Baltimore-Washington SCMAGLEV Project

Final Ridership Report

2.2. Document Travel Demand

Deliverable Description: Final Documentation of methodology, data sources, and results of ridership study

2018-11-08

Table of Contents

Notes/Revisions for Version Control:

Final Report:
File Name: Task 2.2_BW_SCMAGLEV_Final_Ridership_Report_2018-11-08

Revision 2 - 2018/08/07
File Name: LB_Task Number 2.2_BW SCMAGLEV_Draft_Ridership Report_Rev2_2018-08-07.docx

EXECUTIVE SUMMARY

The Federal Railroad Administration (FRA), in coordination with the Maryland Department of Transportation (MDOT), is preparing an Environmental Impact Statement (EIS) for the proposed Baltimore-Washington Superconducting Magnetic Levitation (SCMAGLEV) Project between Baltimore, MD, and Washington, DC, with an intermediate stop at Baltimore/Washington International Thurgood Marshall Airport (BWI). Louis Berger has prepared this ridership study of the proposed service in support of the EIS.

ES-1 Project Overview

Magnetic levitation (Maglev) is defined as an advanced transportation technology in which magnetic forces elevate, propel, and guide a vehicle over a specially designed guideway. Central Japan Railway (JRC) has developed SCMAGLEV technology that currently holds the record as the world's fastest train having attained travel speeds of more than 375 miles per hour under test conditions.

The implementation of SCMAGLEV technology in the Baltimore-Washington corridor will provide a high-speed, high-capacity transportation connection between these two major cities substantially improving current travel times and reliability. The project will also provide improved connectivity to BWI for residents and visitors to Anne Arundel and neighboring counties.

Options for terminals include two locations in Washington (Mount Vernon Square or NoMA Gallaudet) and two locations in Baltimore (Westport/Cherry Hill or Inner Harbor/Camden Yards). For the purposes of this report, Louis Berger assumed the Mount Vernon and Westport/Cherry Hill locations for the Washington, DC and Baltimore locations respectively as a base case, with sensitivity analyses conducted to evaluate the ridership impact of alternative station locations.

ES-2 Study Objective and Methods

The objective of this study is to provide all stakeholders engaged in the planning process with an estimate of ridership potential that will inform and advance the project development efforts.

The ridership forecasts were prepared according to best practices in travel forecasting for intercity passenger rail as recommended by the FRA. The study effort included the following work activities.

- An extensive primary data collection program that included the development of a stated preference (SP) survey designed to measure characteristics of existing travel demand, and the willingness to pay for travel time savings and reliability in the Baltimore-Washington corridor.
- A comprehensive review of data sources to establish base year levels of travel demand and origin/destination patterns was undertaken. Data on the existing and planned future regional road and transit network was collected through collaboration with two metropolitan planning organizations in the region (Metropolitan Washington Council of Governments (MWCOG) and Baltimore Metropolitan Council (BMC)) along with MTA and other regional agencies. (b) (4) [redacted]

- A critical assessment of economic growth projections was conducted to establish a reasonable level for the overall increase in travel demand that will occur in the study area. The review included regional MPO forecasts and third-party economic demographic forecasts.
- An intercity passenger forecasting model for the corridor was developed. (b) (4) [redacted]
- Alternative model estimates (sensitivity tests) were used to quantify the impacts of alternative assumptions of key forecasting inputs on corresponding ridership projections. The results of these tests are outlined in this report.
- The study also included a peer review process using independent experts to review forecasting assumptions and procedures.

The key features of the methodology noted above are designed to ensure highly reliable forecasts. It is important to note, however, that it is not possible to forecast future events with certainty. Assumptions employed in the development of this forecast regarding economic growth, competition between modes, and external factors affecting overall travel demand and SCMAGLEV may change in the future. Changes from these assumptions and other unforeseeable factors could produce lower or higher actual ridership than the estimates contained in this report.

ES-3 Travel Demand Model

The ridership analysis was conducted using a travel demand model based on available regional data and customized specifically to analyze intercity trips within the study area. Key features of the travel demand model framework are noted below.

- To support the engineering and environmental analyses, Louis Berger developed a model of average daily travel for four daily time periods with distinct characteristics for intercity travel: Morning (AM) 6:00am to 9:00am; Midday (MD) 9:00am to 4:00pm; Evening (PM) 4:00pm to 7:00pm; and Overnight (NT) 7:00pm to 6:00am.
- Average daily ridership estimates were converted to annual estimates through the application of an annualization factors that differed by trip purpose, e.g., commuter, airport-related, business, non-business, to account for differences in the mix of weekday and weekend travel patterns for each type of trip. (b) (4) [redacted]
- To facilitate the collection of travel data a study area was set to correspond to the boundaries of the MWCOG and BMC regional planning jurisdictions (see Section 2.1). To establish reasonable limits for the market area for intercity travel to be served by SCMAGLEV stations, a catchment area of a 25-mile boundary around each of the three proposed stations was first delineated. Within the Baltimore/Washington region, the 25-mile zone was further refined to reflect what was considered a reasonable catchment area for short distance trips within those respective larger areas.
- Louis Berger assembled a comprehensive accounting of the current level of intercity trips from MPO surveys and models, transit agency data, airport data, and mobile phone O/D data. Given the

catchment area delineation, the total volume of travel in 2017 that constitutes the market for SCMAGLEV is over 117 million person trips annually (see Section 3.2).

- Louis Berger conducted an analysis by travel mode to determine the growth in the total volume of trips into the future. The analysis drew upon data from MPO demographic and economic forecasts, transit agency data, airport data, and third-party economic data sources (see Section 3.2). The overall level of growth in intercity trips in the study areas was estimated at 0.93% compound average annual growth from 2017 through 2050.
- Using the findings of the SP survey on trip characteristics, traveler characteristics, mode choice preferences and willingness to pay, Louis Berger conducted a discrete choice analysis to estimate mode choice models representing the existing travel market and future market with the inclusion of SCMAGLEV (see Section 5.2). (b) (4) [redacted]
- The mode choice model was developed with a nested structure (b) (4) [redacted]
- The implied value of time resulting from the discrete choice analysis is consistent with USDOT guidelines and the household income profile of the study area (see Section 5.1).

ES-4 SCMAGLEV Forecast

Louis Berger developed ridership demand estimates of the proposed SCMAGLEV project using the travel demand model described above. These ridership demand forecasts were developed through a process that first tested fare sensitivity of the various market segments before identifying and applying optimized fares in the forecasting process.

The projected ridership demand for the period from 2025 to 2050 is depicted in Figure ES-1. The forecast includes a 2-year ramp-up period, a period of time during which ridership is building up to "steady-state" forecast levels as travelers become acquainted with the new rail service and adjust their trip-making habits. During the initial two years of the forecast ramp-up, adjusted ridership is 40 and 80 percent respectively, of steady state growth levels predicted by the travel demand model. Ridership following the end of the ramp up period grows from approximately 16.3 million annual trips in 2027, to approximately 24.5 million annual trips at the model's forecast horizon of 2050 – corresponding to an annualized average growth rate of 1.8 percent over that time frame.

(b) (4)

(b) (4)

(b) (4)

[redacted]

(b) (4)

[redacted]

(b) (4)

The SCMAGLEV ridership forecast did not include some additional sources of potential ridership that could accrue to the proposed system. Although not an exhaustive list, the additional factors could result in some potential upside to the base ridership forecast presented here. Key elements of additional sources of ridership are discussed in Section 7.3 and include: 1) economic development activity in and around station areas, and in the regional economy more generally, that may be prompted by the investment and improved mobility and accessibility afforded by SCMAGLEV; 2) capacity constraints on the existing passenger rail system; 3)air-rail code sharing arrangements facilitated by the direct terminal access that SCMAGLEV will provide at BWI; 4) yield management through dynamic fare pricing, already in use by many airline carriers and Amtrak, could further enhance projected ridership demand significantly by more efficiently managing demand for SCMAGLEV service.

1.0 INTRODUCTION

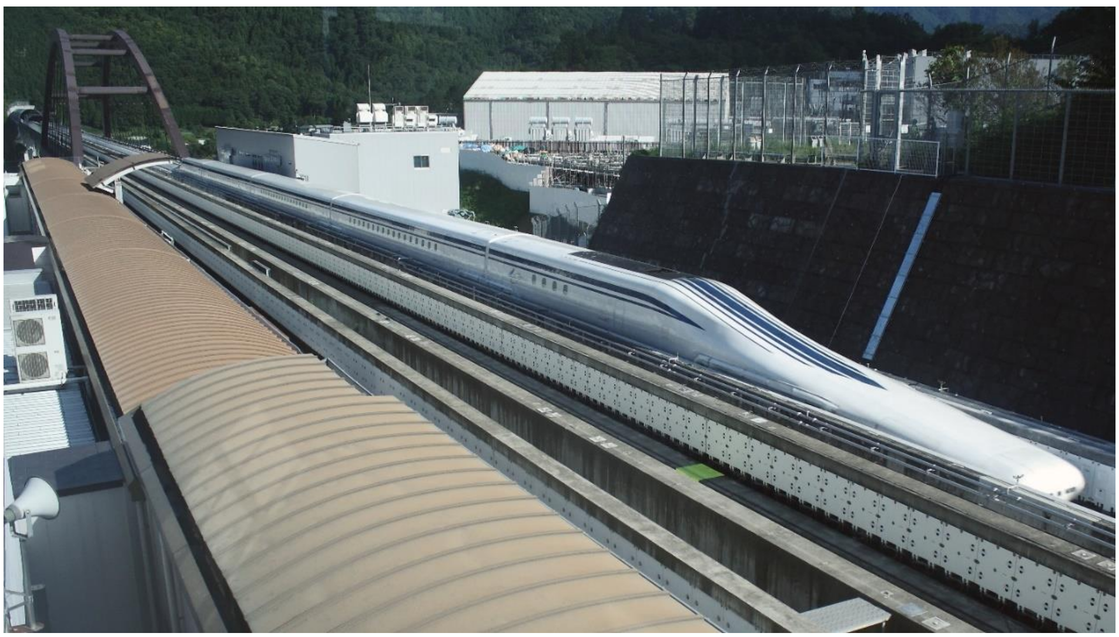
The Federal Railroad Administration (FRA), in coordination with the Maryland Department of Transportation (MDOT), is preparing an Environmental Impact Statement (EIS) for the proposed Baltimore-Washington Superconducting Magnetic Levitation (SCMAGLEV) Project between Baltimore, MD, and Washington, DC, with an intermediate stop at Baltimore-Washington International – Thurgood Marshall (BWI) airport.

Louis Berger has prepared this ridership study of the service in support of the EIS.

1.1 SCMAGLEV Technology

Magnetic levitation (Maglev) is defined as an advanced transportation technology in which magnetic forces elevate, propel, and guide a vehicle over a specially designed guideway. Central Japan Railway (JRC) has developed SCMAGLEV technology that currently holds the record as the world's fastest train having attained travel speeds of more than 375 miles per hour under test conditions.

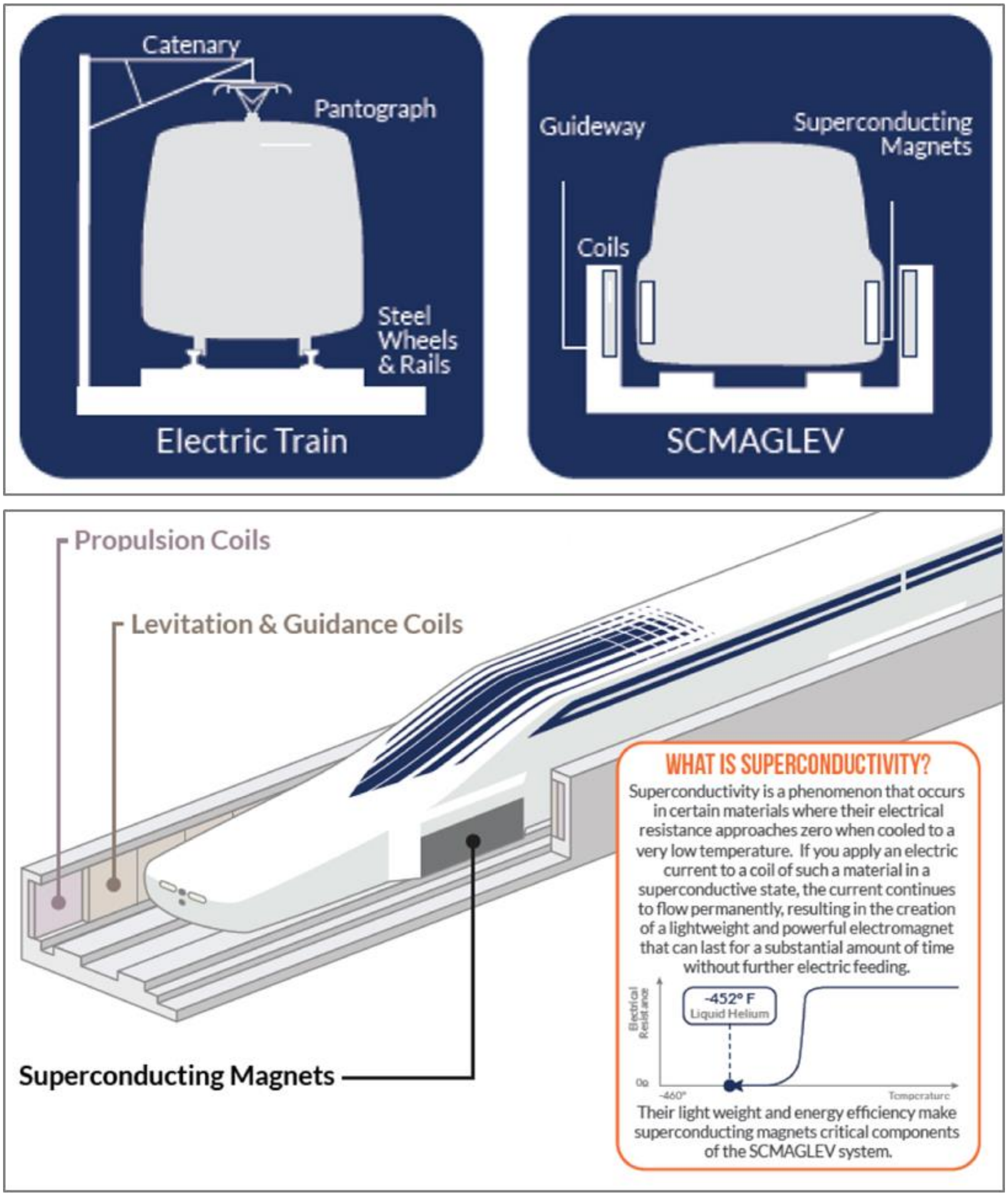
FIGURE 1-1 SCMAGLEV VEHICLE



Source: Saruno Hirobano

Unlike the conventional steel wheel rail systems, SCMAGLEV technology relies on powerful magnetic forces to both suspend and propel train vehicles at speeds of approximately 311 miles per hour under normal operating conditions. Rather than riding directly on standard steel railroad tracks, SCMAGLEV trains travel between the walls of a U-shaped concrete structure as shown in Figure 1-2.

FIGURE 1-2 SCMAGLEV TECHNOLOGY



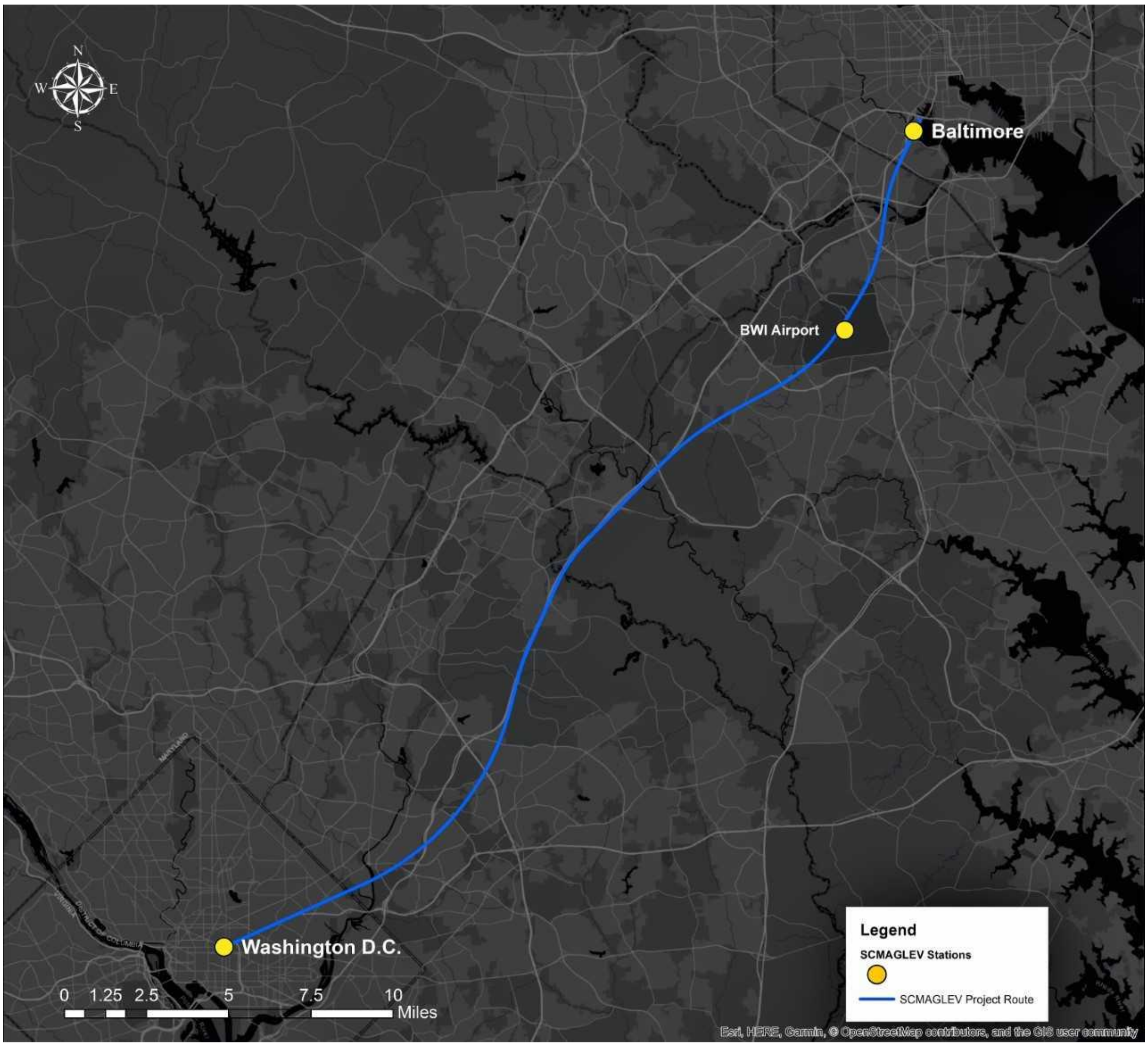
Source: http://www.bwmaglev info/index.php/overview/what-is-scmaglev

In addition to preventing derailment, the guideway carries coils that are used to levitate, propel and guide the SCMAGLEV vehicles in conjunction with powerful superconducting magnets that are installed into the bogies of each train car. Superconductivity is the phenomenon of near zero electric resistance that results when the temperature of certain metals, alloys and oxides falls below a certain level – a superconductive state is achieved in the SCMAGLEV system by cooling a niobium-titanium alloy to a temperature of minus 452 Fahrenheit (minus 269 degrees Celsius) with liquid helium. When an electrical current is applied to the coil in a superconductive state (superconductive coil), this current continues to flow permanently, resulting in the creation of a very large magnetic field.

