FEHR PEERS DC

Memorandum

Date: October 25, 2019
To: Eric Graye, Maryland-National Capital Parks and Planning Commission
From: Jesse Cohn, Matthew Ridgway, and Sogand Karbalaieali, Fehr & Peers DC
Subject: Thrive Montgomery 2050 – Transportation Analysis Approach White Paper

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Executive Summary

As Montgomery County embarks on Thrive Montgomery 2050, its first comprehensive General Plan Update in 50 years, it is important to reflect on how much the County has changed in the intervening years and will change in the years to come. This white paper provides a framework and analysis approach for understanding the future of Montgomery County and enables Montgomery Planning to answer the following questions:

- How will the County be impacted by ongoing trends related to the economy, climate change, demographics, technology, and lifestyle choices?
- Are these trends in support of the County's vision for the future, or are there gaps the agency needs to address through policies and capital improvements?

Transportation Approach to Thrive Montgomery 2050

The Transportation Working Group and Fehr & Peers DC developed a framework to guide Thrive Montgomery 2050. This process has three primary pieces:

- **Vision:** The Vision is the idealized future for Montgomery County. Associated with the vision are goals, objectives, metrics, and targets that further refine this vision.
- **Impacts of Alternative Futures**: The Impacts of Alternative Futures is what Montgomery County could look like in an unchecked future. Without intervention, what are the possible impacts for the County?

- **Thrive Montgomery Policy Recommendations:** Thrive Montgomery Policy Recommendations identifies the gaps between the Vision and Impacts of Alternative Futures and identifies policy recommendations and future work program tasks for Montgomery Planning to bridge that gap.

Transportation Evaluation

The Transportation Working Group has drafted a vision statement to guide development of Thrive Montgomery 2050: "Provide a high-quality, equitable and environmentally-friendly transportation system for all residents, employees and visitors of Montgomery County that supports the County's continued economic growth and development."

From this vision springs an increasingly specific description or image of an ideal Montgomery County through goals and objectives. Montgomery Planning has drafted six transportation goals for Thrive Montgomery 2050: expanding access, reducing travel time, creating safety, ensuring reliability, building resiliency, and maintaining infrastructure. Each goal is paired with more specific objectives, and this white paper describes analysis approaches to quantify these objectives.

Alternative Futures Workshop

Montgomery Planning hosted a workshop on June 17, 2019 with Steering Committee and Working Group Leaders to address three objectives:

1) **Identify key Drivers of Change** (e.g., climate change) as well as the specific Individual Drivers associated with each Driver of Change (e.g., flooding, infrastructure closures),
2) **Develop Alternative Futures** – future scenarios consisting of a combination of Individual Drivers – to be analyzed in Thrive Montgomery 2050, and
3) **Brainstorm transportation impacts**, such as changes to travel behavior or the transportation network, that may occur in the context of these Alternative Futures.

This workshop shaped the Individual Drivers, Alternative Futures, and transportation assumptions summarized throughout the rest of the white paper.

Drivers of Change

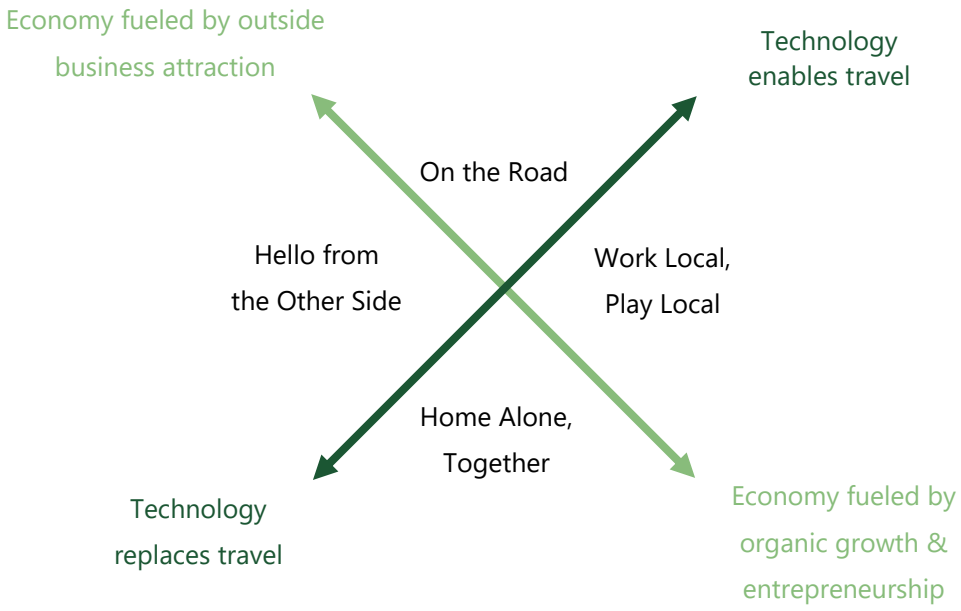
Many factors shape our communities. Some are within local or County control, while others are more far-reaching, and are beyond the County's control, representing national or global trends. The scope of work for Thrive Montgomery 2050 outlines five overarching Drivers of Change that are beyond the County's control: economic disruptions, climate change, demographic changes,

technological innovations, and changes in lifestyle. These Drivers of Change are characterized by multiple Individual Drivers, or factors associated with the Driver of Change. Each Individual Driver is then summarized, including how it could impact travel behavior, land use, and the transportation network; and how these impacts can be modeled using the Montgomery Planning's Travel/4 model, the Metropolitan Washington Council of Governments (MWCOG) regional travel demand model or "off-model" travel forecasting tools.

