 21.3 percent for the 2012 base scenario to 20.5 percent for the 2000 backcast scenario. It is not clear why this change occurs, but it is not large. As shown in Table 4.54, the number of full-time and part-time workers increases from 2,519,084 in 2000 to 2,663,656 in 2010, or about 5.7 percent.

Table 4.54. Workers with No Regular Workplace

Person Type	2012 Base Scenario				2010 Backcast Scenario			
	No Regular Workplace	Have Regular Workplace	Total	Percent with No Regular Workplace	No Regular Workplace	Have Regular Workplace	Total	Percent with No Regular Workplace
Full Time Worker	175,730	2,145,440	2,321,170	7.6%	165,615	2,015,106	2,180,721	7.6%
Part Time Worker	72,896	269,590	342,486	21.3%	69,317	269,046	338,363	20.5%
Total	248,626	2,415,030	2,663,656	9.3%	234,932	2,284,152	2,519,084	9.3%

Daily Activity Pattern

The overall changes in numbers of persons by person type making each type of daily activity pattern appear to be logical for the backcast scenario. In general, the percentages of daily activity patterns involving work decrease and the numbers of travel patterns involving non-mandatory travel or stay at home activity patterns increase. At a more disaggregate level, some changes in daily activity patterns appear to be illogical. However, the illogical changes affect relatively few people/activity patterns.

Table 4.55 shows the difference in the distribution of daily activity patterns by person type for the 2012 base and the 2000 backcast scenarios. While there are differences in the population totals for each person type between the scenarios, there are only very small differences in the percentages of daily activity patterns for every person type. So while there are, for example, many more university tours in the base scenario than the backcast scenario, this is due to the much higher number of adult students in the base scenario, rather than due to changes in daily activity pattern generation. It should be noted that differences by various population segments, including county, vehicle availability, gender, age, and income level also showed only small differences in the percentages of daily activity patterns between the two scenarios. Perhaps the largest differences was for seniors in households with more autos than workers (about two thirds of seniors live in such households), where 49 percent of these seniors stayed at home in the backcast scenario, compared to 41 percent in the base scenario.

Table 4.55. Difference in the Proportions of Population by Daily Activity Pattern Type and Person Type 2000 Backcast – 2012 Base

Daily Activity Pattern Type	Full-Time Worker	Part-Time Worker	Adult Student	Non-Working Adult	Senior	Child 1	Child 2	Child 3	Total
One Work Tour, No Stops	0%	0%	1%	0%	0%	0%	0%	0%	0%
One Work Tour, With Stops	0%	0%	1%	0%	0%	0%	0%	0%	0%
Two Work Tours, No Stops	0%	0%	0%	0%	0%	0%	0%	0%	0%
Two Work Tours, Stops On One	0%	0%	0%	0%	0%	0%	0%	0%	0%
Two Work Tours, Stops On Both	0%	0%	0%	0%	0%	0%	0%	0%	0%
One University & One Work Tour, No Stops	0%	0%	0%	0%	0%	0%	0%	0%	0%
One University & One Work Tour, Stops On Work Tour	0%	0%	0%	0%	0%	0%	0%	0%	0%
One School & One Work Tour, No Stops	0%	0%	0%	0%	0%	0%	0%	0%	0%
One School & One Work Tour, Stops On Work Tour	0%	0%	0%	0%	0%	0%	0%	0%	0%
One University Tour	0%	0%	0%	0%	0%	0%	0%	0%	0%
Two University Tours	0%	0%	0%	0%	0%	0%	0%	0%	0%
One School Tour	0%	0%	0%	0%	0%	0%	0%	0%	0%
Two School Tours	0%	0%	0%	0%	0%	0%	0%	0%	0%
Non-Mandatory Travel	0%	0%	1%	0%	-1%	0%	0%	0%	0%
Stay At Home	0%	0%	-3%	0%	1%	0%	0%	0%	0%
Total Population Change	0%	0%	0%	0%	0%	0%	0%	0%	0%

Tour Destination Choice

Summaries of both mandatory tour destination choices, which are mainly determined in the regular workplace and school location choice models, and non-mandatory tours are summarized in this section.

The overall changes in the numbers of work tours by person type and the average work tour durations and distances for the 2000 backcast scenario are reasonable in comparison to the 2012 base scenario. The results suggest that some employment in the region is filled by casual (and volunteer) employees rather than full- or part-time workers. However, the results also suggest that slightly over five percent of the jobs in the BMC region will not be filled by workers.

Likewise, the changes in numbers, durations, and distances of individual non-mandatory tours for the aging scenario are reasonable in comparison to the 2012 base scenario and suggest that overall vehicle-miles of travel in the region for the aging scenario should decrease slightly from the 2012 base scenario.

The tour length frequency distributions for the backcast scenario are almost identical to those for the base scenario, with coincidence ratios for both time and distance greater than 0.95 for every tour purpose.

Table 4.56 summarizes the average work tour trip durations and distances (from home to work location) for the different person types. InSITE shows small changes between the two scenarios in average durations and distances for full- and part-time workers. Average durations and distances change more for other person types with the average durations and distances in the backcast scenario higher for adult students and older children and lower for the other person types. Overall, the average work tour distance is one percent lower in the backcast scenario, and the average work tour time is four percent lower.