1.2 Proposed Service

The SCMAGLEV Project will have the three aforementioned station locations in the Baltimore-Washington region. The proposed service will directly serve stations located in Washington, DC and Baltimore, as well as The BWI airport location will be accessible both to airport-related and other trip purposes. Figure 1-3 depicts the various station location options in the corridor while the full list of potential stations in the corridor is provided below.

FIGURE 1-3 SCMAGLEV PROPOSED SERVICE AND STATIONS



- **Washington, DC**

  - Mount Vernon Square or
  - NoMA Gallaudet
- **Baltimore-Washington International Thurgood Marshall Airport (BWI)**
- **Baltimore**
  - Harbor West (Westport/Cherry Hill) or
  - Inner Harbor/Camden Yards

For the purposes of this report, the Louis Berger Team assumed the Mount Vernon and Westport/Cherry Hill locations for the Washington, DC and Baltimore locations, respectively, as a base case, with sensitivity analyses conducted to evaluate the ridership impact of alternative station locations.

1.3 Study Objectives

The objective of this study is to provide all relevant stakeholders engaged in the planning process with an estimate of ridership potential that will inform and advance the project development efforts.

The ridership forecasts were prepared according to best practices in travel forecasting for intercity passenger rail as recommended by the FRA. The integrity of the study is underpinned by the following key features:

- The use of experienced travel demand forecasting consultants.
- A peer review process using independent experts to review forecasting assumptions and procedures.
- Extensive primary data collection including a stated preference (SP) survey designed to measure characteristics of existing travel demand in the Baltimore-Washington corridor.
- A critical assessment of economic growth projections that are used to estimate the overall increase in travel demand.
- The development of a forecasting model for the corridor based on current travel, transport system and economic growth data.
- The adoption of conservative assumptions regarding factors affecting SCMAGLEV usage.
- Alternative model estimates (sensitivity testing) intended to quantify the impacts of different assumptions of key forecasting inputs on corresponding ridership projections.

The key features noted above are designed to ensure highly reliable forecasts. However, it is not possible to forecast future events with certainty. Assumptions regarding economic growth, competition between modes and external factors affecting overall travel demand and SCMAGLEV usage may prove inaccurate. Changes from these assumptions could produce lower or higher actual ridership than the estimates contained in this report.

Outputs of the forecast that were used to determine the economic, financial, and business planning dimensions of the proposed investment include the following:

- Overall ridership demand estimates

- Station-station segment ridership estimates
- Market share analysis
- Market breakdown by user type (business/non-business etc.)
- Ridership demand elasticity with respect to fare
- Ridership demand with respect to level-of-service characteristics
- User benefit metrics (values-of-time)

1.4 Organization of Report

Louis Berger's technical approach and analysis is broken down into six distinct areas of study outlined below. Each of these study areas are discussed in greater detail within their respective chapters of this report.

- Methodological overview (Section 2)
- Market assessment (Section 3)
- Stated preference survey (Section 4)
- Model Estimation and discrete choice analysis (Section 5)
- Travel demand model development (Section 6)
- Ridership forecast development (Section 7)
- Peer review (Section 8)

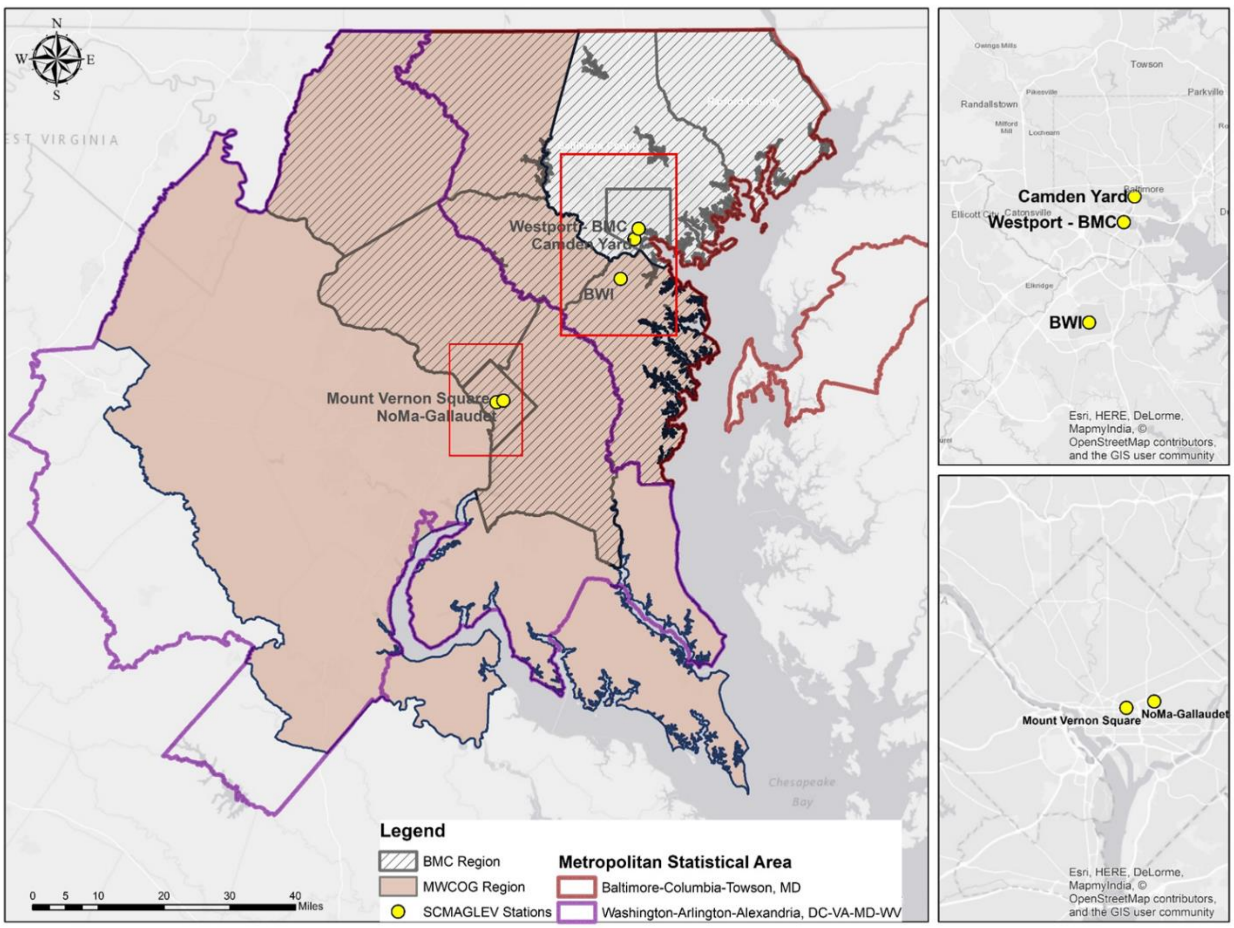
2.0 Methodological Approach Overview

This section of the report provides a high level overview of the methodological approach used to develop the SCMAGLEV ridership forecast. The first portion of this Section details the study area and the geographic definitions governing downstream discussions of methodology in this and subsequent sections of the report. The remaining portions of this section outline the work flow of the methodological approach.

2.1 Study Area

MPOs are agencies designated by the U.S. Department of Transportation to carry out transportation planning and project prioritization for federally funded projects in urbanized areas. These agencies collect data on demographic changes, trip-making patterns, travel demand, and transportation infrastructure in the metropolitan region they cover. The Louis Berger Team used the jurisdictional boundaries of the two Metropolitan Planning Organizations (MPOs), specifically, the BMC (cross-hatched in Figure 2-1 below) and MWCOG (shaded tan), to delineate the initial limits of the study coverage area.

Figure 2-1 Study Area



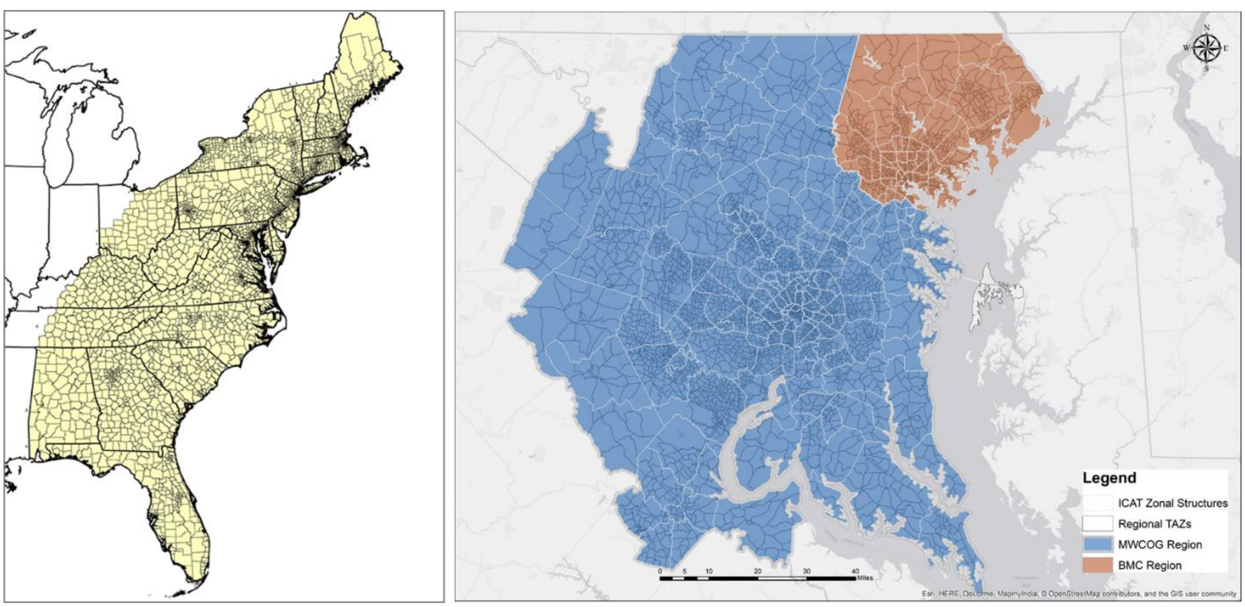
The combined region encompasses 27 counties in the Baltimore-Washington region, spread across both Maryland, Virginia, portions of West Virginia, and the District of Columbia. The geographic extent of both model areas overlap as depicted by the shaded cross-hatched region in Figure 2-1 that covers seven counties in Maryland and the District of Columbia as further discussed in Section 3.1.2.1 of this report.

Figure 2-1 also shows that the area covered by the two MPO regions almost perfectly coincides with geographic reach of the Washington, DC (purple boundary) and Baltimore, MD (red boundary) Metropolitan Statistical Areas (MSA). Because MSAs are typically considered the geographic limit for economic linkages of a region, they thereby provide another useful basis for collecting and organizing the regional databases used in this study.

2.1.1 Zonal Structure

Although MPO TAZ typically form the unit of analysis for intra-urban/regional travel demand studies, Louis Berger sought a level of geographic resolution that was more practical from an intercity travel standpoint but still afforded high degree of granular detail. The Louis Berger Team elected to use the integrated corridor analysis tool (ICAT) zonal system created for the I-95 Corridor Coalition that was intended to support the type of multi-jurisdictional analysis required for this study, given that neither regional model encompasses the likely travel market area. The ICAT zonal system consists of 3,200 zones that span 16 states across the eastern United States as shown in the left portion of Figure 2-2. Each ICAT zone represents aggregations of US Census Bureau census tract boundaries as shown by the left portion of Figure 2-2 that overlays ICAT zones against census tract-based TAZs from the two regional models.

FIGURE 2-2 ICAT ZONAL SYSTEM



Of 3,271 ICAT zones spanning Maine to Florida, 207 zones were located within the 27 counties of the Baltimore-Washington study area as shown in Table 2-1. For comparison, the interregional travel demand model used in theFRA's NEC Futures ridership study was developed based on an Amtrak travel demand model that initially relied on county-based boundaries to delineate a 135 zone system covering a wide multi-state region extending from Virginia in the south, to Massachusetts and portions in New Hampshire in the north.[1]

Table 2-1 also compares the county-level zonal density of the ICAT system against the existing TAZ detail from the two MPOs as shown in Figure 2-2, as well as a comparison against the zonal system that was used in evaluating the 2003 Maglev Draft Environmental Impact Statement (DEIS). Both the 2003 study and this current effort reflect a similar level of zonal detail.

TABLE 2-1 ZONAL SYSTEM COMPARISON

	Maglev Studies		MPO	
County	SCMAGLEV	2003 DEIS	BMC	MWCOG
Alexandria, VA	2	0	0	65
Anne Arundel, MD	15	16	256	98
Arlington + Alexandria	7	29	0	206
Arlington, VA	5	0	0	141
Baltimore City, MD	20	22	300	0
Baltimore, MD	25	19	410	0
Calvert, MD	2	2	0	47
Carroll, MD	5	5	99	58
Charles, MD	8	3	0	113
Clarke + Jefferson	2	2	0	22
Clarke, VA	1	0	0	9
District of Columbia, DC	16	31	35	393
Fairfax, VA	17	24	0	540
Falls Church, VA	1	0	0	9
Fauquier, VA	3	2	0	50
Frederick, MD	7	5	35	130
Fredericksburg, VA	1	0	0	14
Harford, MD	6	3	155	0
Howard, MD	9	13	167	68
Jefferson, WV	1	0	0	13
King George, VA	1	1	0	25
Loudoun, VA	5	9	0	282
Manassas, VA	1	0	0	13
Montgomery, MD	20	23	115	376
Prince George's, MD	23	25	195	635
Prince William, VA	4	6	0	363
Spotsylvania, VA	3	1	0	62
St. Mary's, MD	2	2	0	75
Stafford, VA	4	2	0	90
TOTAL	**207**	**245**	**1,767**	**3,669**

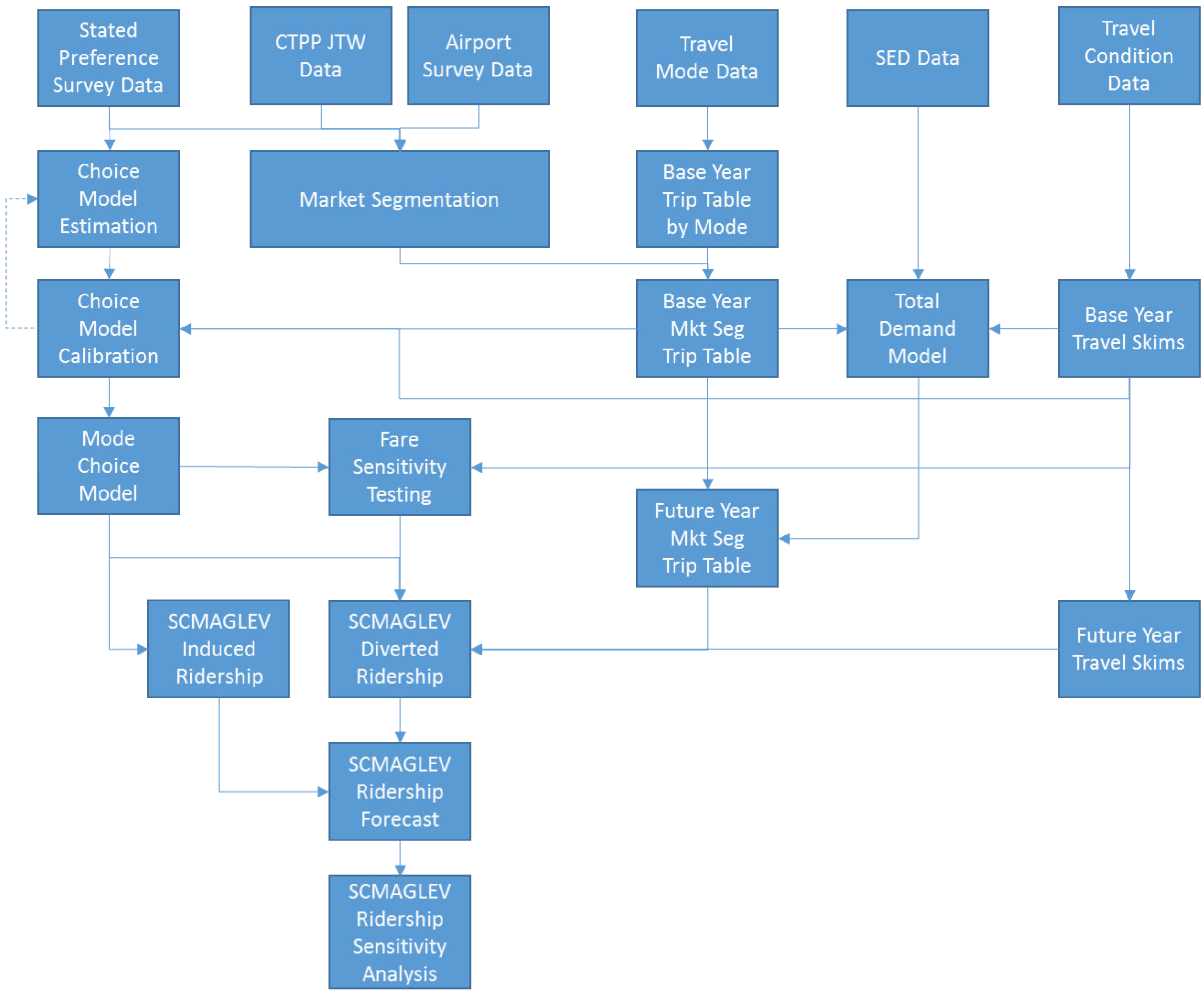
2.2 Modeling Approach

Figure 2-3 provides a high level schematic overview of the process that was used to generate the SCMAGLEV ridership estimates contained in this report. The methodological approach underpinning this study was

[1] Parsons Brinckerhoff/AECOM, NEC Future Ridership Analysis Technical Memorandum, Final Version, 2015.

designed to reflect the state-of-the-practice as described in the High Speed Intercity Passenger Rail (HSIPR) Best Practices documents.[2]

FIGURE 2-3 METHODOLOGICAL OVERVIEW



The interlinked processes presented in the figure can be summarized in four broad work streams briefly described below:

- **Data collection** is further segmented into three broad categories.
  - **Socioeconomic and demographic (SED) data** that provides the basis for understanding rates of current trip generation (production and attraction) as well as growth in future trip generation rates.

[2] Steer Davies Gleave, HSIPR Best Practices: Ridership and Revenue Forecasting, Prepared for the Office of the Inspector General, 2011

  - **Travel mode data** that provides an indication of the addressable travel market size through the triangulation of several data sources supplying information on trip volumes by mode.
  - **Travel condition data** providing information on the levels of service (LOS) by mode for use in understanding current and future mode choice.