Alternative Futures

There are a number of different individual Driver that could impact the future of Montgomery County. Alternative Futures are plausible futures that can reasonably be expected to occur and will incorporate a range of changes that could occur in Montgomery County between now and 2050. They are essentially different baseline conditions that are a combination of one or more Drivers of Change. Based on the discussions during the workshop, four Alternative Futures were created that are defined by two Drivers of Change:

- **Technology:** Technological innovation is inevitable. Several of these anticipated innovations are linked to travel. One end of the spectrum represents technology trends that encourage travel, such as autonomous and electric vehicles. The other end of the spectrum represents technological trends that replaces travel, such as e-commerce, virtual reality, and 3D printing.
- **Economy:** The economy is inextricably linked to the demographic, environmental, and equity outcomes for the region. One end of the spectrum represents a focus on existing Montgomery County industries and residents, encouraging local entrepreneurship, with no effort to attract outside businesses. The other end of the spectrum represents Montgomery County as a regional leader in attracting global corporations to establish employment opportunities in the county.



Each Alternative Future is briefly summarized below. These narratives are intended to paint a picture of what life could be in Montgomery County.

- **On the Road -** Montgomery County, having further diversified its industries, attracts employees from throughout the region. Some of these new employees move to Montgomery County, while most commute from other parts of the region. Autonomous vehicles and transit transport these high-skill workers to the county's job centers. However, commutes are often unreliable, as extreme weather events regularly close key bridges and highways, requiring long detours. Housing demand continues to rise, exacerbating today's affordability challenges. The number of intergenerational homes increases across the county, both for affordability and cultural reasons. Income inequality and health disparities persist along economic and racial lines.
- **Work Local, Play Local -** The County's strategic focus on retaining and expanding existing industries and small businesses has removed the County from regional competition for employers. Growth industries have largely chosen to locate in other parts of the region. Montgomery County residents across the income spectrum are employed locally; nearly all residents work within the county borders and unemployment is at an all-time low. Local restaurants and entertainment are thriving. Residents can walk and bike to most of what they need, and shared autonomous vehicles support longer trips within the county. Rising temperatures make walking and bicycling uncomfortable in the summer, but health breakthroughs have eliminated the risk of skin cancer.

- **Home Alone, Together** - Local biotech and hospitality companies are the major employers of highly educated Montgomery County residents, and virtual reality enables nearly all employees to work from home. Local companies prioritize local hires despite the pervasive telework culture. Residents teleworking for companies outside the county supplement local employment. Few errands need to be run in-person, as most goods and services can be acquired online. Some grocery stores and retailers move from downtowns and shopping centers to more affordable, industrial areas, tapping into the growing distribution and delivery system. Digital sports and entertainment reign, with low user and membership fees accessible to all residents. Residential energy use skyrockets, eclipsing transportation energy use and exacerbating climate issues.
- **Hello from the Other Side -** Successfully recruiting key digital service providers, there are more jobs in Montgomery County than any other jurisdiction in the region. However, given the remote nature of all work, these jobs –filled by residents throughout the region and the world – rarely require travel to the companies' minimalist campuses. Corporations require less commercial office space, resulting in significantly lower commercial property taxes and demand for commercial space. Urban streets are generally empty of vehicles, pedestrians, and bicyclists, as most socializing happens online. Obesity increases as physical activity declines, though exposure to air pollution is mitigated through limited time spent outdoors. There are limited employment opportunities for blue collar workers. As a last resort, they often work in service of the booming sharing economy, renting their personal goods, homes, and vehicles for income.

In addition to these Alternative Futures, Montgomery Planning aims to analyze a Business as Usual Future reflecting a 2050 future that assumes the status quo with regards to the five Drivers of Change.

Next Steps

This white paper provides an analytical approach for understanding the future of Montgomery County. It enables Montgomery Planning to assess how the County will be impacted by ongoing trends, as well as whether or not these trends are in support of Montgomery Planning's vision for the future. Throughout this document, there are several recommendations for next steps for Montgomery Planning. This section compiles those recommendations and summarizes alternative approaches for moving forward with the Alternative Futures analysis.