Table 4.56. Average Work Tour Times and Distances

	Average Time			Average Distance		
Person Type	2012 Base	2000 Backcast	Percent Difference	2012 Base	2000 Backcast	Percent Difference
Full-Time Worker	20.7	20.0	-3.7%	11.0	10.9	-1.6%
Part-Time Worker	17.2	16.5	-3.9%	8.8	8.6	-1.5%
Senior	15.7	14.0	-7.6%	7.2	7.0	-3.1%
Non-Working Adult	14.6	13.4	-8.3%	6.9	6.4	-6.2%
Adult Student	14.7	14.3	-3.1%	6.6	6.9	4.1%
Child 3	17.2	17.3	0.5%	8.4	9.0	7.7%
Total	20.3	19.6	-3.6%	10.7	10.6	-1.3%

Table 4.57 summarizes the average school tour trip durations and distances for the two scenarios by child age group. Average school tour lengths are a bit lower in the backcast scenario though less so for children age 6-15.

Table 4.57. Average School Tour Times and Distances

	Average Time			Average Distance		
Person Type	2012 Base	2000 Backcast	Percent Difference	2012 Base	2000 Backcast	Percent Difference
Child 3	17.8	17.3	-2.9%	8.8	8.4	-4.3%
Child 2	10.1	10.1	0.1%	5.2	5.1	-1.7%
Child 1	11.9	11.6	-2.4%	6.2	5.9	-3.9%
Total	11.4	11.3	-0.8%	6.0	5.8	-2.2%

Table 4.58 summarizes the average individual non-mandatory tour trip durations and distances for the different person types. InSITE shows very little change in average durations and distances for all person types.

Table 4.58. Average Individual Non-Mandatory Tour Times and Distances

	Average Time			Average Distance		
Person Type	2012 Base	2000 Backcast	Percent Difference	2012 Base	2000 Backcast	Percent Difference
Full-Time Worker	11.9	11.9	-0.3%	5.6	5.6	1.5%
Part-Time Worker	11.8	11.9	0.9%	5.6	5.7	2.1%
Senior	12.3	12.1	-1.6%	5.8	6.1	-1.2%
Non-working Adult	12.5	12.4	-0.5%	5.9	5.8	-0.7%
Adult Student	11.4	11.6	1.4%	5.1	5.2	3.0%
Child 3	10.0	10.2	1.1%	4.5	4.6	2.6%
Child 2	10.2	10.2	-0.2%	4.7	4.7	0.8%
Child 1	10.1	10.0	-1.2%	4.5	4.5	0.2%
Total	11.9	11.8	-0.5%	5.5	5.6	0.8%

Tour Time of Day of Travel

The overall arrival times at workplaces and departure times from workplaces, and the average durations spent at workplaces for the 2000 backcast scenario are very similar to those for the 2012 base scenario. The percentages of both arrivals at and departures from work for each half hour period are within 0.1 percent for the two scenarios. The average work tour durations are essentially identical between the two scenarios, with some very small differences by person type and income level.

Similar results are seen for school tours, with very small changes in peaking between the two scenarios, and very little difference in duration by child age, gender, or income group. The same thing occurs for non-mandatory tours (of all purposes).

The tour time of day choice model uses mainly variables that would not be expected to vary much over time, including constants and shift variables for specific time ranges and person and household characteristics such as person type, age, and income level. Congestion related variables are included so that peak spreading can be considered; however, it appears that congestion levels in the model region did not change substantially enough between 2000 and 2012 to significantly affect travel scheduling. It might be worthwhile to examine changes in time of day choices within geographic subregions, some of which may have seen greater changes in congestion levels. However, the county level summaries used in other model components (including the treatment of the Washington region as a single district) may be too coarse to notice these differences. Using smaller subregions might identify specific places where congestion levels changed more significantly, but the smaller numbers of tours considered along with the likelihood of many tours not being contained within smaller subregions could make such an analysis difficult.

Tour Mode Choice

The major difference between the mode shares for 2000 backcast scenario the 2012 base is the substantial decrease in the share of transit with auto access mode in 2000 (Table 6.1). Most tour purposes also showed a slight increase in transit shares with walk access in 2000 as compared to 2012, with work tours showing more than a 20 percent increase. There was also a small increase in walk mode share for nearly all tour purposes (individual non-mandatory tours showed stable walk shares for 2000 and 2012).

The main driver of these changes is the change in the transit service provided in the region between 2000 and 2012 along with fare changes. It is notable that the increases in 2000 walk access transit mode shares are much smaller for travelers from low income households, and travelers from households without autos actually have lower mode shares for transit with walk access in 2000 than in 2012. The decreases in mode share for transit with auto access occur across all demographics although geographically, these decreases are concentrated in the Washington region. All of these trends hold for both work and non-mandatory tours.

Table 4.59. Work and Non-Mandatory Tour Mode Shares

	Work Tours		Non-Mandatory Tours	
Tour Mode	**2012 Base**	**2000 Backcast**	**2012 Base**	**2000 Backcast**
Drive Alone	55.2%	56.2%	43.2%	42.5%
Shared Ride 2	14.5%	15.5%	23.0%	24.2%
Shared Ride 3	8.5%	8.5%	11.6%	12.3%
Walk To Transit	8.9%	10.9%	7.8%	7.9%
Drive To Transit	9.0%	4.6%	2.2%	0.8%
Walk	3.0%	3.2%	11.6%	11.6%
Bike	0.9%	1.0%	0.7%	0.8%
School Bus	0.0%	0.0%	0.0%	0.0%

5.0 References

Cambridge Systematics, Inc. (2016). BMC InSITE Activity Based Model Estimation. Prepared for Baltimore Metropolitan Council.

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