- **Trip table development** is a key component of the forecasting process as it defines the scope of the potential ridership. This phase of the study can be further decomposed into four discrete tasks:
  - **Base year trip table development** that proceeds from the travel mode data collection exercise to define the volume of trips between the various city pairs of interest to this study.
  - **Market segmentation** of the trip table that breaks down the estimated volume of trips according to several different categories that may drive mode choice decisions such as trip purpose, household income, time-of-day, etc.
  - **Total demand model estimation** based on currently observed correlations between local socioeconomic conditions, and patterns of trip generation and distribution.
  - **Future year trip table development** using the total demand model to develop future forecasts of overall travel demand market growth by travel market

- **Primary market research** is a critical component of the overall ridership demand forecasting effort is further segmented into two distinct efforts:
  - **Stated preference (SP) survey** that collects data on the potential travel market information including existing travel patterns and travel characteristics of each respondent. The hypothetical choice tasks presented to respondents are then used as the basis for developing mode choice models through model estimation and calibration procedures.
  - **Model estimation processes** develop mathematical algorithms describing observed mode choice behavior of hypothetical choice tasks. Resulting market-segmented models of mode choice are used to derive rates of diversion from existing modes of travel.

- **SCMAGLEV ridership forecasting** comprised three distinct phases listed below
  - **Fare sensitivity testing** evaluating the various ranges of potential SCMAGLEV fares and resulting ridership demand responses
  - **SCMAGLEV base case ridership forecasts** estimating two sources of ridership that pivot off fare sensitivity analysis:
    - Diverted ridership
    - Induced ridership
  - Sensitivity tests to evaluate forecast uncertainty and areas of forecast risk.

The following sections of the report discuss each of the major topic areas in greater detail.

3.0 MARKET ASSESSMENT

The Louis Berger Team conducted a detailed assessment of the intercity travel market from both the demand and supply side. This analysis included a detailed review of socioeconomic and demographic characteristics of the study areas, together with an evaluation of existing intercity travel conditions through the various modes serving the corridor.

3.1 Socioeconomic & Demographic Conditions

Regional socioeconomic and demographic conditions are a principle determinant of travel demand that drive both trip generation and trip distribution. Using data obtained from the MPOs comprising the model study area as well as independent third-party forecasts obtained from Woods & Poole's 2017 Complete Economic and Demographic Data Source (CEDDS 2017), Louis Berger evaluated recent historic trends and future projections of the following key variables:

- Population
- Households
- Employment
- Income

These analyses were conducted at both county and ICAT zonal levels (where applicable) and are presented in tabular and graphical form throughout the following subsections of this chapter of the report. The use of socioeconomic and demographic data obtained from both MPOs as well as third party vendors affords a number of key benefits that enhance the reliability of this study's results. MPO's are mandated by the Federal Government to develop forecasts of population and employment change to support planning efforts at multiple levels of government and as such, this data reflects local knowledge of key factors that are likely to affect the magnitude and trajectory of growth in the region. Conversely, the procedures governing the development of third party vendor forecasts typically links local changes to macroeconomic conditions and scenarios that offer an alternative view of regional growth that can be used to benchmark and evaluate the plausibility of MPO forecasts.

3.1.1 Historical Trends

The historic population, number of households, and employment, levels of the Baltimore-Washington region are presented in Tables 3-1 to 3-3. The tables show that while the overall region has grown at a rate of about 1.22 to 1.38 percent per annum between 1990 and 2017, some locations – particularly the District of Columbia and Baltimore City areas – have either grown at slower rates or witnessed declines over that same time period.

However, looking at the more recent trends of growth between 2010 and 2017, the rate of population decline in the Baltimore central district has slowed down while the rates of employment have not only slowed down but dramatically increased to approximately 1 percent per annum. The District of Columbia on the other hand has experienced notably increases in growth over the more recent time period.

The fastest rates of growth in population, households and employment is observed in Loudon County however the District of Columbia leads the region in terms of household income growth rates.

TABLE 3-1 POPULATION (1990-2017)

County	1990	2000	2010	2015	2017	CAGR	
						1990-17	2000-17
Alexandria (Independent City), VA	111,491	129,225	140,833	153,511	155,622	1.24%	1.44%
Anne Arundel, MD	428,877	491,670	539,308	564,195	576,030	1.10%	0.95%
Arlington, VA	171,164	189,198	209,429	229,164	231,785	1.13%	1.46%
Baltimore, MD	694,782	755,598	806,171	831,128	843,719	0.72%	0.65%
Baltimore (Independent City), MD	735,632	649,086	621,180	621,849	618,203	-0.64%	-0.07%
Calvert, MD	51,954	75,118	88,947	90,595	93,141	2.19%	0.66%
Carroll, MD	124,086	151,454	167,205	167,627	172,297	1.22%	0.43%
Charles, MD	101,751	121,229	147,137	156,118	160,890	1.71%	1.28%
Clarke, VA	12,079	12,672	14,038	14,363	14,627	0.71%	0.59%
District Of Columbia	605,321	572,046	605,126	672,228	679,708	0.43%	1.67%
Fairfax, Fairfax City + Falls Church, VA	851,111	1,007,517	1,121,870	1,180,139	1,222,056	1.35%	1.23%
Fauquier, VA	48,908	55,470	65,481	68,782	71,246	1.40%	1.21%
Frederick, MD	151,345	196,563	234,196	245,322	251,642	1.90%	1.03%
Spotsylvania + Fredericksburg, VA	78,237	110,848	147,378	158,593	164,473	2.79%	1.58%
Harford, MD	183,717	219,797	245,239	250,290	258,445	1.27%	0.75%
Howard, MD	189,367	249,590	288,634	313,414	324,649	2.02%	1.69%
Jefferson, WV	36,145	42,485	53,626	56,482	58,528	1.80%	1.26%
King George, VA	13,603	16,916	23,680	25,515	26,510	2.50%	1.63%
Loudoun, VA	87,208	173,907	315,600	375,629	396,888	5.77%	3.33%
Montgomery, MD	765,476	877,478	976,179	1,040,116	1,059,872	1.21%	1.18%
Prince Georges, MD	725,896	803,111	865,912	909,535	923,824	0.90%	0.93%
Prince William, Manassas + Manassas Park, VA	251,587	329,784	459,077	509,211	528,063	2.78%	2.02%
St. Marys, MD	76,361	86,498	105,758	111,413	114,901	1.52%	1.19%
Stafford, VA	62,600	93,625	129,844	142,003	148,935	3.26%	1.98%
TOTAL	**6,558,698**	**7,410,885**	**8,371,848**	**8,887,222**	**9,096,054**	**1.22%**	**1.19%**

Source: Woods & Poole 2017

TABLE 3-2 NUMBER OF HOUSEHOLDS (1990-2017)

County	1990	2000	2010	2015	2017	CAGR	
						1990-17	2000-17
Alexandria (Independent City), VA	53,619	62,396	68,538	73,777	75,769	1.29%	1.44%
Anne Arundel, MD	149,721	179,422	199,980	213,463	220,980	1.45%	1.44%
Arlington, VA	79,037	86,312	98,843	107,161	110,086	1.23%	1.55%
Baltimore, MD	269,587	300,638	317,106	332,940	341,746	0.88%	1.07%
Baltimore (Independent City), MD	277,817	257,221	249,760	251,683	253,531	-0.34%	0.21%
Calvert, MD	17,046	25,664	30,936	33,928	35,380	2.74%	1.94%
Carroll, MD	42,387	52,746	59,831	65,434	68,270	1.78%	1.90%
Charles, MD	33,059	41,943	51,411	56,839	59,357	2.19%	2.07%
Clarke, VA	4,253	4,975	5,524	5,920	6,102	1.35%	1.43%
District Of Columbia	249,530	248,618	268,140	283,375	290,589	0.57%	1.16%
Fairfax, Fairfax City + Falls Church, VA	305,329	364,895	406,712	450,223	472,125	1.63%	2.15%
Fauquier, VA	16,568	20,025	23,725	26,332	27,624	1.91%	2.20%
Frederick, MD	52,787	70,531	85,098	93,993	97,721	2.31%	2.00%
Spotsylvania + Fredericksburg, VA	26,515	39,858	51,676	58,040	60,775	3.12%	2.34%
Harford, MD	63,426	80,054	90,359	99,310	103,989	1.85%	2.03%
Howard, MD	68,604	90,659	105,263	117,593	123,320	2.20%	2.29%
Jefferson, WV	12,941	16,306	19,986	22,130	23,146	2.18%	2.12%
King George, VA	4,750	6,144	8,407	9,229	9,682	2.67%	2.04%
Loudoun, VA	30,627	61,380	105,593	124,464	133,065	5.59%	3.36%
Montgomery, MD	283,434	325,947	358,457	383,719	395,324	1.24%	1.41%
Prince Georges, MD	259,145	287,104	304,698	320,891	329,418	0.89%	1.12%
Prince William, Manassas + Manassas Park, VA	81,766	110,700	149,452	170,096	178,000	2.92%	2.53%
St. Marys, MD	25,575	30,795	37,821	42,137	44,004	2.03%	2.19%
Stafford, VA	19,478	30,554	42,035	47,812	50,830	3.62%	2.75%
TOTAL	**2,427,001**	**2,794,887**	**3,139,351**	**3,390,489**	**3,510,833**	**1.38%**	**1.61%**

Source: Woods & Poole 2017

TABLE 3-3 EMPLOYMENT (1990-2017)

County	1990	2000	2010	2015	2017	CAGR	
						1990-17	2000-17
Alexandria (Independent City), VA	113,703	119,040	123,715	126,524	127,780	0.43%	0.46%
Anne Arundel, MD	245,851	291,829	345,913	393,927	399,105	1.81%	2.06%
Arlington, VA	195,863	201,053	210,581	221,163	223,109	0.48%	0.83%
Baltimore, MD	390,426	440,376	488,147	513,721	523,262	1.09%	1.00%
Baltimore (Independent City), MD	525,752	462,863	397,797	425,650	427,908	-0.76%	1.05%
Calvert, MD	18,766	27,051	33,501	35,416	35,982	2.44%	1.03%
Carroll, MD	50,928	66,804	77,386	81,212	82,718	1.81%	0.96%
Charles, MD	37,747	49,159	59,301	63,058	64,229	1.99%	1.15%
Clarke, VA	5,770	6,667	7,045	7,216	7,300	0.87%	0.51%
District Of Columbia	774,544	735,891	809,918	873,102	881,655	0.48%	1.22%
Fairfax, Fairfax City + Falls Church, VA	550,909	739,337	826,401	875,953	892,919	1.80%	1.11%
Fauquier, VA	21,516	25,810	32,339	35,005	35,707	1.89%	1.43%
Frederick, MD	72,452	104,877	127,219	137,613	140,028	2.47%	1.38%
Spotsylvania + Fredericksburg, VA	39,523	59,049	73,259	78,594	80,317	2.66%	1.32%
Harford, MD	75,308	98,315	114,756	126,108	128,496	2.00%	1.63%
Howard, MD	109,700	166,262	200,591	225,608	229,809	2.78%	1.96%
Jefferson, WV	15,183	18,294	21,976	24,124	24,584	1.80%	1.61%
King George, VA	8,120	11,764	13,354	14,437	14,684	2.22%	1.37%
Loudoun, VA	53,567	112,365	184,044	217,727	223,386	5.43%	2.81%
Montgomery, MD	518,208	603,953	652,369	697,816	707,018	1.16%	1.16%
Prince Georges, MD	374,101	395,999	427,155	457,027	464,246	0.80%	1.20%
Prince William, Manassas + Manassas Park, VA	104,580	143,444	194,650	226,901	231,445	2.99%	2.50%
St. Marys, MD	34,180	46,499	57,662	60,562	61,522	2.20%	0.93%
Stafford, VA	20,233	35,993	51,587	58,923	60,322	4.13%	2.26%
TOTAL	4,356,930	4,962,694	5,530,666	5,977,387	6,067,531	1.23%	1.33%

Source: Woods & Poole 2017

TABLE 3-4 HOUSEHOLD INCOME (1990-2017) ($2009)

County	1990	2000	2010	2015	2017	CAGR	
						1990-17	2000-17
Alexandria (Independent City), VA	$99,092	$128,116	$152,337	$155,571	$159,390	1.78%	0.65%
Anne Arundel, MD	$94,756	$121,281	$137,688	$143,287	$144,966	1.59%	0.74%
Arlington, VA	$102,185	$139,225	$163,312	$166,456	$171,630	1.94%	0.71%
Baltimore, MD	$90,755	$109,724	$120,601	$121,414	$126,169	1.23%	0.65%
Baltimore (Independent City), MD	$67,759	$71,867	$89,231	$98,053	$100,080	1.45%	1.65%
Calvert, MD	$101,355	$112,695	$140,537	$135,787	$132,971	1.01%	-0.79%
Carroll, MD	$90,761	$111,843	$129,821	$128,896	$128,593	1.30%	-0.14%
Charles, MD	$96,597	$109,365	$133,393	$129,986	$132,842	1.19%	-0.06%
Clarke, VA	$76,829	$98,447	$122,776	$123,615	$125,801	1.84%	0.35%
District Of Columbia	$86,116	$112,834	$130,085	$151,160	$151,726	2.12%	2.22%
Fairfax, Fairfax City + Falls Church, VA	$127,683	$172,844	$177,734	$177,986	$180,461	1.29%	0.22%
Fauquier, VA	$102,391	$132,769	$148,274	$146,666	$143,921	1.27%	-0.42%
Frederick, MD	$86,794	$109,606	$131,029	$128,963	$130,723	1.53%	-0.03%
Spotsylvania + Fredericksburg, VA	$82,013	$94,580	$114,356	$113,943	$114,723	1.25%	0.05%
Harford, MD	$88,483	$105,989	$123,001	$119,998	$121,306	1.18%	-0.20%
Howard, MD	$114,194	$147,273	$171,065	$169,571	$172,496	1.54%	0.12%
Jefferson, WV	$69,756	$83,655	$101,426	$102,559	$99,417	1.32%	-0.29%
King George, VA	$81,246	$89,008	$124,008	$125,284	$119,858	1.45%	-0.49%
Loudoun, VA	$108,469	$143,580	$184,611	$192,031	$203,106	2.35%	1.37%
Montgomery, MD	$133,353	$172,754	$188,382	$188,867	$188,171	1.28%	-0.02%
Prince Georges, MD	$89,996	$96,511	$112,176	$114,052	$116,835	0.97%	0.58%
Prince William, Manassas + Manassas Park, VA	$98,233	$114,261	$140,066	$136,941	$139,404	1.30%	-0.07%
St. Marys, MD	$77,318	$97,379	$125,773	$122,979	$123,558	1.75%	-0.25%
Stafford, VA	$92,490	$110,655	$138,094	$132,860	$137,540	1.48%	-0.06%
TOTAL	**$98,836**	**$124,513**	**$142,364**	**$145,941**	**$148,437**	**1.52%**	**0.60%**

Source: Woods & Poole 2017

3.1.2 Future Outlook

Louis Berger reviewed both the MPO and third party vendor forecasts of future changes in the four variables listed above. Data from the MPOs provided not only the regional magnitude of change but also included the spatial assessment of change at the zonal level. This more granular detail was used in the travel demand model to predict future growth in both trip generation and distribution as discussed in later sections of this report.

3.1.2.1 BMC/MWCOG Forecast Comparison

Given the importance of the regional socioeconomic and demographic projections in determining the magnitude and location of future trip, Louis Berger compared both the BMC and MWCOG county-level projections for the areas where the two regional models overlap as discussed in Section 2. 1. Figure 3-1 shows the common overlapping area of the two models that includes the District of Columbia as well as Ann Arundel, Carroll, Frederick, Howard, Montgomery, and Prince George's counties in Maryland.

Table 3-5 shows that both models have very similar estimates of population, households, and employment in the 2010 base year. The projected changes from Table 3-5 (that are also graphically depicted in Figure 3-2) show that both models project similar levels of change in both population and households between 2010 and 2040 – with the exception of Washington D.C. where MWCOG predicts higher levels of population growth. The BMC model however, predicts fractionally higher population and household growth in Prince George's and to a lesser extent Howard and Montgomery counties.

Figure 3-2 also shows that two model's projected change in employment differs notably in Washington D.C., Montgomery and Prince George's counties. However, the net effect of these growth patterns results in similar estimated rates of overall employment growth in this overlapping region.

The differences in regional growth rates across all three variables are relatively small and the use of one source of data over the other is not expected to impact the overall volume of growth but rather the distribution of that growth with the MWCOG centering more growth in the urban core of Washington D.C., while the BMC model predicting more growth in the surrounding suburban areas around the capital. Ultimately, the MWCOG forecasts were used adopted as the MPO data source for the overlapping area in part due to the greater level of granularity that might prove useful in further future planning efforts.