Table of Contents

Contents

Appendix List

Appendix A. Bicycle Master Plan – Appendix E: Bikeway Prioritization Methodology

Appendix B. Workshop Summary – Drivers of Change

Appendix C. Workshop Summary – Transportation Assumptions

Introduction

As Montgomery County embarks on Thrive Montgomery 2050, its first comprehensive General Plan Update in 50 years, it is important to reflect on how much the County has changed in the intervening years and will change in the years to come. This white paper provides an analytical approach for understanding the future of Montgomery County and enables Montgomery Planning to answer the following questions:

- How will the County be impacted by ongoing trends related to the economy, climate change, demographics, technology, and lifestyle choices?
- Are these trends in support of Montgomery Planning's vision for the future, or are there gaps the agency needs to address through policy recommendations and future tasks in the agency's work program?

This white paper provides a method for understanding how future conditions might impact Montgomery County's values. It does this by identifying a range of plausible futures and developing approaches for quantifying the impact of these futures. Once that analysis is complete, the next steps for Montgomery Planning are to identify policy recommendations and future tasks in the agency's work program to bridge the differences between the County's vision and where it may end up without interventions.

This white paper is divided into six sections:

- **Transportation Approach to Thrive Montgomery 2050:** This section provides an overview of the Transportation Working Group's approach to developing the transportation component of Thrive Montgomery 2050. At a high level, the framework seeks to identify gaps between the agency's vision for the County's future and the range of futures that could occur in Montgomery County. The goal of Thrive Montgomery 2050 is to identify policy recommendations and work program items that bridge these gaps.
- **Transportation Evaluation:** Montgomery Planning and Fehr & Peers DC staff have developed a set of goals and objectives to define the County's vision for the future. This section summarizes the agency's objectives and provides an analysis approach for quantifying them under existing conditions and future conditions (2050), while tracking progress in interim years.
- **Alternative Futures Workshop:** In June 2019, Montgomery Planning and Fehr & Peers DC staff collaborated in a full-day workshop to identify the exogenous trends (herein

referred to as Drivers of Change) affecting Montgomery County during the next 30 years, brainstorm the implications of these Drivers of Change on travel behavior and the transportation network, and develop future baseline scenarios (Alternative Futures) comprising different Drivers of Change. This section summarizes the activities conducted during the workshop.

- **Drivers of Change:** The Alternative Futures workshop yielded feedback about what the future could look like, and how it could impact transportation in the County. This section summarizes each Driver of Change (e.g., climate change) as well as the specific Individual Drivers associated with that Driver of Change (e.g., flooding, infrastructure closures, weather variability). This section then outlines the transportation impacts associated with the Individual Drivers, as well as how Montgomery Planning could move forward with evaluating each impact.
- **Alternative Futures:** Alternative Futures are future scenarios consisting of a combination of Individual Drivers. For Thrive Montgomery 2050, five Baseline Futures have been identified, including a Business as Usual Future that maintains existing trends and four Alternative Futures, each of which assumes major shifts in the County as a result of technological and economic trends. This section summarizes the Alternative Futures and provides guidance for how to analyze them.
- **Next Steps:** Throughout this document, there are several recommendations for next steps for Montgomery Planning. This section compiles those recommendations and summarizes alternative approaches for moving forward with the Alternative Futures analysis.

Transportation Approach to Thrive Montgomery 2050

The Transportation Working Group and Fehr & Peers DC developed a framework to guide Thrive Montgomery 2050. Summarized in **Figure 1** (next page), this process has three primary pieces:

- **Vision (left panel)**: The Vision is the idealized future for Montgomery County. Associated with the vision are goals, objectives, metrics, and targets that further refine this vision.
- **Impacts of Alternative Futures (right panel)**: The Impacts of Alternative Futures is what Montgomery County could look like in an unchecked future. Without intervention, what are the possible impacts for the County?
- **Thrive Montgomery Policy Recommendations (center panel):** The center panel, Thrive Montgomery Policy Recommendations, identifies the gaps between the Vision and Impacts of Alternative Futures and identifies policy recommendations and future work program tasks for Montgomery Planning to bridge that gap.