FIGURE 3-1 BMC/MWCOG MODEL COVERAGE AREAS

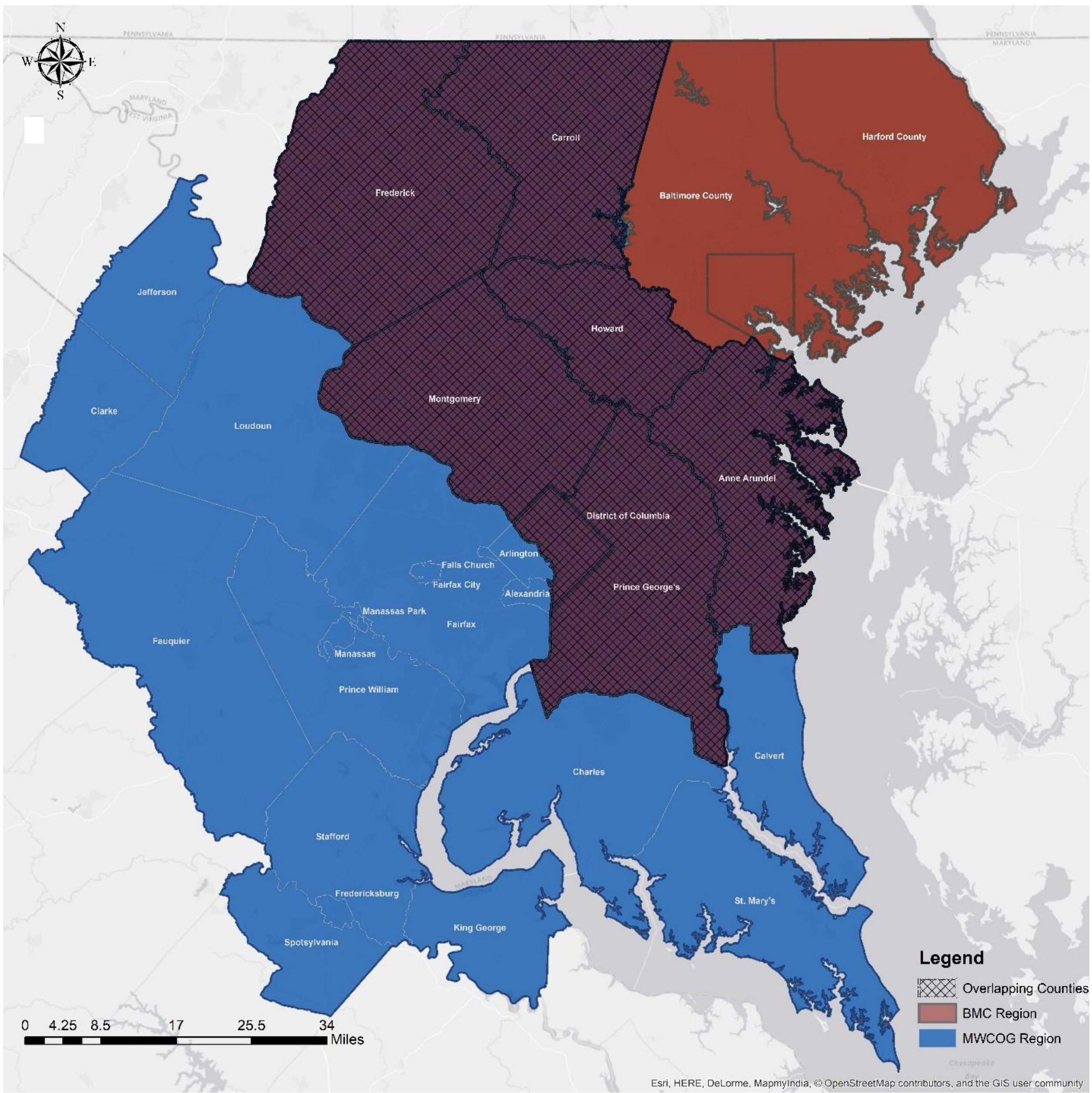


FIGURE 3-2 BMC/MWCOG SOCIOECONOMIC & DEMOGRAPHIC FORECAST COMPARISON

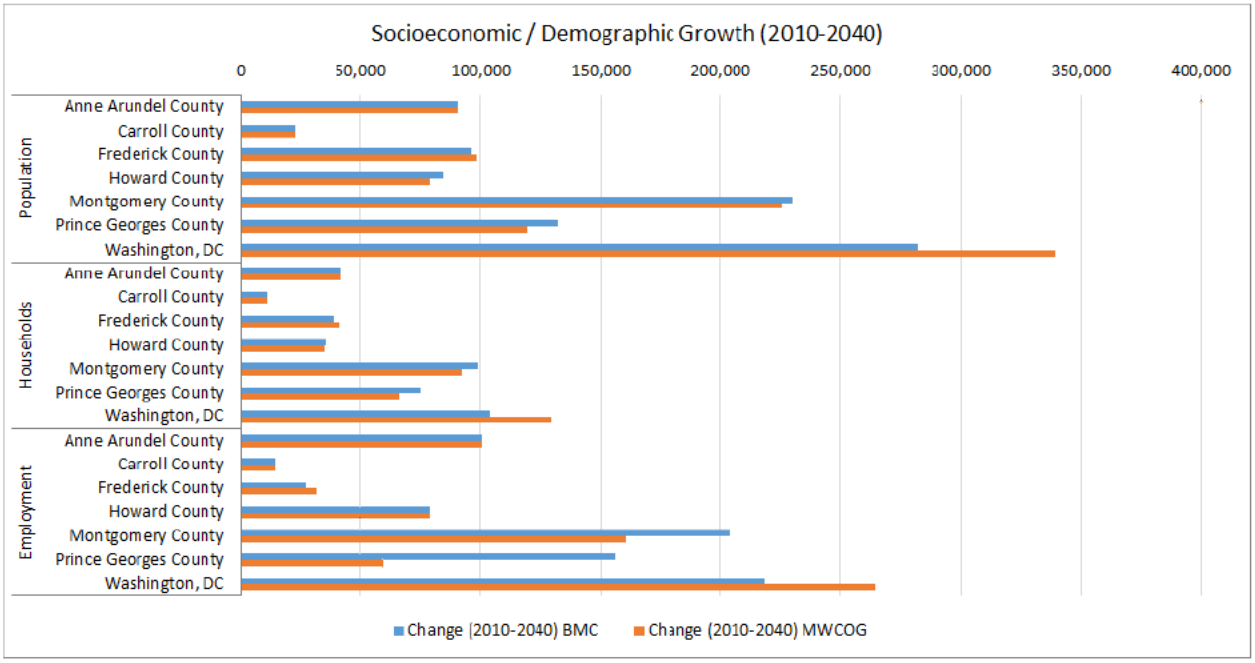


TABLE 3-5 COMPARISON OF BMC & MWCOG FORECASTS

		2010 Base		2040		Change (2010-2040)		2010-40 CAGR	
		BMC	MWCOG	BMC	MWCOG	BMC	MWCOG	BMC	MWCOG
Population	Anne Arundel County	537,656	537,655	628,048	628,047	90,392	90,392	0.5%	0.5%
	Carroll County	167,134	167,134	189,574	189,574	22,440	22,440	0.4%	0.4%
	Frederick County	233,383	233,383	329,955	332,151	96,572	98,768	1.2%	1.2%
	Howard County	287,085	287,085	371,621	366,352	84,536	79,267	0.9%	0.8%
	Montgomery County	965,712	971,713	1,195,538	1,197,132	229,826	225,419	0.7%	0.7%
	Prince George's County	871,231	863,420	1,003,754	982,385	132,523	118,965	0.5%	0.4%
	Washington, DC	601,764	601,764	883,568	940,687	281,804	338,923	1.3%	1.5%
	TOTAL	**3,663,965**	**3,662,154**	**4,602,058**	**4,636,328**	**938,093**	**974,174**	**0.8%**	**0.8%**
Households	Anne Arundel County	199,378	199,378	241,542	241,542	42,164	42,164	0.6%	0.6%
	Carroll County	59,784	62,406	70,668	72,853	10,884	10,447	0.6%	0.5%
	Frederick County	84,800	84,800	123,247	126,539	38,447	41,739	1.3%	1.3%
	Howard County	104,749	104,749	139,697	139,497	34,948	34,748	1.0%	1.0%
	Montgomery County	359,041	358,574	458,019	450,922	98,978	92,348	0.8%	0.8%
	Prince George's County	306,167	304,042	381,184	370,023	75,017	65,981	0.7%	0.7%
	Washington, DC	266,707	266,707	370,758	396,233	104,051	129,526	1.1%	1.3%
	TOTAL	**1,380,626**	**1,380,656**	**1,785,115**	**1,797,609**	**404,489**	**416,953**	**0.9%**	**0.9%**
Employment	Anne Arundel County	323,151	323,148	424,052	424,061	100,901	100,913	0.9%	0.9%
	Carroll County	70,890	70,889	85,348	85,351	14,458	14,462	0.6%	0.6%
	Frederick County	98,695	102,375	125,556	133,934	26,861	31,559	0.8%	0.9%
	Howard County	181,372	181,381	260,318	260,309	78,946	78,928	1.2%	1.2%
	Montgomery County	509,185	493,454	712,926	653,917	203,741	160,463	1.1%	0.9%
	Prince George's County	343,680	333,942	499,847	393,336	156,167	59,394	1.3%	0.5%
	Washington, DC	783,457	746,235	1,001,814	1,011,071	218,357	264,836	0.8%	1.0%
	TOTAL	**2,310,430**	**2,251,424**	**3,109,861**	**2,961,979**	**799,431**	**710,555**	**1.0%**	**0.9%**

3.1.2.2 Zonal Forecasts of Population, Households, and Employment

Louis Berger obtained the population, household, and employment projections both MPOs at the TAZ level. However, because most of the MPO projections had forecast horizons that only extended to either 2040 or 2045, Louis Berger extrapolated the zonal trends of the native MPO forecasts as needed to ensure that a common 2050 TAZ level forecast was available for the three variables.

TABLE 3-6 REGIONAL SOCIOECONOMIC & DEMOGRAPHIC FORECASTS

Region	2010	2020	2030	2040	2050	CAGR
			POPULATION			
Baltimore/Washington	8,311,606	9,212,115	9,991,419	10,630,014	11,416,590	**0.80%**
			HOUSEHOLDS			
Baltimore/Washington	3,120,620	3,482,714	3,823,788	4,092,817	4,423,195	**0.88%**
			EMPLOYMENT			
Baltimore/Washington	4,650,892	5,183,057	5,728,851	6,209,009	6,729,169	**0.93%**
Total for Washington-New York	**17,591,551**	**19,098,858**	**20,092,888**	**21,125,744**	**22,267,560**	**0.59%**

Source: BMC/MWCOG, Louis Berger (2018)

Table 3-6 presents the zonal MPO forecasts aggregated up to regional and corridor levels. Figures 3-3 to 3-5 map the zonal forecasts of the three variables for the MPOs aggregated to the ICAT zonal level. Figures 3-3 to 3-5 show that the Washington, DC area and its surrounding suburbs appear to grow at relatively faster rate than the Baltimore area.

FIGURE 3-3 POPULATION GROWTH 2017-2050 (BALTIMORE/WASHINGTON REGION)

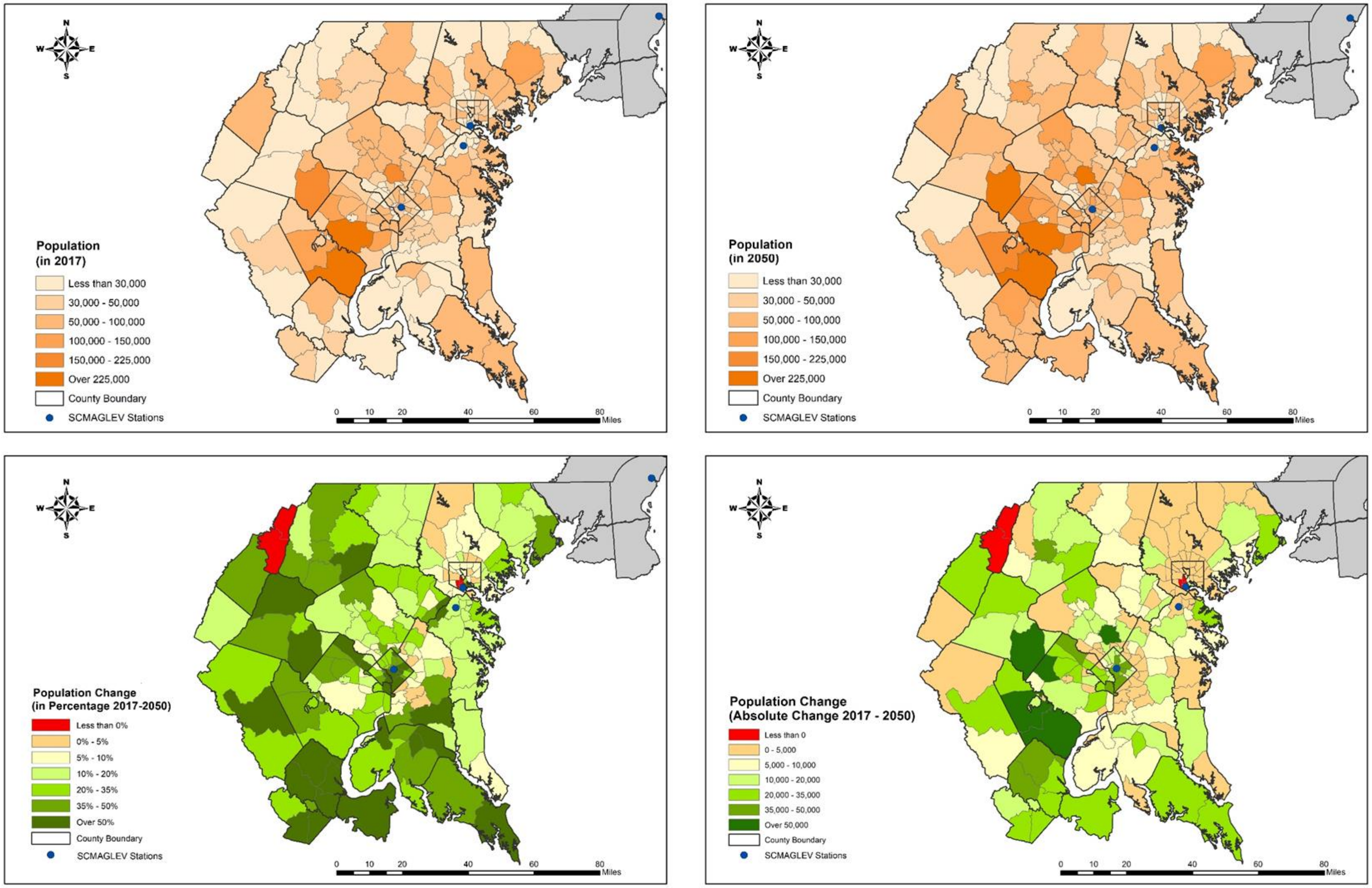


FIGURE 3-4 HOUSEHOLD GROWTH 2017-2050 (BALTIMORE/WASHINGTON REGION)

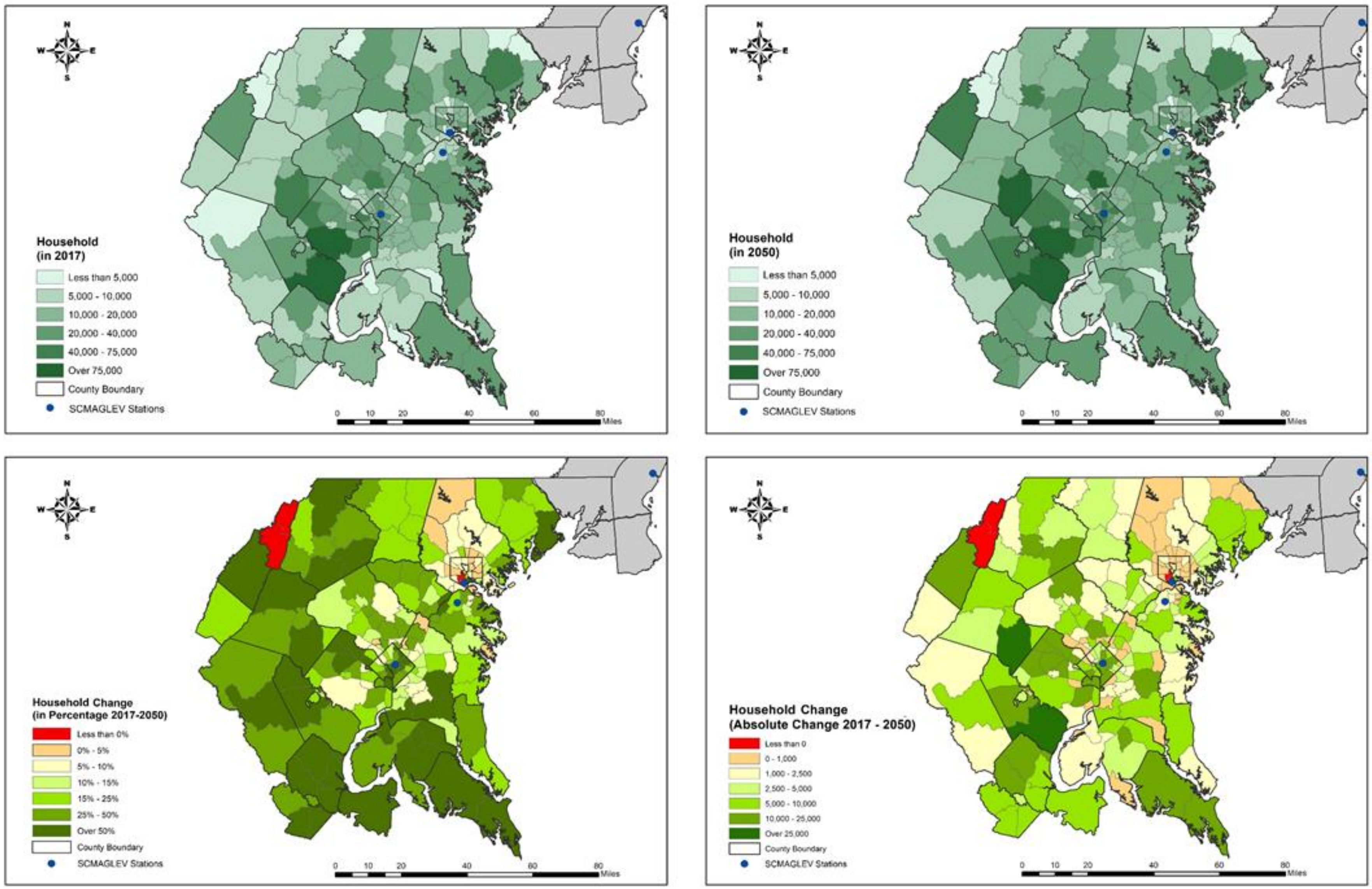
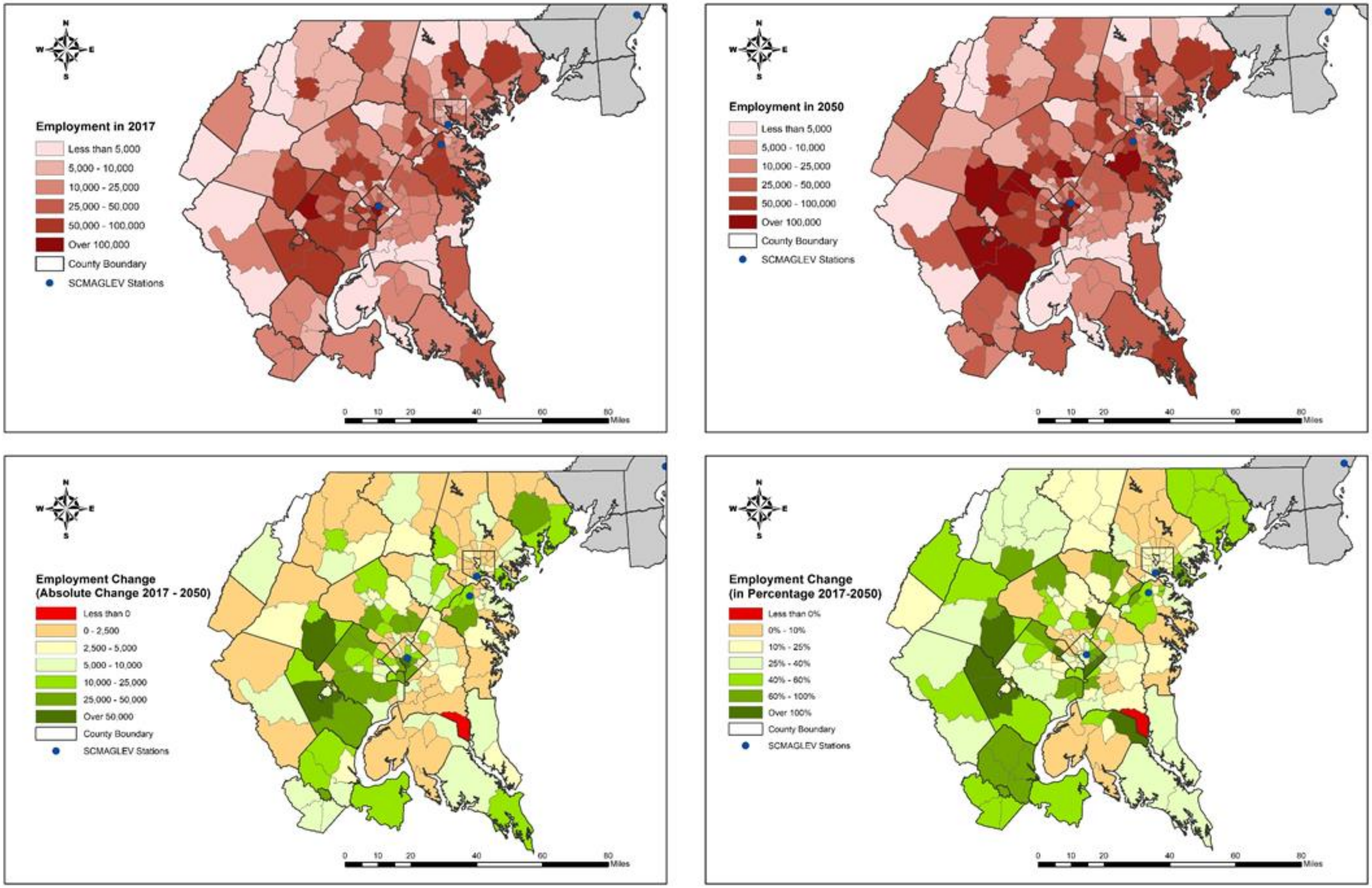