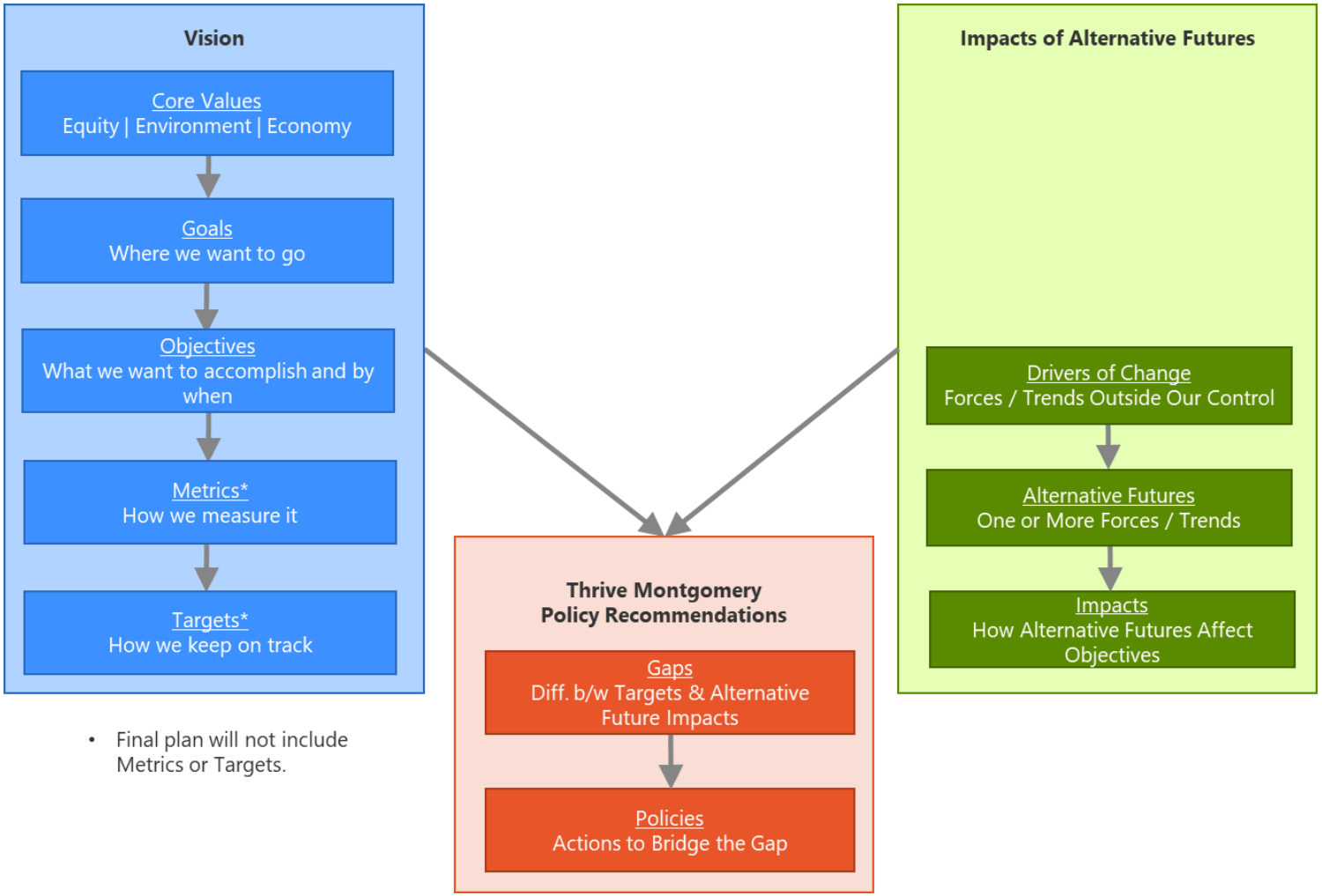
Vision

Montgomery Planning has drafted a transportation vision statement to guide development of Thrive Montgomery 2050:

> "Provide a high-quality, equitable and environmentally-friendly transportation system for all residents, employees and visitors of Montgomery County that supports the County's continued economic growth and development."

From this vision springs an increasingly specific description or image of an ideal Montgomery County. This description comprises several components, including core values, goals, objectives, metrics, and targets.

Figure 1. Transportation Working Group Process



- Final plan will not include Metrics or Targets.

Core Values

The framework consists of three core values/outcomes for Thrive Montgomery 2050: economic health, community equity and environmental resilience. The three themes permeate all other issues and areas of concern and, in turn, are impacted by all major changes and trends. They are:

- **Economic health** means that Montgomery County has a forward-looking economy that is strong and competitive, with a variety of stable and well-paying jobs.
- **Community equity** means that Montgomery County is a place where all residents, regardless of race, age, religion, ethnicity, national origin, income, physical ability or gender, have equal access to affordable housing, healthy food options, parks and open spaces, facilities and services, employment opportunities, a quality education and a variety of mobility options.
- **Environmental resilience** means that Montgomery County is prepared to address the threats of climate change and uses the best available strategies to protect both built and natural resources to allow them to be enjoyed by future generations.

Goals

Goals express our values – what Montgomery County wants to achieve. Montgomery Planning has drafted six transportation goals for Thrive Montgomery 2050:

1. **Expanding Access:** Convenient travel to a wide variety of destinations in the County and region
2. **Reducing Travel Time:** Reducing the amount of time that Montgomery County residents, employees and visitors spend traveling in the County
3. **Creating Safety:** Eliminating transportation fatalities and severe injuries
4. **Ensuring Reliability:** Making travel predictable on Montgomery County's roadway and transit network
5. **Building Resiliency:** Providing sufficient capacity to enable the transportation system to rebound from man-made and environmental disasters
6. **Maintaining Infrastructure:** Maintain a state of good repair for the County's transportation system

Objectives

Objectives describe goals in specific statements, outlining the "who, what, when, where, and how" of reaching the goals. Objectives associated with the goals listed above are included in the Objectives and Metrics section below.