FIGURE 3-5 EMPLOYMENT GROWTH 2017-2050 (BALTIMORE/WASHINGTON REGION)



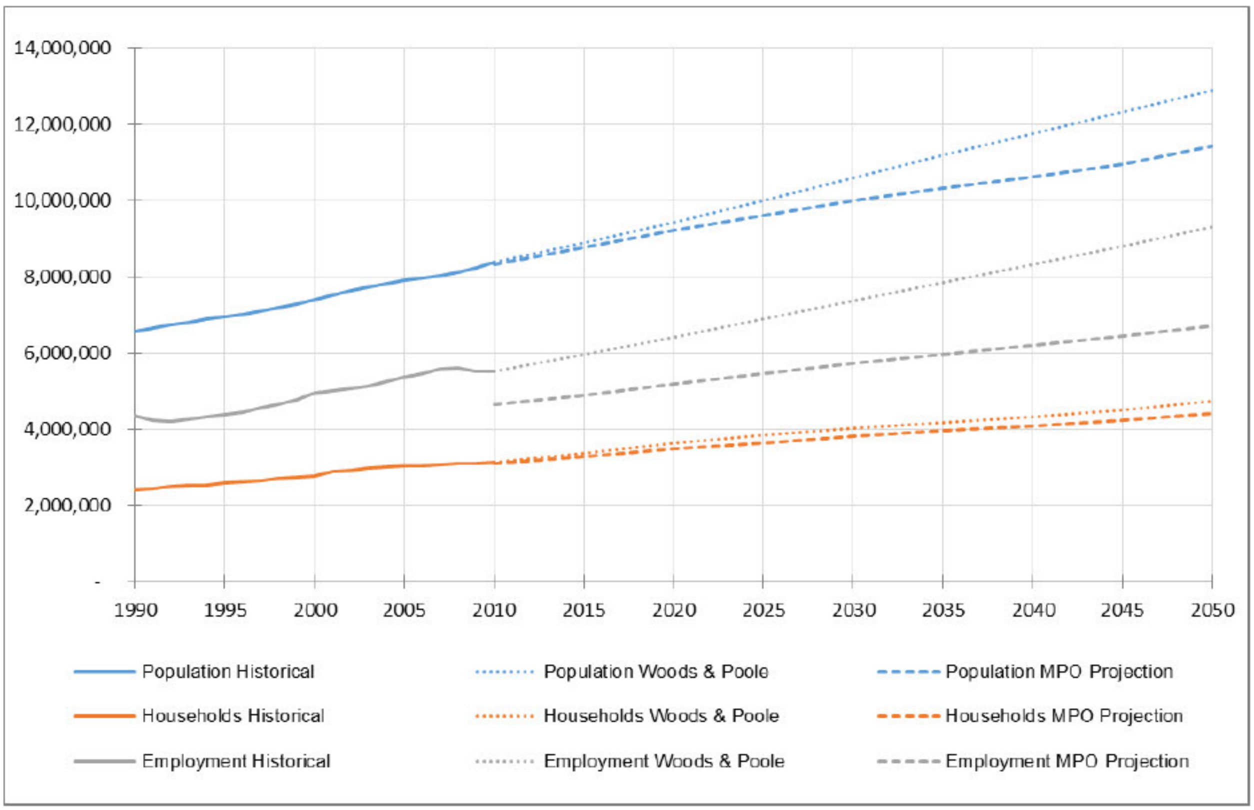
Louis Berger compared the socioeconomic and demographic forecasts provided by the MPOs against third party vendor forecasts obtained from Woods & Poole as shown in Table 3-7 and also graphically depicted in Figure 3-6.

TABLE 3-7 REGIONAL SOCIOECONOMIC & DEMOGRAPHIC FORECASTS – WOODS & POOLE

Region	2010	2020	2030	2040	2050	CAGR
POPULATION						
MPO Data	8,311,606	9,212,115	9,991,419	10,630,014	11,416,590	0.80%
Woods & Poole Data	8,371,848	9,428,257	10,600,341	11,757,672	12,873,538	1.08%
HOUSEHOLDS						
MPO Data	3,120,620	3,482,714	3,823,788	4,092,817	4,423,195	0.88%
Woods & Poole Data	3,139,351	3,659,154	4,025,230	4,324,766	4,748,898	1.04%
EMPLOYMENT						
MPO Data	4,650,892	5,183,057	5,728,851	6,209,009	6,729,169	0.93%
Woods & Poole Data	5,530,666	6,430,252	7,372,211	8,318,723	9,319,665	1.31%

Source: BMC, MWCOG, Woods & Poole (2017), Louis Berger (2018)

FIGURE 3-6 MPO-THIRD PARTY DATA COMPARISON



Source: BMC, MWCOG, Woods & Poole (2017), Louis Berger (2018)

The Woods & Poole projections of both population and households lie higher than the MPO forecasts for the Baltimore/Washington region – with a greater divergence observed in population forecasts. Similar direct comparisons of the MPO and Woods & Poole projections of employment were not possible because Woods

& Poole employment statistics also include employment held by proprietors (self-employed) while the MPO projections are typically limited to wage and salary employment only – hence the discontinuity between the two data sources for this variable as shown in Figure 3-6. However, a comparison of projected employment level growth rates across the two data sources in the Baltimore/Washington region shows a consistent pattern of higher growth assumptions in the Woods and Poole projections.

3.1.2.3 Forecasts of Household Income

Even though the MPOs provided geospatial forecasts of household income, this data was not provided in a uniform format that could be applied across the two MPO jurisdictions. As such Louis Berger relied on other data sources to develop useable zonal forecasts of household income. Table 3-8 presents the Woods & Poole forecasts of mean household total personal income[3] of the metropolitan regions defined in Section 2.1 that correspond to the SCMAGLEV study area.

TABLE 3-8 MEAN HOUSEHOLD TOTAL PERSONAL INCOME[3] – WOODS & POOLE

Region	2010	2020	2030	2040	2050	CAGR
Baltimore/Washington	$136,204	$148,366	$171,612	$196,844	$219,163	1.20%

Source: Woods & Poole 2017 (all values inflation-adjusted from 2009 base year dollars)

Whereas the regional or even county-level estimates of household income growth rates are informative, the Louis Berger Team sought to develop zonal level estimates of household income change as this was considered a key factor in determining the existing and future patterns of trip generation. Given the issues of non-standard presentation of household income data across the various regional models, Louis Berger synthesized zonal estimates of mean household income using data from both Woods & Poole and the 2008-2012 American Community Survey (ACS).

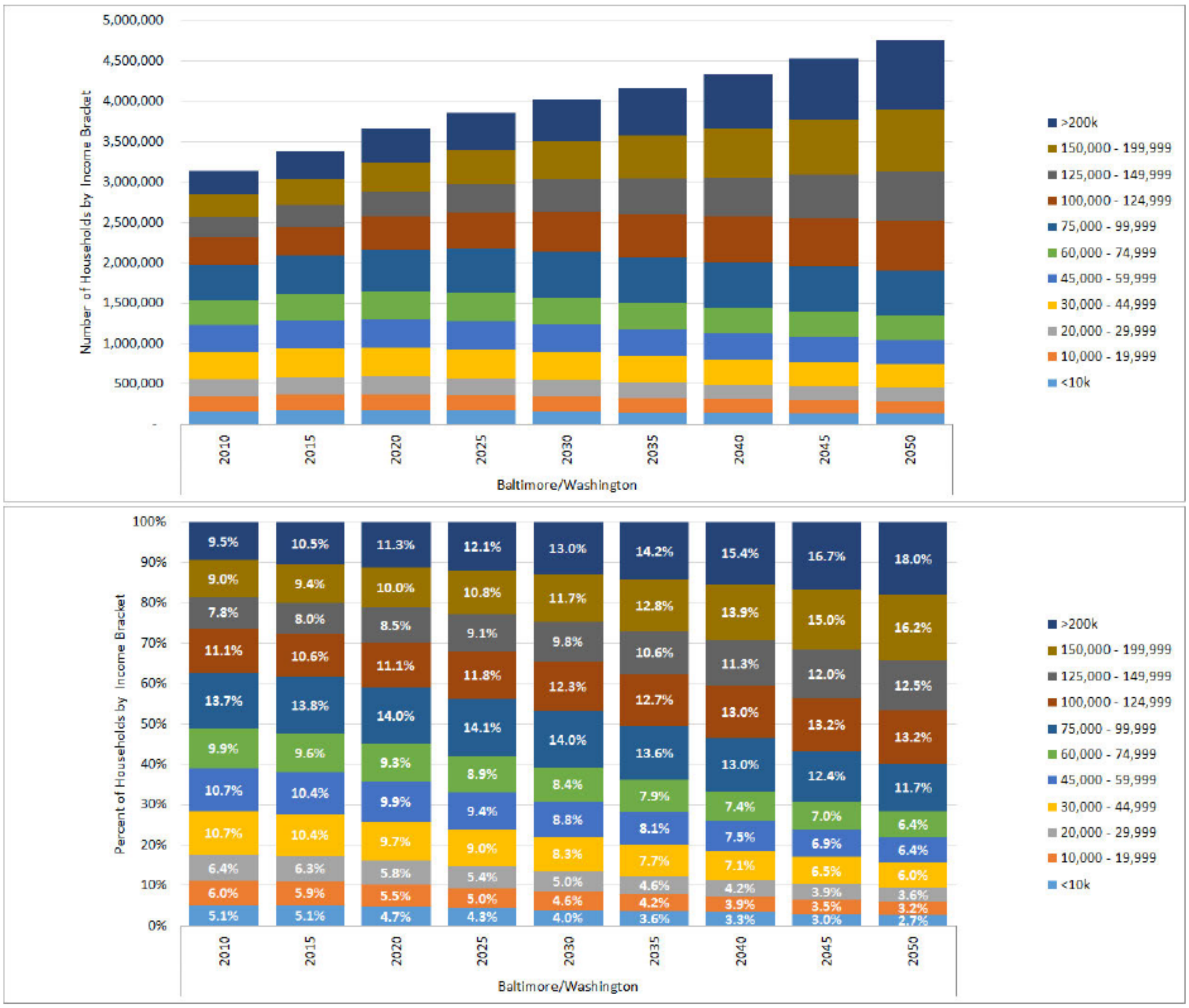
Woods & Poole provide county-level forecasts of money household income at various household income brackets out to the year 2050 as shown in Figure 3-7 that displays the projected number of households in each income bracket aggregated up to the entire Baltimore-Washington region. Figure 3-7 also shows the relative change in household income distribution. To translate the projected county-level changes from Woods & Poole to the zonal level, Louis Berger aggregated block group-level ACS data on household income up to the ICAT zonal level. These zonal level income aggregations were then used to estimate each county's zonal distribution of household income for each income bracket level. The Woods & Poole county-level forecasts of household income at each income bracket level were then distributed down to the zonal level using the ACS-based county-to-zone distributions. Figure 3-8 presents the resulting zonal distribution of household incomes consolidated into four broad categories in 2010.

These detailed household income profiles were used to estimate mean household income at the ICAT zonal level by calculating a weighted average that multiplied the number of households in each income group by the midpoint income of each bracket. Incomes above $200,000 in the weighted mean calculation were top coded at $225,000 to minimize the influence of extreme outliers in this category.

[3] The definition of total personal income used by Woods & Poole is the most comprehensive one available. Another commonly used measure of income is money income of persons. Money income is the concept used by the Bureau of the Census and is widely used in other sources. Total personal income includes all of money income plus the exclusions to money income.

Table 3-9 presents the resulting estimates of mean household income calculated in the manner described above. The values of mean household money income differ notably from the total personal income values as explained by the corresponding footnote from Table 3-8. These differences manifest both in terms of absolute values and projected growth rates. However, because zonal estimates could only be developed using household money income estimates, Louis Berger used the this data source as the basis for analyzing existing and future trip generation rates related to household income. As such, using the lower projected growth in mean household money income represents a conservative forecast assumption.

FIGURE 3-7 MONEY HOUSEHOLD INCOME DISTRIBUTION BY REGION ($2009)



Source: ACS 2008-2012, Woods & Poole 2017, Louis Berger

TABLE 3-9 MEAN HOUSEHOLD MONEY INCOME ($2009)

Region	2010	2020	2030	2040	2050	CAGR
Baltimore/Washington	$91,402	$97,094	$104,982	$113,960	$122,580	0.77%

Source: Woods & Poole, ACS 2008-12 Louis Berger (2018)

FIGURE 3-8 HOUSEHOLD INCOME DISTRIBUTION BY CONSOLIDATED INCOME CATEGORIES (2010)

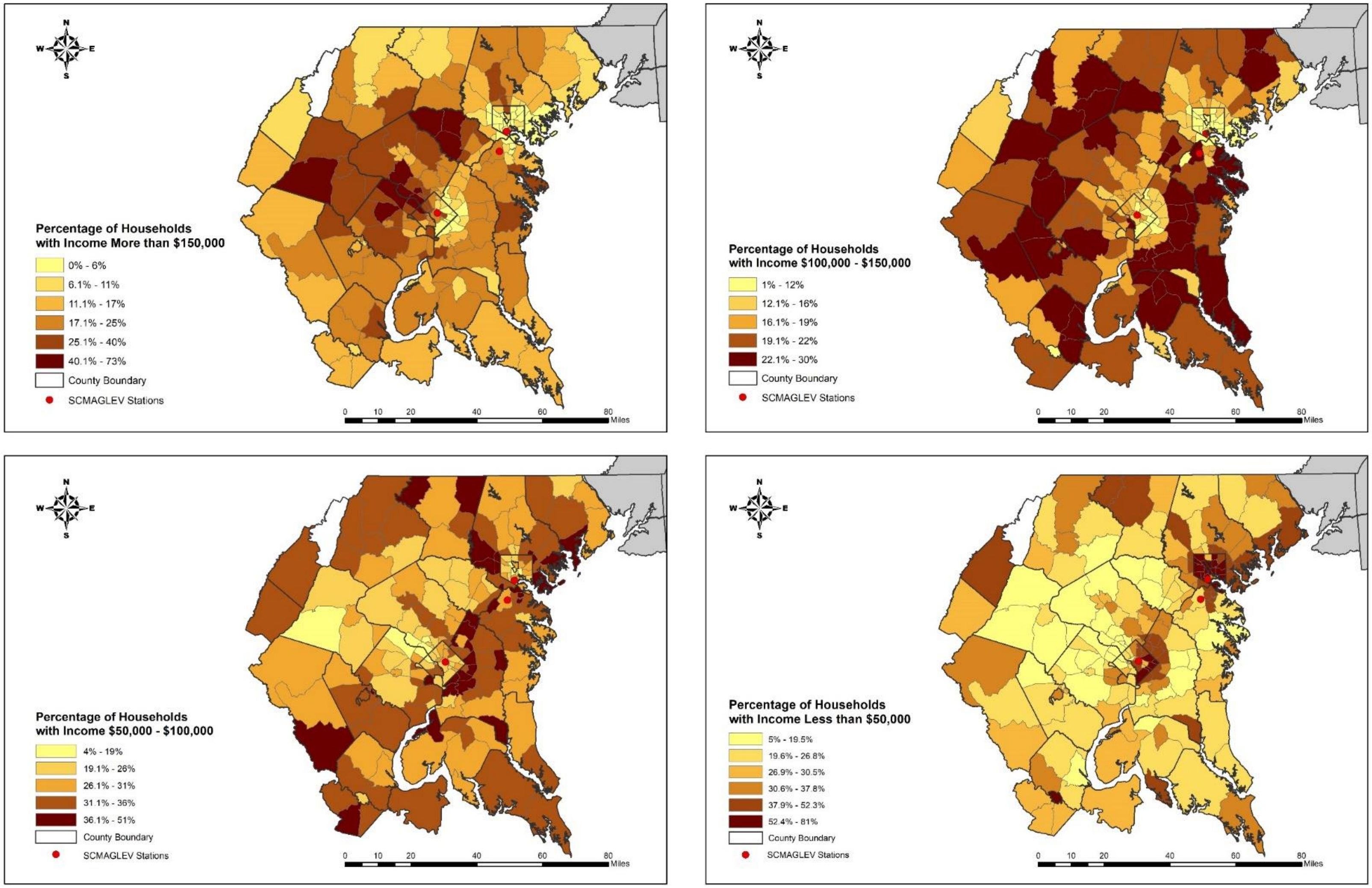


Figure 3-9 presents the resulting pattern of mean household income change for the overall study area in 2017. Future Woods & Poole county level projections of household incomes by bracket were allocated down to the zonal level using the same ACS county-to-zone distribution and the corresponding zonal mean household income was estimated. Figure 3-10 depicts the future year predictions of mean household income at the zonal level.