Metrics

Metrics are how objectives are measured. The identified metrics associated with the objectives listed above are included in the Objectives and Metrics section below.

While metrics play an important role in this analysis approach in Thrive Montgomery 2050, metrics will not be included in the Plan itself. They will be used to monitor implementation of the goals and objectives over time.

Targets

Targets represent the desired value for the metrics and make it possible to measure how close the County is to achieving its vision. For example, Montgomery Planning has a Vision Zero policy. Vision Zero's goal is to eliminate all traffic fatalities and severe injuries. The metric for measuring progress towards this goal would be the number of fatalities or severe injuries in Montgomery County. Given the goal of "eliminating" these types of crashes, the target for this metric would be zero.

While targets assist Montgomery Planning in identifying how Alternative Futures exceed or fall short of the agency's goals, the General Plan itself will not include the targets specified by the Transportation Working Group. As with metrics, they will be used to monitor implementation of the goals and objectives over time.

Impacts of Alternative Futures

Undoubtedly there will be obstacles to achieving Montgomery County's transportation vision by forces that are both within and beyond the County's control. While a typical master planning process would attempt to understand how the future may impact the County's vision by projecting past trends forward, this approach is insufficient in a rapidly changing world. This section of the transportation approach to Thrive Montgomery 2050 identifies a range of Alternative Futures that could occur in Montgomery County and seeks to quantify their impacts. By understanding the range of possible outcomes, Montgomery Planning can "bracket" what the future might look like and develop a set of policy responses to steer the future towards its desired vision.

Drivers of Change

Many factors shape our communities. Some are within local or County control, while others are more far-reaching and beyond the County's control, representing national or global trends. The

scope of work for the Thrive Montgomery 2050 outlines five overarching Drivers of Change that are beyond the County's control, identified during the pre-planning work by Montgomery Planning staff and Rhodeside & Harwell as part of developing the strategic framework:

- **Economic disruptions,** such as the impacts of global trade, technological innovations and growing competition among regions and jurisdictions.
- **Climate change** and its potential impacts on the economy, infrastructure, agriculture, health, recreation and natural habitat due to more frequent and severe storms, floods and extreme temperature fluctuations.
- **Demographic changes,** such as international migration, an aging population with more people working longer than the average retirement age in the past, increasing diversity, family size and structure, decreasing birth rates and a changing mix of household types.
- **Technological innovations,** such as Internet of Everything, artificial intelligence, autonomous vehicles, robotic deliveries and many others that are going to influence how we live and work, plan our communities, build and maintain our infrastructure, and develop our economy during the next 30 years.
- **Changes in lifestyle** and locational preferences for walkable communities with easy access to amenities over suburban cul-de-sacs and office parks. The dominance of the traditional nine-to-five job schedule is declining with the growth of telecommuting and flexible work hours, which is creating new dynamics for commercial office space and commuting patterns. The We Company (previously WeWork), which offers physical and virtual shared spaces and office services for individual companies, is now ranked as the largest commercial space lessee in the world.

These Drivers of Change are characterized by multiple factors associated with each Driver of Change, referred to as Individual Drivers within the white paper. For example, global trade is an Individual Driver associated with the economic disruptions Driver of Change.

There are a number of different Individual Drivers that could impact the future of Montgomery County. Some of these Individual Drivers stem from the same underlying trend and are likely to occur together. Other Individual Driver are quite different and are unlikely to occur concurrently.

Alternative Futures

Alternative Futures are plausible futures that can reasonably be expected to occur and will incorporate a range of economic, environmental, demographic, technological and lifestyle changes that could occur in Montgomery County between now and 2050. They are essentially

different baseline conditions that are a combination of one or more Drivers of Change. Alternative Futures are distinguished from the Business as Usual Future, which is a Baseline Future that would occur if the County continues along its current path.

Impacts

Impacts represent how each of the Baseline Futures affect the County's ability to achieve its value, as defined by the metrics and their targets. It is in the section of the transportation approach to Thrive Montgomery 2050 that the metrics are evaluated for each Alternative Future.

Thrive Montgomery Policy Recommendations

The focus of Thrive Montgomery 2050 is to identify policy recommendations that will be instituted by future Montgomery Planning and the County's work program items. This portion of the transportation approach to Thrive Montgomery 2050 shown in **Figure 1** identifies the gaps between the County's vision and where it may otherwise end up without additional interventions and identifies policy recommendations to bridge that gap.

Gaps

Different technological or economic trends can impact travel behavior, inching the County closer or farther from its intended goals. Gaps measure this difference; they are the difference between Montgomery Planning's established targets and the impacts of the different Alternative Futures.

Policies

As gaps are quantified through this analysis, Montgomery Planning will develop policy recommendations to eliminate or minimize the gaps. Actions shift the outcomes of Alternative Futures closer to the County's targets.

Transportation Evaluation

Montgomery Planning has drafted six transportation goals for Thrive Montgomery 2050, addressing accessibility, travel time, safety, reliability, resiliency, and state of good repair. The following sections summarize the draft objectives associated with each goal and outline an approach for quantifying them. These objectives can be evaluated at three time points:

- **Evaluate Existing Conditions:** The evaluation of existing conditions may be calculated using the outputs from the Travel/4 model (for simulated data) or based on observed data.
- **Evaluate Baseline Futures:** The evaluation of the Baseline Futures may be calculated using outputs from the Travel/4 model.
- **Track Progress:** Montgomery Planning may want to track interim progress towards the targets established during the Thrive Montgomery 2050 process. Depending on the interim metric outcomes, Montgomery Planning may choose to shift its policy priorities. This evaluation could occur during any year between today and 2050. Depending on the interim year, the evaluation may be calculated using the outputs of the Travel/4 model or based on observed data.

A high-level summary of the analysis tools and data needed to evaluate each objective is included in **Table 1** (next page). A numeric definition of each objective, as well as a more thorough description of each objective's analysis approach is in the section that follows. In the text, each numeric objective includes highlighted text. These highlighted placeholders represent the targets set by Montgomery Planning for each objective. Where placeholders are listed as X1 or X2, the expectation is that the target value will be the same for all placeholders of the that number within that objective.

For some objectives, we recommend revising the current text based on the level of effort needed to quantify the objective and the expected level of confidence in the resulting outcome.

Table 1. Analysis Approach by Goals and Objectives

Objectives	Existing Conditions	Baseline Futures	Track Progress
Expanding Access			
Regional Job Access	Model	Model	Model*
County Job Access	Model	Model	Model*
Access to Destinations	Model Data in ArcMap	Model Data in ArcMap	Model Data in ArcMap*
Reducing Travel Time			
Auto and Transit Travel Time	Model	Model	Model*
Auto/Transit Competitiveness	Model	Model	Model*
Creating Safety			
Auto Fatalities and Severe Injuries by Exposure	Observed Data (Fatalities and Severe Injuries) and Model Data (Exposure)	Observed Data (Rate from Existing Conditions) and Model Data	Observed Data (Fatalities and Severe Injuries) and Model Data (Exposure)*
Pedestrian Fatalities and Severe Injuries by Exposure	Recommend revising these objectives		
Bicycle Fatalities and Severe Injuries by Exposure			
Ensuring Reliability			
Auto Reliability	Model	Model	Model*
Transit Reliability	Observed Data	Model Data as Proxy	Observed Data
Building Resiliency			
Trips Completed with Disruption	Model	Model	Model*
Maintaining Infrastructure			
Condition of Sidewalks	Observed Data	Model Data as Proxy	Observed Data
Condition of Bikeways			
Condition of Transit Vehicles			
Condition of Bridges			
Condition of Pavement			

* Analysis is dependent on whether model data is available for the interim year.

Addressing Core Values

Thrive Montgomery 2050 includes three core values: economic health, community equity, and environmental resilience. Economic health and environmental resilience are indirectly addressed through analysis of the below objectives, while equity is evaluated explicitly. Economic health, represented by a forward-looking economy that is strong and competitive, is evaluated by proxy based on Montgomery County residents' access to jobs within the County across all modes. Environmental resilience is addressed through the infrastructure resiliency goal, as well as through the multimodal nature of the County's objectives. By evaluating transit, bicycle, and pedestrian metrics alongside auto metrics, Montgomery Planning is demonstrating a commitment to advancing these modes. With competitive alternatives to driving, the County can reduce its emissions and environmental impact.

Equity

Community equity is a core value of Thrive Montgomery 2050. As mentioned previously, the Thrive Montgomery 2050 draft scope defines community equity where:

> "Montgomery County is a place where all residents, regardless of race, age, religion, ethnicity, national origin, income, physical ability or gender, have equal access to affordable housing, healthy food options, parks and open spaces, facilities and services, employment opportunities, a quality education and a variety of mobility options."

All draft objectives identified in this white paper will be evaluated from an equity perspective. Equity can be measured in multiple ways, often through a person-based or place-based approach. A person-based approach would look at individual traveler's outcomes, such as the travel time for low-income residents in Montgomery County. A place-based approach focuses on the location where activity is occurring, then categorizes locations based on whether or not they are an area with a concentration of underserved populations. In this instance, the metric would be travel time from TAZs designated as low income.

Given the structure of the Travel/4 model, individual trips in the model are not assigned to specific travelers. TAZs comprise travelers of different income groups, but the model outputs do not distinguish between travel behavior for each of these groups. As a result, place-based equity analysis is most suitable when using a four-step regional travel demand model, such as the Travel/4 model.