FIGURE 3-9 ZONAL MEAN HOUSEHOLD INCOME ESTIMATE (2017)

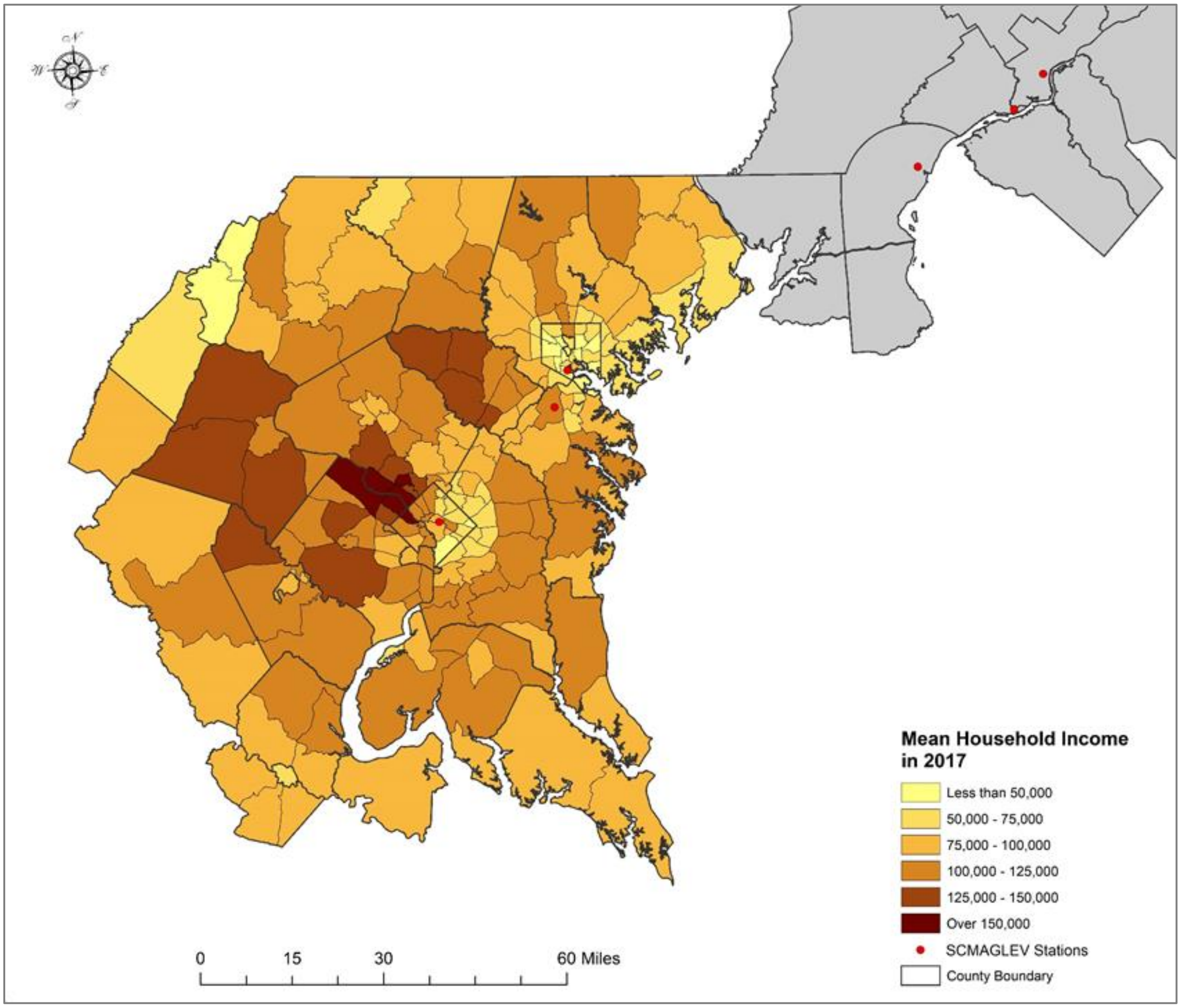
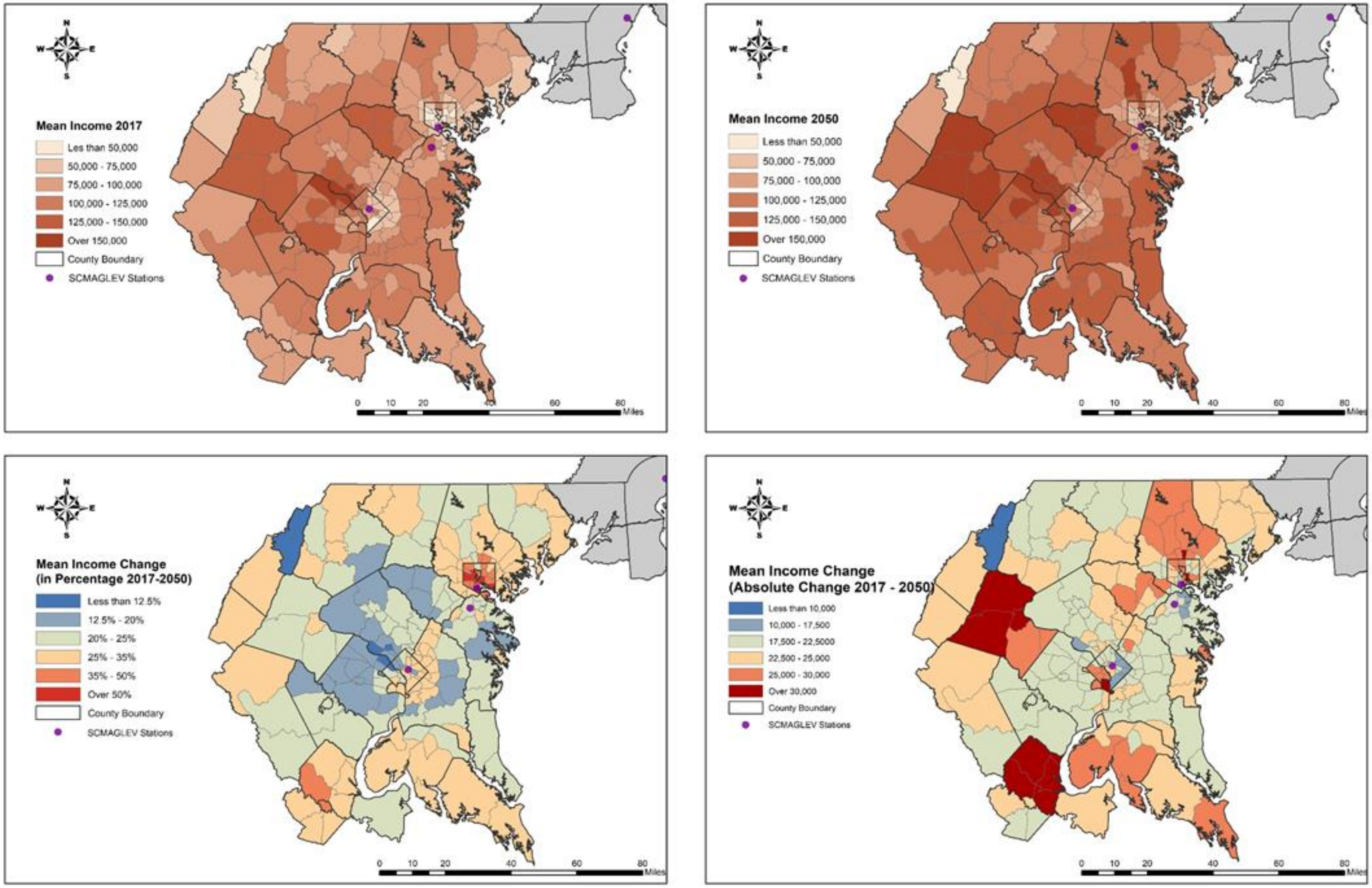


FIGURE 3-10 MEAN HOUSEHOLD INCOME GROWTH 2017-2050 (BALTIMORE/WASHINGTON)



3.2 Trip Table Development

Louis Berger also conducted a detailed survey of the travel data from the study area to help understand the potential SCMAGLEV market size. Whereas typical travel demand studies focus on study areas that are almost entirely contained within a single MPO's jurisdiction where detailed information on travel patterns is more readily available, the Baltimore-Washington Corridor study area's aggregation of two MPO regions required a greater research effort that evaluated a number of independent data sources – each of varying quality and specificity. The key data sources consulted in this evaluation include the following:

- Air Travel
  - Bureau of Transportation Statistics - 10% Ticket Sample (Airline Origin and Destination Survey DB1B). This data provided the most accurate picture of air trips that originated and ended at airports located within the study region.
  - Bureau of Transportation Statistics - Airline On-Time Statistics and Delay Causes
  - Washington-Baltimore Regional Air Passenger Survey – 2015 (MWCOG)

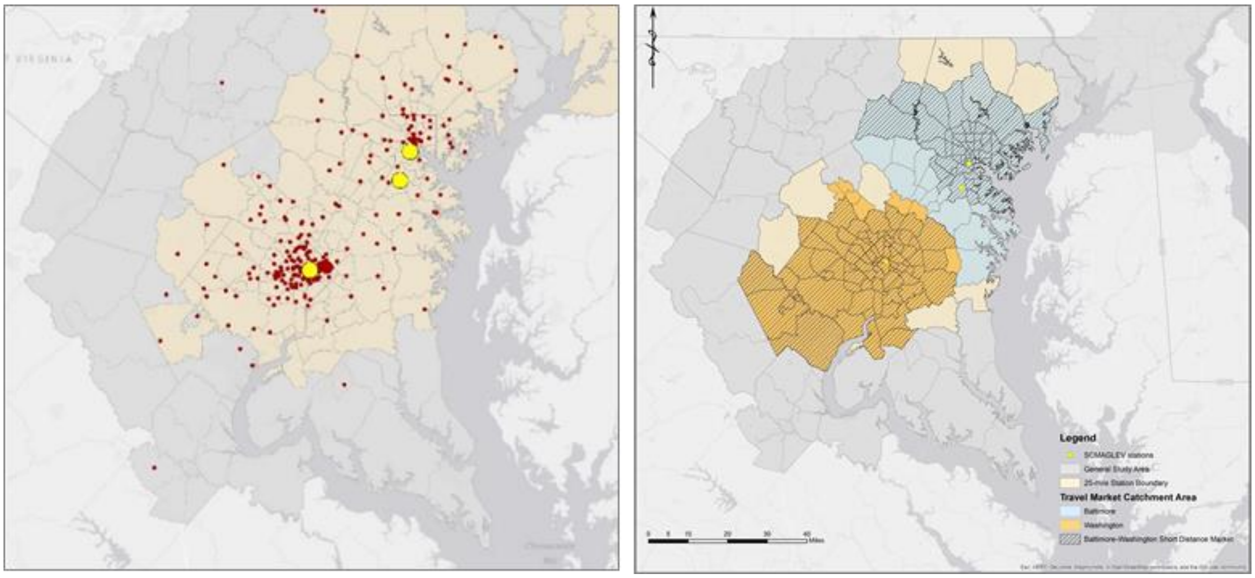
- Rail
  - Amtrak
    - Ridership and revenue statistics
    - Amtrak Five Year Service Plans 2019-2023
  - National Association of Rail Passengers (NARP) – Amtrak ridership statistics
  - Maryland Area Regional Commuter (MARC)
    - Maryland Transit Administration (MTA) – Origin-Destination Survey
    - Maryland Open Data Portal – Monthly average weekday ridership statistics
    - MARC – Growth and Investment Plan Update 2013-2050

- Intercity Bus
  - Resource System Group (RSG) Intercity Bus Model
- Auto
  - AirSage, an Atlanta based wireless information and data provider, has developed an approach to gathering data about population mobility throughout a region. AirSage analyzes anonymous location and movement of mobile devices, which is derived from wireless signaling data, to provide new insights into where populations, are, were, or will be, and how they move about over time and in response to special events or disruptions to the roadway network.

3.2.1 SCMAGLEV Catchment Areas

Although the MPO jurisdictional boundary provides a useful basis for initial analysis of the travel market, the Louis Berger team initially limited to the SCMAGLEV catchment area to a 25-mile boundary around each of the three proposed stations. This approach comports with best practice recommendations highlighted in the High Speed Intercity Passenger Rail planning guidelines that discourage artificially restrictive catchment areas – particularly in the case of a proposed new service such as SCMAGLEV that promises to deliver unprecedented levels of travel time savings to travelers in the corridor.[4] The left portion of Figure 3-11 depicts the 25 mile boundaries around each station together with distribution of non-auto mode origins and destinations observed from Louis Berger's stated preference (SP) survey discussed in greater detail in Section 4.0. The distribution of non-auto trips in this figure justifies the size the of the 25 mile boundary as several records are observed throughout each area – albeit with a greater concentration in the downtown centers of each city.

FIGURE 3-11 PRELIMINARY SCMAGLEV MARKET AREAS



The 25-mile zone was further refined to reflect what was considered a reasonable catchment area for short distance trips. The first part of the refinement was defining zones with centroids that were within a 30-40 minute drive of the proposed SCMAGLEV stations (the blue and orange shaded regions in the right portion of Figure 3-11 that demarcate the Baltimore and Washington regions respectively). These delineated areas were further revised to exclude short cross-jurisdictional movements between the Baltimore and Washington regions, and are depicted by the cross-hatched area in right portion of Figure 3-11.

It should be noted that these cross-hatched regions only represent the potential catchment area, and that intercity trips between to the two regions will still be subject to other mode choice decision factors applied in the travel demand model's probabilistic estimates of diversions to SCMAGLEV that take into account the appropriate penalties for both line-haul and station access/egress travel time.

A comparison of the proposed SCMAGLEV market area to that observed from the 2003 Maglev DEIS study (Figure 3-12) shows a close correspondence between catchment areas of the two study efforts. It should be noted that the 2003 Maglev DEIS catchment area was defined solely on the basis of existing MARC or Amtrak use, thereby further validating the proposed market area for SCMAGLEV service that will provide a faster and more reliable option for travelers in the corridor. For additional reference, Figure 3-13 depicts the MARC catchment shed observed in a recent 2016 origin-destination survey of customers.

---

[4] Steer Davies Gleave, HSIPR Best Practices: Ridership and Revenue Forecasting, Prepared for the Office of the Inspector General, 2011

FIGURE 3-12 BALTIMORE-WASHINGTON CATCHMENT AREAS COMPARISON

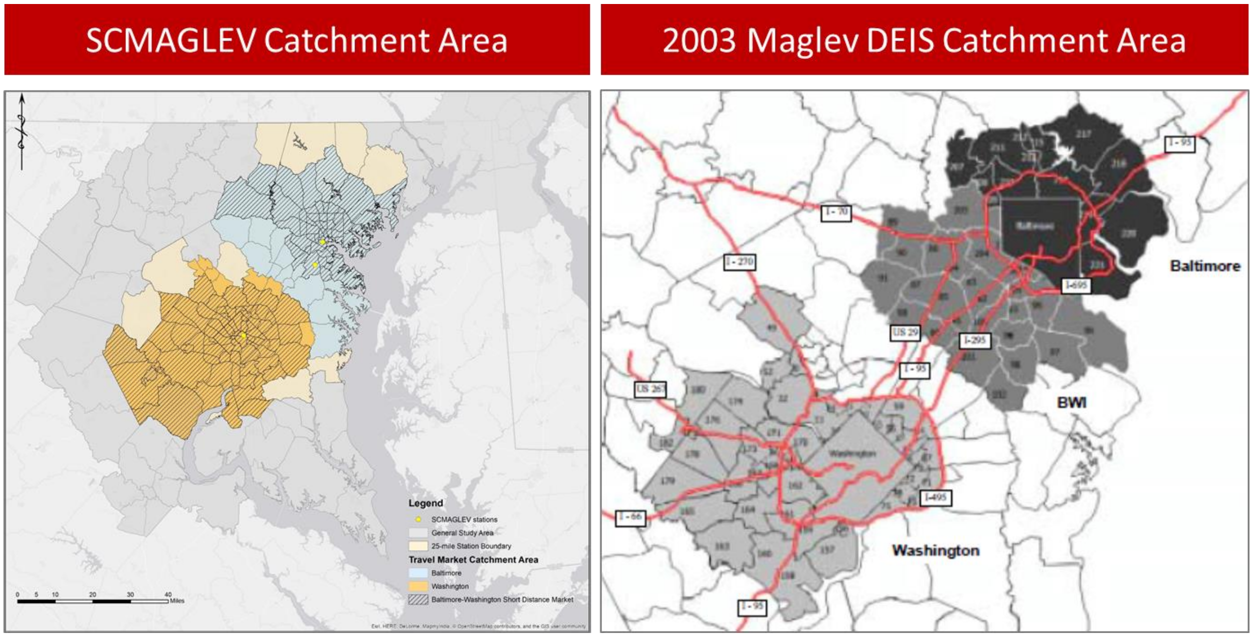
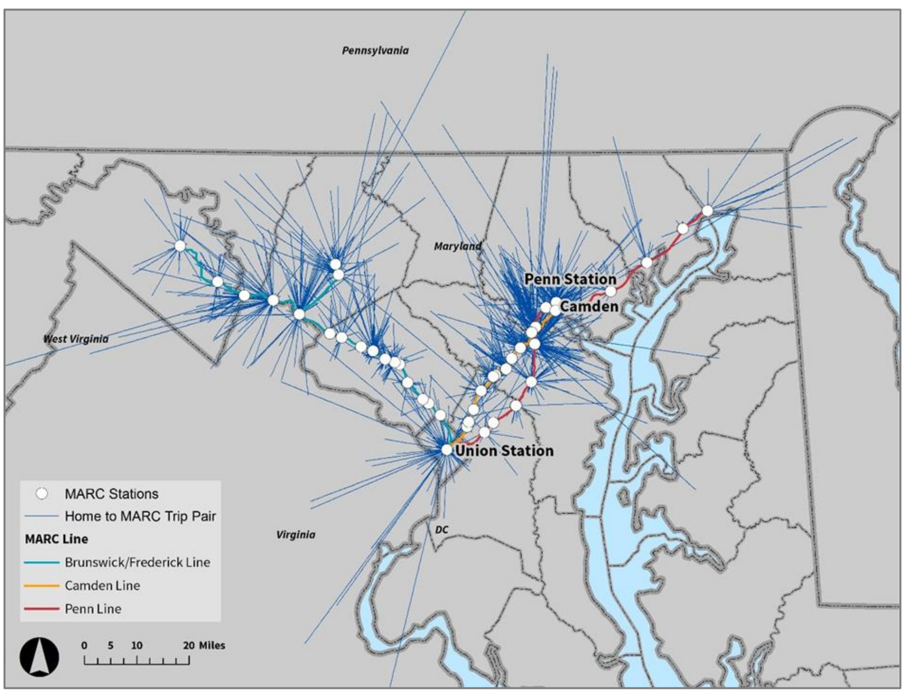


FIGURE 3-13 MARC SYSTEM RIDERSHIP CATCHMENT AREAS



3.2.2 Base Year Trip Table

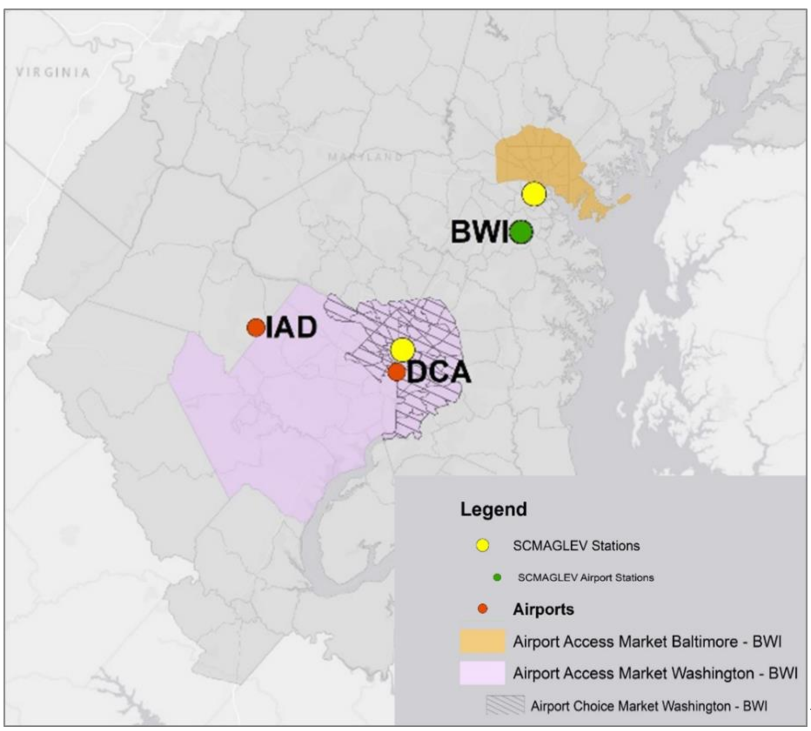
The base year trip table was developed by compiling available information on all the public modes of travel using the data sources described above. Given that the AirSage data reflects all trips (both auto and non-auto) the volume of auto trips was determined by subtracting out the volume of public modes travel from the AirSage volumes at the city pair level within the refined travel market catchment areas delineated in Figure 3-9.

Although the BWI airport market shed covers a large portion of the Baltimore-Washington travel market, the market areas delineating airport access trips for this study were first circumscribed within the travel market catchment area defined in Figure 3-11 and then further narrowed to represent reasonable access patterns that take into account the proximity of the proposed SCMAGLEV stations within the corridor. Given the very short distances between Downtown Baltimore and BWI, the airport access market areas in Baltimore were limited to relatively small geography depicted by the tan shaded area in Figure 3-14 while the airport access market in the Washington region had larger coverage area given the longer distance to BWI. As defined, the SCMAGLEV BWI airport access market only represents a smaller portion of the airport's wider market.

The airport choice zones that are a subset of airport access markets represent the contested ground between the regional airports in the Washington area (BWI, DCA, IAD). This region is depicted by the cross-hatched area around Washington DC in Figure 3-14.

Data from the MWCOG airport ground access surveys were used to develop estimates of trip volumes from the delineated airport access catchment areas by mode of travel – including taxi and transportation network companies (TNCs).

FIGURE 3-14 SCMAGLEV AIRPORT ACCESS AND AIRPORT CHOICE TRAVEL MARKETS



(b) (4) [redacted]

(b) (4) [redacted]

(b) (4) [redacted]

(b) (4) [redacted]

3.2.3 Future Year Trip Table

3.2.3.1 Non-Airport Access Trips

Future year growth of the trip table was achieved through two means, a total demand model was developed that related base year trip table patterns at the ICAT zonal level, to corresponding zonal estimates of socioeconomic and demographic characteristics at both the origin and destination zones as shown in Table 3-12.

This total demand model applied to commute, business and non-business trips and utilized the county level projections of the Woods & Poole data, shared down to the zonal level based on the MPO TAZ distributions discussed previously in this Section of the report.

(b) (4) [redacted]

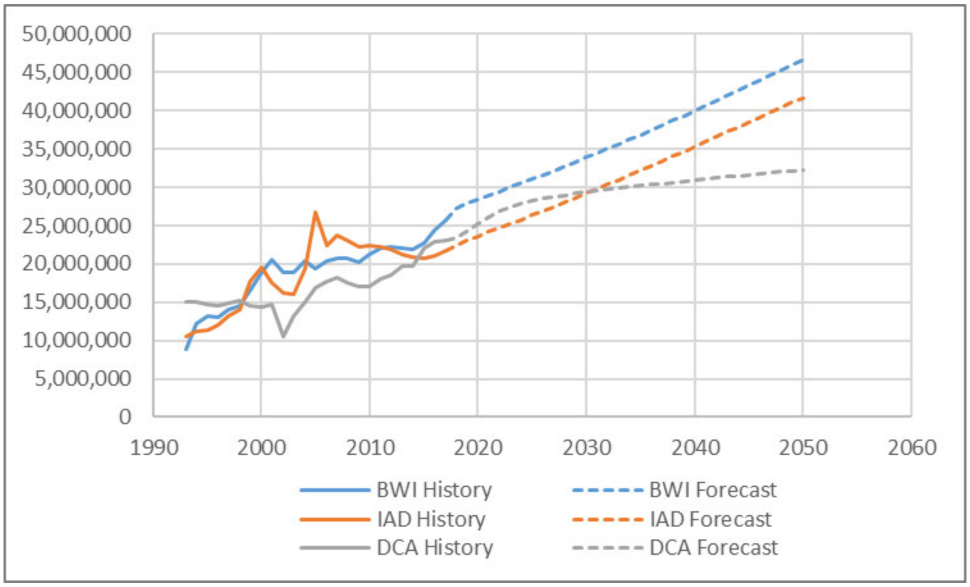
(b) (4) [redacted]

(b) (4) [redacted]

3.2.3.2 Airport Access Trips

Airport access trips to and from BWI on the other hand were predicted to grow at the rates of implied by the latest FAA terminal area forecasts (TAF) as shown in Figure 3-15. The TAF projected growth at both Washington Dulles International Airport (IAD) and DC Reagan Airport (DCA) were used to grow the airport choice travel market.

FIGURE 3-15 AIR PASSENGER ENPLANEMENTS BY REGIONAL AIRPORT



Source: FAA Terminal Area Forecasts (2017), Louis Berger (2018)

(b) (4)

(b) (4)

4.0 STATED PREFERENCE SURVEY

The 2017 SP survey supported the following ridership tasks:

- Develop SCMAGLEV demand estimates for travel between BWI and Washington, DC.
- Develop SCMAGLEV demand estimates by time-of-day, for weekdays and weekends.
- (b) (4) [redacted]
- (b) (4) [redacted]
- (b) (4) [redacted]

4.1 Survey Design

The survey instrument was designed to be administered electronically. Advantages of an electronic survey instrument compared to a paper questionnaire include that the questionnaire is customized for each respondent based on their responses throughout the survey. Built-in error checks further improve the quality of the data collected with an electronic survey instrument. Because the survey instrument was online, an additional advantage is that data collection can be followed live remotely. (b) (4) [redacted]

The survey instrument included the following types of questions:

- Screening Questions – Screening questions determine whether a person is qualified to participate in the survey.
- Reference trip – (b) (4) [redacted]
- Choice Exercise – (b) (4) [redacted]
- Induced Travel - (b) (4) [redacted]
- Socioeconomic/demographic characteristics – (b) (4) [redacted]

4.1.1 Screening

To be qualified to participate in the survey, potential respondents were required to meet the following criteria:

- Age 18 or older
- Within the past 6 months, the respondent must have traveled at least once between an origin and a destination pair that would be served by the proposed SCMAGLEV service. Stops included in the survey are located in Washington, DC, the Baltimore area, and at BWI.

Participants were qualified to participate regardless of which mode that they used.

4.1.2 Reference Trip

Respondents who meet the screening criteria were asked to describe their most recent (for occasional travelers) or typical (for frequent travelers) qualified trip. The reference trip provides a realistic context for the stated choice exercise.

Questions regarding the most recent or typical trip:

- Origin - Location and Type of Location (i.e., home, work, school, airport, other).
- Destination - Location
- Time - Day of week and time of day of travel.
- Trip Purpose –
- Intercity Business, Intercity Leisure, Intercity Commute (i.e., travel between home and usual place of work), Airport Access.
- Travel Party - Number of persons in travel party, travel party composition, special needs.
- Mode of Travel – Auto (Driver or Passenger), Train (Amtrak Regional, Amtrak Acela, MARC), Express/Long Distance Bus, Rideshare/Taxi (for airport access trips only)Access and Egress modes (for non-auto) – Walking, Bicycling, Bus, Rail, Drive and Park, Ride and Park, Kiss and Ride, Taxi, Rideshare.
- Fare type and class (for Amtrak)- Amtrak Fare types: Saver, Value, Flexible, Premium, Multi-ride, Rail pass, Package deal; Amtrak Class: Coach, Business, First.
- E-ZPass or cash (for auto only).
- Parking cost and location (for auto only).
- Number of nights spent at destination
- Trip payment responsibility - Business trips are typically reimbursable by the employer or business; Company travel policy effect on mode choice for reimbursed travelers. Carpool cost may be shared with passengers.

- Ticket Purchase and Trip Planning - Respondents were asked how far in advance that they purchased their ticket (for non-auto) and when they planned their trip to obtain an understanding if they would be able to benefit from discounts with advance purchase requirements.
- Flexibility – Respondents were asked to what extent that they have the flexibility to alter the day of week or time of day that they traveled (arrival time).

4.1.3 Choice Exercise

The purpose of the choice exercise was to explore the survey respondent's interest in various travel mode options including the proposed SCMAGLEV service. The choice exercise is the principal section of the survey and the resulting data forms the basis of the ridership forecast.

(b) (4) [redacted]

(b) (4) [redacted]

(b) (4) [redacted]

- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]

[redacted]

- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]

[redacted]

[redacted]

(b) (4)

(b) (4)

Responses provide insight into how travelers value the travel time savings, reliability, service frequency and amenities that the SCMAGLEV offers while taking into account the characteristics of other available modes of travel.

4.1.4 Induced Travel

High speed rail often has the potential to generate induced travel, which are trips that would not take place if the service were not available. To explore this potential, respondents who stated that they would take the SCMAGLEV for their reference trip will be asked if they think they would travel more often to any of the destinations served by the SCMAGLEV if the service were available.

4.1.5 Socioeconomic Characteristics

Respondents were asked to report socioeconomic and demographic characteristics including the following:

- Age
- Gender
- Household size
- Household income

- Education
- Number of working adults in household
- Number of motor vehicles in household

4.2 Survey Administration

The survey was administered as an intercept and internet survey. (b) (4) [redacted]

(b) (4) [redacted]

(b) (4) [redacted]

4.2.1 Intercept Survey

The intercept survey was conducted from October 31, 2017 to November 5, 2017 and from December 12, 2017 to December 19, 2017 at two locations in Baltimore. The first data collection phase took place at the

BWI Airport MARC rail station and on board of Penn Line MARC trains. The second data collection phase took place in the secure area of BWI Airport.

The survey was administered using computer-assisted personal interviewing (CAPI) techniques, which involved interviewers intercepting travelers and administering the online survey using Android tablets to those agreeing to participate. To obtain adequate participation rates, it was necessary to reduce the survey duration and therefore the intercept survey instrument was a shorter version of the survey instrument outlined in section 4.1. Upon completion of each questionnaire, the data was automatically uploaded to the survey database, which allowed for real time monitoring of data quality and progress towards sample size goals.

Individuals selected to collect data were required to exhibit the qualities needed for a successful interviewer. Some of these skills involve familiarity with a tablet, an outgoing personality, excellent communication skills, and reliable personal transportation. Interviewers were required to attend a four-hour training session. During the training session, interviewers were advised about the purpose of the study, work schedule (survey times and location), dress code, and data collection methodology. The training session also included a focused review of the survey instrument to familiarize the staff with each question and appropriate responses to be collected. Interviewers were instructed to communicate each question completely as worded. Throughout the data collection, interviewers also received sampling instructions (e.g., every travel party encountered or every nth travel party) from the field supervisor depending on the level of activity at the site at the time.

4.2.2 Internet Survey

The internet survey was conducted from November 1, 2017 to December 2, 2017. The survey was conducted using Computer Assisted Web Interviewing (CAWI) techniques as part of which respondents access the online survey and complete the survey on their computer or phone without an interviewer. Internet surveys have been a growing trend in travel survey research due to the lower costs and faster data collection. Respondents to the internet survey were recruited in two ways.

(b) (4)

- [redacted]
- [redacted]

(b) (4) [redacted]

4.3 Summary Tabulation & Frequencies

4.3.1 (b) (4) [redacted]

(b) (4) [redacted]

(b) (4) [redacted]

4.3.2 Interest in SCMAGLEV

While the choice exercise data formed the basis for ridership forecasts, the survey instrument also directly asked respondents if they would choose the SCMAGLEV service for their reference trip. The direct question presented the SCMAGLEV service in terms of in-vehicle travel, access, and egress time, frequency, cost and service level. While this direct question does not include any information about alternative travel options, it offers additional insight in understanding travelers' interest in the SCMAGLEV service and their willingness to pay for the travel time savings, reliability and service amenities.

(b) (4) [redacted]

(b) (4)

(b) (4)

(b) (4)

4.3.3 (b) (4)

(b) (4)

4.3.4 (b) (4)

(b) (4) [redacted]

(b) (4) [redacted]

4.3.5 (b) (4)

(b) (4) [redacted]

(b) (4)

5.0 DISCRETE CHOICE ANALYSIS

The SP data from both the web and internet surveys was analyzed and provided a set of mode choice model coefficients that would be integrated into the travel demand model used to generate SCMAGLEV ridership forecasts. In selecting between the modes of travel presented in each of the hypothetical choice experiments, and by making trade-offs between the varying levels of travel time, travel cost, service frequency presented in each screen, respondents implicitly provided information on their travel preferences. Using discrete choice analysis techniques, Louis Berger was able to determine the relative importance of each individual level-of-service (LOS) travel attribute on traveler mode choice, as well as the general modal bias or preference for each market segment.

5.1 Conceptual Overview

The basic concept driving discrete choice analysis is the idea of utility maximization. Utility in economics is described as the satisfaction an individual gains from the consumption of goods or services. Each alternative in a decision maker's choice set provides a level of utility that is both a function of the attributes specific to that alternative, as well as the decision maker's own characteristics.

The logit model's mathematical form has been found to most closely articulate a number of the theoretical principles of utility theory maximization. It has been deployed in various forms as the basis for the development of several discrete choice models used in analyzing transportation mode choice. The utility of a given alternative is assumed to comprise a deterministic portion that is a function of measurable characteristics, as well an error term that accounts for the portion of an individual's utility derived from a given mode that cannot be observed or measured by an analyst.

$U_i = V_i + \varepsilon$

Where:

U_i = represents the utility accruing to individual i
V_i = represents the deterministic portion of utility accruing to individual i
ε = represents the error term

(b) (4) [redacted]

(b) (4) [redacted]

The multinomial logit model (MNL) that forms the basis of discrete choice models calculates the probability of selecting a given alternative by comparing the utility of that mode against the total utilities of all mode alternatives in a choice set. Formally it is expressed as:

$$P_{(i)} = \frac{e^{U_i}}{\sum_{j=J} e^{U_j}} \qquad (4)$$

Where:

i and *j* are alternatives in a choice set,
P(*i*) is the probability of choosing Mode *i*,
J is the set of all alternatives available to the individual (including modes *i* and *j*),
U is the utility associated with a given mode (as shown above)

Although Louis Berger tested and applied a variety of functional forms in the final model specification, the general MNL form was used in the preliminary assessments of data quality and the evaluations of conceptual relationships among select variables.

5.1.1 Value of Time

Value-of-Time (VoT) is the estimated price an individual is willing to pay to save time on a given journey. This measure is typically calculated as the ratio of the travel time coefficient (converted from minutes to hours) and the cost coefficient as shown in equation 6.

$$VoT = \frac{\beta_{traveltime(utils/min)} \times 60_{(min/hour)}}{\beta_{cost(utils/\$)}} \qquad (5)$$

The VoT is a measure of price sensitivity in transportation planning, and provides a useful summary metric to evaluate the conceptual consistency of an estimated model. (b) (4) [redacted]

The United States Department of Transportation (U.S. DOT) has provided guidelines for recommended values of time based on estimated hourly wages, trip length and trip purpose. Louis Berger used these guidelines to estimate the corresponding set of anticipated VoT ranges specific to the income composition of the survey data collected (Table 5-1) that would be used to evaluate the conceptual consistency of some of the estimated models.

They further provide guidance for reasonable values of time based on the mode of transportation and distance of travel – based again on nationwide median household incomes. As per the latest 2016 guidelines, these values range between $16.30 and $24.50/hr for personal non-business intercity travel (which would technically include commuting trips), and between $20.30 and $30.50/hr for intercity business travel using traditional surface modes of travel. For intercity travel by air or high speed rail, the corresponding values range between $31.00 and 46.50/hr for non-business travel and $50.60 and $75.80/hr for business travel.

TABLE 5-1 SP SURVEY ANTICIPATED VALUE-OF-TIME ESTIMATES

Market Segment	Commuters[1]	Non Business	Business
(b) (4)			
US DOT Values of Time Guidelines (% Hourly Wage)			
Lower Bound	35%	60%	80%
Upper Bound	60%	90%	120%
LBG Stated Preference Survey Value-of-Time Targets			
(b) (4)			
Notes: 1. VoTs for commuters based on US DOT guidelines for personal local travel estimates			

Source: US DOT, Louis Berger (2018)

5.2 Base Model Estimation

Louis Berger conducted some preliminary assessments of the SP data collected in the survey. Data was scanned to identify potential records for exclusion from model estimation based on observed choice making patterns in the sample – e.g. respondents who rushed through the survey by picking the same choice option. A simple trading analysis was also performed to evaluate the degree to which respondents meaningfully engaged with the hypothetical scenarios presented. Less than two percent of the sample was excluded from further analysis in the mode choice estimation process.

(b) (4)

Following the preliminary data assessment Louis Berger estimated a number of simple base models segmented by the respondents reported mode of most recent or typical intercity travel. Summarized results of this process are presented in Figure 5-1 that show the expected pattern of VoTs that generally conformed to the guidance provide by US DOT and Louis Berger's previous experience studying intercity travel in this corridor..

5.3 Final Model Estimation

Following the estimation of several MNL model specifications that tested various combinations of variables, Louis Berger proceeded to develop the final set of models to be applied in the travel demand model. This analysis involved segmentation of the travel market to reflect the following distinctions:

- Travel distance
- Income (household)
- Trip purpose

For purposes of this study, the Baltimore-Washington city pair is defined as a short-distance travel market, in this case, 44 miles by highway distance.

(b) (4) [redacted]

(b) (4) [redacted]

(b) (4) [redacted]

(b) (4)

(b) (4)

6.0 Travel Demand Forecast Model

The ridership analysis was conducted using a spreadsheet based travel demand model that was customized to analyze trips within the SCMAGLEV catchment areas. The rest of this section of the report highlights the various features of the model that were used to generate the ridership forecast.

6.1 Analysis Years & Time-of-Day

The travel demand model assumed 2025 opening year for proposed service and a forecast horizon of 2050 that represented the limits of data obtained from the regional models and third party vendors.