Equity Emphasis Areas

There are different ways to define where in a city, region, or county, should be a priority for improving equitable outcomes. In 2017, MWCOG used tract-level Census data to identify Equity Emphasis Areas (EEAs), geographic areas in the region that have significant concentrations of low-income and/or minority populations, specifically African American, Asian, and Hispanic populations. MWCOG defines persons as low-income if their household income is less than 1.5 times the Federal government's official poverty threshold, which varies by household size. Tracts are identified as EEAs if one of three criteria are met:

1) a high concentration of low-income individuals,
2) a high concentration of two or more minority population groups, or
3) a high concentration of one or more minority population groups and low-income concentration.

A concentration is defined as between 1 and 1.5 times the regional average, and a high concentration is defined as greater than 1.5 times the regional average.

EEAs are calculated as Census tracts, but the Travel/4 model's units are TAZs, and these geographies are not coterminous. Montgomery Planning can select TAZs as EEAs and non-EEAs (NEEAs) in such a manner as to minimize the population of EEA tracts not included in EEA TAZs and to minimize the population of NEEA tracts included in EEA TAZs.

EEAs are designated based on the regional average. The demographic makeup of the region is not the same as the demographic makeup of Montgomery County. Montgomery Planning may want to consider developing its own EEA designation for Census tracts in the County to reflect areas that have a concentration or high concentration of demographic groups based on the countywide average. There are benefits and drawbacks to developing a county-specific measure; it would result in a more nuanced metric but would be inconsistent with the countywide measure.

Goal 1: Expanding Access

Three draft objectives have been defined for Thrive Montgomery 2050's access goal:

1) Expand the number of Montgomery County residents that can reach jobs in the region (by auto and transit).
2) Expand the number of Montgomery County residents that can reach jobs in the County (by auto, transit, bicycle, and walk).

3) Expand the number of Montgomery County residents that can reach vital services, such as grocery stores, parks / park trails, open space / recreation, health services, shopping and education (by auto, transit, bicycle and walk).

Accessibility is a potential measure; it assesses how many locations (jobs, parks, etc.) *could* be reached within a set amount of time. As a result, the data required to calculate accessibility is simply the transportation network and the locations of interest. Activity data – the number of trips made – is not part of this calculation.

Objective 1.1: Regional Job Access

Numeric Objective

By 2050, Montgomery County residents will be able to reach XX% of jobs in the County within:

- X1 minutes by automobile in non-Equity Emphasis Areas.
- X1 minutes by automobile in Equity Emphasis Areas.
- X2 minutes by transit in non-Equity Emphasis Areas.
- X2 minutes by transit in Equity Emphasis Areas.

Analysis Approach

For any year in which the Travel/4 model is available, job access by auto and transit can be calculated. The Model-Based Performance Metric Tool, provided during a previous phase of work, includes scripts to post-process model outputs and provide job access within 45 minutes by auto and transit for each TAZ. To calculate the regional job access for Montgomery County residents by these modes, the job access by mode for each TAZ in the County would be averaged, weighted by population of each TAZ.

Objective 1.2: County Job Access

Numeric Objective

By 2050, Montgomery County residents will be able to reach XX% of jobs in the region within:

- X1 minutes by automobile in non-Equity Emphasis Areas.
- X1 minutes by automobile in Equity Emphasis Areas.
- X2 minutes by transit in non-Equity Emphasis Areas.
- X2 minutes by transit in Equity Emphasis Areas.
- X3 minutes by bicycle in non-Equity Emphasis Areas.
- X3 minutes by bicycle in Equity Emphasis Areas.

- X4 minutes by walking in non-Equity Emphasis Areas.
- X4 minutes by walking in Equity Emphasis Areas.

Analysis Approach

County job access can be calculated similarly to regional job access for auto and transit. However, given the limited geography, edit the job access script to only calculate job access between TAZs identified as within Montgomery County.

Bicycle and Pedestrian Job Access

For bicycle and pedestrian access, export Montgomery County jobs by TAZ from the Travel/4 model and upload to ArcMap. Disaggregate jobs by TAZ to the "block combinations" geographies applied in the Bicycle Master Plan. For the roadway network, use either the County's BikePedHybrid network or the County's Level of Traffic Stress (LTS) network, (limited to LTS 1 and 2; suitable for all bicyclists and most adult bicyclists, respectively) and Pedestrian Level of Comfort (PLOC) network (limited to very comfortable and somewhat comfortable segments). Buffer the bicycle and pedestrian networks by a small distance (between 0.1 and 0.25 miles), then calculate the number of jobs and households within each bicycle or pedestrian "island" (connected network of low-stress facilities). This number is the percent of each "block combination" within the "island". The sum of the jobs for each "block combination" for a given "island" represents the jobs accessible by bicycling and walking to the population of that "island". Aggregate all "islands" through a weighted average, weighted by the population of that "island", keeping in mind that many residents will be outside of any "island", and will not have access to jobs by a low-stress network. This approach assumes even distribution of jobs and households across each "block combination".

The master-planned bicycle network and resulting low-stress network is available for future conditions based on the Bicycle Master Plan. However, the pedestrian network is currently only available under Existing Conditions. For Baseline Futures, the pedestrian network would need to be revised to reflect expected improvements. For tracking progress, revise the pedestrian and bicycle networks to reflect expected improvements.