To support the engineering and environmental analyses, Louis Berger developed a model of average daily travel that distinguished four different times-of-day that separated the morning and evening peak periods as listed below together with corresponding abbreviation codes AM, MD, PM, and NT:

- Morning (AM) – 6:00am to 9:00am
- Midday (MD) – 9:00am to 4:00pm
- Evening (PM) – 4:00pm to 7:00pm
- Overnight (NT) – 7:00pm to 6:00am

Annualization factors used to convert average daily traffic to annual volumes were applied on an individual market segment basis. (b) (4) [redacted]

6.2 Zonal Structure

The ICAT zonal structure described in Section 2.0 of this report provided the zonal basis for the model. Table 6-1 provides a summary of the number of origin-destination zonal pairs in each of the three major city-pairs. Both Baltimore-BWI and Washington-BWI primarily represent the air travel market and based on both the narrower geographic market delineated for this trip purpose, and the convergence of all trips to or from a single zone, there is a notably smaller travel market serving these airport access city-pairs.

Table 6-1 Origin-Destination Pairs by City Pair

City Pair			Zone-Pairs	
1	Baltimore-Washington		7,302	97.54%
2	Baltimore-BWI		50	0.67%
3	Washington-BWI		134	1.79%
Total			**7,486**	**100.0%**

6.3 Diversion and Induced Models

The SCMAGLEV ridership estimates were estimated through the calculation of both mode diversions, and the estimation of induced trips that are not currently reflected in the base or future year trip tables.

(b) (4)

(b) (4)

6.3.2 *Induced Ridership*

In addition to the diverted model, SCMAGLEV was projected to induce ridership that is currently not reflected in the trip tables developed. Two approaches were identified to quantify this additional volume of ridership on a zone-pair basis:

- Generalized cost of travel approach
- Airport choice

6.3.2.1 Generalized cost of travel

Assuming that the total number of trips (T) generated between a given O-D pair in equation 9 is a function of both socioeconomic/demographic factors (SED) and travel impedance (U) that is characterized by equation 10, the estimated volume of induced trips is therefore obtained from equation 13.

$$T = SED \times U \quad (9)$$

Where:

SED = the socioeconomic/demographic factors at both the origin and destination

U = generalized cost/utility of travel between the origin and destination pairs

And:

$$U = -(LN(exp^{Uauto} + exp^{Upublic})) \quad (10)$$

$$\text{Induced Trips} = \text{Trips after SCMAGLEV } (T_A) - \text{Trips before SCMAGLEV } (T_B) \quad (11)$$

Based on equation 11, the total travel before and after SCMAGLEV implementation are estimated as follows:

$$T_A = SED \times U_A \quad (12)$$

$$T_B = SED \times U_B \quad (13)$$

Holding the SED factors constant, the percentage increase in total travel can therefore be expresses entirely in terms of changes in the generalized cost as shown in equation 14.

$$\text{Induced Demand \%} = (U_A - U_B)/ U_B \quad (14)$$

6.3.2.2 Airport Choice

The generalized cost of travel approach described in Section 3.2.3.1 is based on an analytical concept that directly correlates travel impedance to trip generation. This concept does not apply to airport access trips because the volume of trips to a given airport is ultimately a function of air travel demand at that airport and not the ease of airport ground access.

(b) (4) [redacted]

Louis Berger adopted an airport choice model developed as part of the Federal Aviation Administration's (FAA) Regional Air Service Demand study of the New York/New Jersey Metropolitan area, and relied on the ground access travel time coefficients obtained from that study. The improved generalized cost/utility of ground access travel to BWI as a result of SCMAGLEV service, was converted into equivalent units of travel time savings before being applied to the adopted airport choice model using incremental logit/pivot point analysis techniques. Equation 15 provides a mathematical summary of the incremental logit process.

$$P'_{(i)} = \frac{P_i e^{\Delta Ui}}{\sum_{jEJ} P_{(j)} e^{\Delta Uj}} \qquad (15)$$

Where:

- *i* and *j* → options in a choice set,
- $P_{(j)}$ → original base share for each alternative j (including option i),
- $P'_{(i)}$ → revised probability of choosing option *i*,
- ΔU_j → change in utility associated with a given alternative j (including alternative i),
- *J* → set of *all* alternatives available to the individual

6.3.3 Model Inputs

Data characterizing the travel experience by each mode was used to operationalize the mode choice and induced demand models described above. Louis Berger utilized several sources of information to populate the travel skim files to be used in this process.

6.3.3.1 Auto Travel Time

Auto travel time and distance data feeding the model was obtained through Google Maps Directions API. This is a service that calculates directions and travel times, by mode of travel, between specified locations based on actual travel times experienced in the real-world under conditions. Google API data was collected for a typical Tuesday in April for the four time of day periods included in the model. Tuesday, as well as Wednesday and Thursday, reflects typical weekday travel conditions as it is not affected by weekend shoulder traffic as is the case on Mondays and Fridays. Meanwhile, April is a month reflects typical travel conditions as it is not affected by summer travel. The collected travel times were calculated with consideration of historical traffic conditions to ensure a more accurate characterization of the peak and off-peak travel experiences for each zone-pair. Travel times and distance were collected for each origin-destination (O-D) pair at the ICAT level.

Google API data helped overcome the significant challenge of obtaining (where available) and harmonizing intercity travel data sources from the multiple MPOs in the region. Furthermore, the incorporation of this data also provided an opportunity to evaluate and benchmark such critical inputs as study area auto travel times and distances traveled into the travel model. A comparison of the Google API data to comparable BMC data for travel between Downtown Baltimore, BWI and Downtown DC is presented in Table 6-2 below. This table shows a reasonably close comparison across the two data sources—particularly in the off-peak period, however the BMC model does not distinguish the directionality of peak travel times.

TABLE 6-2 COMPARISON OF MPO & GOOGLE TRAVEL TIME (MINUTES)

	BMC	Google API		BMC	Google API	
	Off Peak	MD (9AM-4PM)	NT (7PM-6AM)	Peak	AM (6AM-9AM)	PM (4PM-7pm)
Washington DC to Baltimore	41	48	44	52	45	76
Washington DC to BWI	37	45	42	49	42	75
Baltimore to Washington DC	41	46	42	79	68	60
BWI to Washington DC	37	41	38	71	63	55

6.3.3.2 Auto Travel Costs

Auto travel costs were obtained from a variety of sources to account for the various costs of driving. Fuel prices were obtained from the latest review of current and future projected prices of gasoline from the Energy Information Agency (EIA). The reference forecast provided the basis for determining the per mile cost of fuel based on fuel efficiency standard assumptions also obtained from the EIA

Parking costs across the corridor were also researched thoroughly by determining the cost of parking in at various reference locations in the region, and defining a relationship that correlated parking cost with employment density and region typology (urban, suburban, residential, etc.)

The cost of taxi/TNC was also researched for each of the airport city pairs and converted into a per minute cost that was applied to the travel demand model estimate of travel time by time-of-day. This formulation ensured that the cost of this mode reflected the impacts of traffic congestion on price.

6.3.3.3 Non-Auto Travel Time & Costs

The line-haul travel time for all non-auto modes were obtained by reviewing published schedules of service. These schedules provided detail on travel time, frequency, and costs.

Rail travel was modeled as a single mode reflecting the relative weight of each type of rail (Amtrak Acela, Regional, and MARC). Given that MARC represents almost 90% of the rail market in the Baltimore-Washington market (see Table 3-10), the travel time, service frequency, and cost of rail was weighted accordingly to reflect that market share.

(b) (4) [redacted]

(b) (4)

The time to travel from the origin zone to the station of departure (i.e., access time) and the time to travel from the station of arrival to the destination zone (i.e., egress time) were obtained with the Google Maps Direction API. In addition to auto drive time between each station access/egress OD pair, bus and rail transit travel times were also collected via Google API.

6.3.3.4 Summary of Model Inputs

Tables 6-5 to 6-9 summarize the average travel times and costs for each of the modes of travel in the corridor weighted by the volume of trips from each zone-pair. This summary is intended to give a high level view of the travel conditions facing various travelers in the corridor, however, individual zonal pairs may exhibit conditions notably different from those depicted in the following tables.

TABLE 6-5 AVERAGE AUTO TRAVEL TIME AND COST (2017)

City Pair	Travel Time (Minutes)				Cost
	AM Peak	Midday	PM Peak	Night	
Washington-Baltimore	60	53	67	51	(b) (4)
Baltimore-BWI	27	25	28	24	
Washington-BWI	56	47	65	45	

TABLE 6-6 AVERAGE RAIL TRAVEL TIME IN MINUTES (2017)

City Pair	Access Time	Egress Time	In-Vehicle Travel Time			
			AM Peak	Midday	PM Peak	Night
Washington-Baltimore	39	47	60	57	54	60
Baltimore-BWI	15	21	18	15	14	18
Washington-BWI	28	31	36	34	35	37

TABLE 6-7 AVERAGE RAIL TRAVEL COST (2017)

City Pair	Access Cost	Egress Cost	In-Vehicle Travel Cost			
			AM Peak	Midday	PM Peak	Night
Washington-Baltimore	(b) (4)					
Baltimore-BWI						
Washington-BWI						

TABLE 6-8 AVERAGE BUS TRAVEL TIME IN MINUTES (2017)

City Pair	Access Time	Egress Time	In-Vehicle Travel Time			
			AM Peak	Midday	PM Peak	Night
Washington-Baltimore	43	50	73	69	75	67
Baltimore-BWI	21	27	34	34	33	31
Washington-BWI	28	31	30	30	30	30

TABLE 6-9 AVERAGE BUS TRAVEL COST (2017)

City Pair	Access Cost	Egress Cost	In-Vehicle Travel Cost			
			AM Peak	Midday	PM Peak	Night
Washington-Baltimore	(b) (4) [redacted]					
Baltimore-BWI						
Washington-BWI						

6.4 Model Calibration

Using the mode choice model formulas and the inputs described above, the travel demand model was calibrated to match the 2017 base year trip table by mode and market segment for each of the three city pairs in the travel market, through adjustments made to the alternative specific constants.

(b) (4) [redacted]

- [redacted]

(b) (4) [redacted]

(b) (4) [redacted]

[redacted]

[redacted]

[redacted]

The resulting calibrated mode choice constants are presented in Table 6-10. The NEC Future study took a similar approach by calibrating the mode constants by individual metropolitan area pairs, however, the resulting mode constant adjustments applied ranged in magnitude between -3 to 14.

The SCMAGLEV ASC adjustments focused on the Baltimore-Washington portion of the model are generally in line with the general magnitude applied in the previous 2003 DEIS study referenced in Section 2.0 of this report.

(b) (4) [redacted]

(b) (4) [redacted]

6.5 Future Year Forecast Considerations

The travel demand model also included a number of future year adjustments to account for anticipated changes on the both travel demand and supply side.

6.5.1 Future Congestion

Future year auto travel times were adjusted to account for the potential build of congestion in the system. The Louis Berger Team evaluated the Federal Highway Administration's (FHWA) freight analysis framework (FAF) data to obtain estimates of future volume increases on roads serving the corridor, and based on the team's analysis of growing traffic volumes measured against anticipated system capacity, estimated that future congestion between Baltimore and Washington would increase 9.1 percent by 2025 and 20.0 percent by 2050.

A review of the BMC model also seemed to imply that future year travel times would increase approximately 20 percent by 2040 – similar in scale to Louis Berger's interpretation of the FAF data. The BMC future year travel conditions reflect the most updated view of major regional transportation investments that are likely to notably impact regional travel conditions.

6.5.2 Value-of-Time Growth

The U.S. DOT guidelines on the value-of-time indicate that these estimates should keep pace with the rate of real growth in projected household income. Given the anticipated increases in household income discussed in Section 3.0 of this report, the Louis Berger Team also adjusted the future year value-of-time in the travel demand model to reflect real growth in household income. This change was effected by adjusting the cost coefficient in the future year mode choice models to match the expected growth of values-of-time assuming a rate of real increase of 1.35 percent per year.

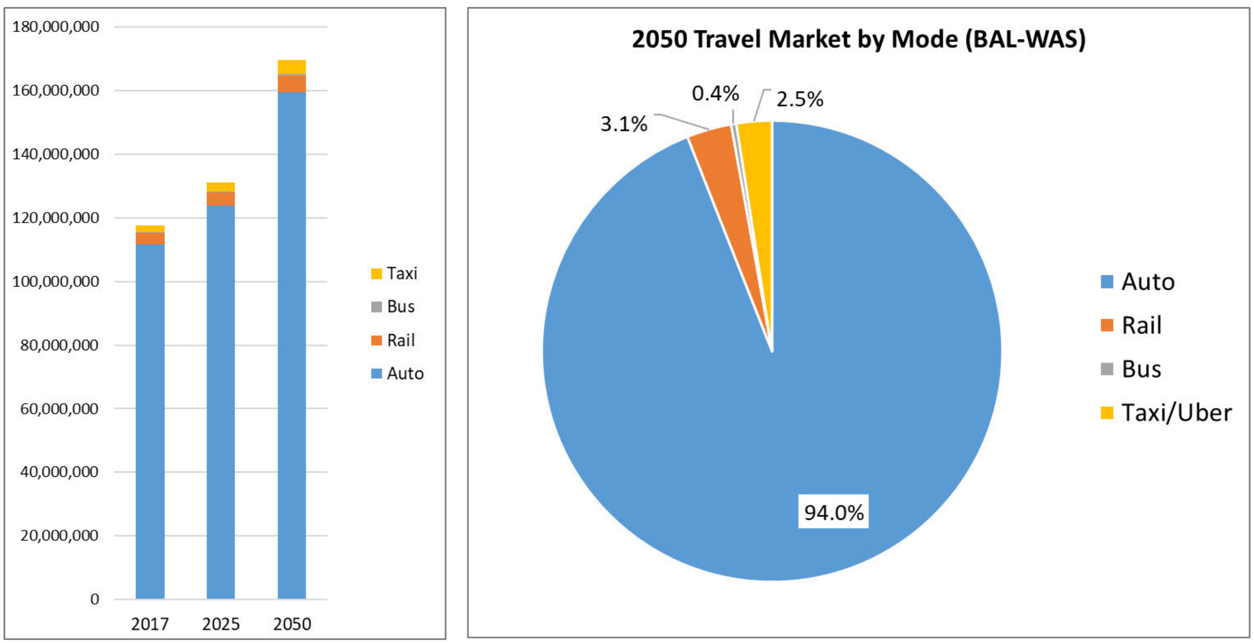
7.0 SCMAGLEV Ridership Forecasts

Louis Berger developed ridership demand estimates of the proposed SCMAGLEV project using the travel demand model described in Section 6.0. These ridership demand forecasts were developed through a process that first tested fare sensitivity of the various market segments before identifying and applying optimized fares to the future year travel markets.

7.1 No Build Travel Market

The calibrated travel demand model was used to estimate future growth in the SCMAGLEV travel market under both the build and no build conditions. Figure 7-1 presents both the growth of the SCMAGLEV travel market over time as well as the model's projected mode split in 2050.

Figure 7-1 SCMAGLEV Travel Market



The rail market share in Figure 7-1 only represents the portion of the rail travel market in the corridor with reasonable access to SCMAGLEV as a potential alternative and does not represent the total volume of rail trips in the corridor. Based on Louis Berger's analysis, SCMAGLEV comprises approximately 33 percent of the total rail travel market in the corridor.

7.2 Ridership Demand Forecast

As indicated in the work flow presented in Section 2.0, Louis Berger conducted a sensitivity analysis on a range of fares as the first step in establishing the SCMAGLEV ridership demand forecast. A varied set of fares ranging between $27.00 and $81.00 depending on trip purpose and travel distance was used to generate a base case ridership demand forecast assuming station locations at Westport/Cherry Hill (Baltimore), BWI and Mount Vernon Square (Washington). Figure 7-2 charts the projected ridership demand forecast for the proposed SCMAGLEV service between the two model years 2025 to 2050.

(b) (4)

The forecasts in Figure 7-2 assume a 2-year ramp up period where actual ridership is 40 and 80 percent respectively, of steady state growth levels predicted by the travel demand model.[8] Ridership following the end of the ramp up period grows from approximately 16.3 million annual trips in 2027 (45,000 daily), to approximately 24.5 million annual trips (67,000 daily) at the model's forecast horizon of 2050 – corresponding to an annualized average growth rate of 1.8 percent over that time frame.

7.2.1 (b) (4)

(b) (4)

(b) (4)

[8] "Ramp-up," a period of time during which ridership is building up to 'steady-state' forecast levels as travelers become acquainted with the new rail service and adjust their trip-making habits

(b) (4) [redacted]

(b) (4) [redacted]

(b) (4) [redacted].

[9] Preston, John, *The Case for High Speed Rail: A Review of the Recent Evidence*, Royal Automobile Club Foundation for Motoring, 2009.

(b) (4)

7.2.2 (b) (4)

(b) (4)

(b) (4)

7.2.3 (b) (4)

(b) (4)

(b) (4)

(b) (4)

---

[10] Segment loadings represent the volume of SCMAGLEV riders onboard between adjacent stations. This measure is critical in determining system capacity needs.

7.3 Sensitivity tests

In addition to the fare sensitivity evaluation, Louis Berger conducted several additional simulations to determine the sensitivity of the forecast outputs to changes in key input parameters. (b) (4) [redacted]

(b) (4) [redacted]

- (b) (4) [redacted]
- [redacted]
- [redacted]
- [redacted]

(b) (4) [redacted]

7.4 Potential Additional Sources of Ridership

The SCMAGLEV ridership forecast did not include some additional sources of potential ridership that could accrue to the proposed system. Although not an exhaustive list, the additional factors that could result in some potential upside the base ridership forecast are listed and briefly discussed below.

- Although the introduction of high speed transportation option in the Baltimore-Washington Corridor could very plausibly trigger economic development in the region it serves, particularly in the form of transit-oriented development near the stations, and subsequently generate even higher levels of travel demand due to this development, this ridership analysis did not include the potential impact of such second order effects that have been studied in megaregions such as the NEC.
- Future capacity limitations of existing rail (Amtrak facilities shared by multiple users with growing demand) were not accounted for in the SCMAGLEV ridership forecasts. Future constraints on train operations and movements on the congested track facilities in the corridor particularly during peak periods, could leave significant portions of the public travel inclined market with limited service options.
- Yield management practices through dynamic time-of-day pricing already in use by many airline carriers and Amtrak could further enhance projected revenues significantly by more efficiently managing demand for SCMAGLEV service.

8.0 PEER REVIEW

Four independent experts reviewed the study methodology and findings, and provided their comments. This chapter provides an overview of the peer review process, a summary of the qualifications of the peer reviewers and a summary of the review.

8.1 Peer Review Process

Identified experts were invited to participate in the peer review process based on their experience and expertise in one or more of the following areas travel demand forecasting methods, regional economics and statistical methods, transportation and technology, and multi-modal transportation systems evaluation.

The Peer Reviewers were invited to a kick-off meeting held at the Louis Berger New York office on June 14, 2018. As part of the meeting, the study methodology and key interim study findings were presented and reviewers had the opportunity to ask questions. One week after the kick-off meeting, the initial version of a Draft Ridership Report was distributed to the reviewers. Reviewers had a two-week period to review the Draft and provided comments at the end of that two-week period.

Louis Berger reviewed the comments submitted and incorporated proposed changes to the Ridership Report, where appropriate. (b) (4) [redacted]

(b) (4) [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

(b) (4) [redacted]

[redacted]

[redacted]

(b) (4) [redacted]

[redacted]

[redacted]