Objective 1.3: Access to Destinations

Numeric Objective

By 2050, XX% of Montgomery County residents will be able to reach grocery stores, parks / park trails, open space / recreation, health services, shopping, education within X minutes.

- X1% of residents by automobile in non-Equity Emphasis Areas.
- X1% of residents by automobile in Equity Emphasis Areas.
- X2% of residents by transit in non-Equity Emphasis Areas.
- X2% of residents by transit in Equity Emphasis Areas.
- X3% of residents by bicycle in non-Equity Emphasis Areas.
- X3% of residents by bicycle in Equity Emphasis Areas.
- X4% of residents by walking in non-Equity Emphasis Areas.
- X4% of residents by walking in Equity Emphasis Areas.

Analysis Approach

The access to destinations analysis can be conducted within ArcMap. The steps are as follows for each location of interest (parks, grocery stores, etc.) for auto and transit access:

- Import the Travel/4 land use information (specifically, population).
- Disaggregate the Travel/4 land use information to the "block combinations" geographies applied in the Bicycle Master Plan.
- Identify or develop shapefiles for the location of interest (e.g., park, grocery store).
- Define a time or distance threshold for each mode. This may differ for different locations of interest. For example, it may be a priority that residents have a less than 15-minute transit trip to a grocery store, while a 30-minute trip to a park is acceptable.
- Apply the Network Analyst tool to develop a service area for each mode.
- Dissolve the service area for each mode. This combines the service area associated with each park (or other location) to determine the County's coverage for that location type.
- Calculate the percent of each "block combination" within the service area for each mode.
- Assuming equal population distribution in each "block combination", calculate the percent of Montgomery County's population within the service area for each mode.

Bicycle and Pedestrian Destination Access

The low-stress bicycle and pedestrian networks are more limited than the auto and transit networks. As a result, a different approach should be applied for these modes. For bicyclists and pedestrians, locations of interest would be considered accessible if they are within a low-stress "island" (described above). The percent of the County population within an "island" with the location of interest would be the percent of the County population with access to the location of interest.

Goal 2: Reducing Travel Time

Four draft objectives have been defined for Thrive Montgomery 2050's travel time goal:

1) Reduce the amount of time spent traveling by Montgomery County residents, employees and visitors (by auto and transit).
2) Increase the travel time competitiveness of transit compared to automobile travel.

Montgomery Planning indicated a preference that these objectives be assessed for multiple time periods, including the peak commute period, an off-peak period (such as midday or evening), and weekends. The methodologies presented below rely on the Travel/4 model. While peak and off-peak can be calculated with this approach, weekend information is not available.

Objective 2.1: Reducing Travel Time

Numeric Objective

By 2050, the average travel time per person will be:

- X1 minutes in non-Equity Emphasis Areas.
- X1 minutes in Equity Emphasis Areas.
- X2 minutes by automobile in non-Equity Emphasis Areas.
- X2 minutes by automobile in Equity Emphasis Areas.
- X3 minutes by transit in non-Equity Emphasis Areas.
- X3 minutes by transit in Equity Emphasis Areas.

Analysis Approach

For any year in which the Travel/4 model is available, travel time by auto and transit can be easily calculated. The Model-Based Performance Metric Tool, provided during a previous phase of work, includes scripts to post-process model outputs and provide person trip duration by auto and transit for each TAZ. This script could be applied here to calculate travel time by those modes.

The metrics tool output also includes the number of trips by auto and transit generated by each TAZ. To calculate the overall travel time by mode in the County, the trip duration by mode for each TAZ in the County would be averaged, weighted by the number of trips generated in that TAZ by each mode.

Objective 2.2: Auto/Transit Competitiveness

Numeric Objective

By 2050, the ratio of auto to transit travel time between Montgomery County TAZs and MWCOG activity centers will not exceed:

- X1 during peak periods in non-Equity Emphasis Areas.
- X1 during peak periods in Equity Emphasis Areas.
- X2 during off-peak periods in non-Equity Emphasis Areas.
- X2 during off-peak periods in Equity Emphasis Areas.
- X3 during weekends in non-Equity Emphasis Areas.
- X3 during weekends in Equity Emphasis Areas.
- X3 during weekends in Equity Emphasis Areas.

Analysis Approach

To calculate auto/transit competitiveness for all trips generated in the County, compare the auto travel time in Objective 1 to the transit travel time in Objective 1.

However, Montgomery Planning may want to prioritize auto/transit competitiveness for some trips over others. Part of the draft objectives specifies an analysis between Montgomery County TAZs and MWCOG Activity Centers. MWCOG works with local governments to determine Activity Centers throughout the region, which are "vibrant, mixed-use and multiple-use communities"[1] And include "existing urban centers, priority growth areas, traditional towns, and transit hubs".[2] To conduct this analysis, edit the trip duration script to only calculate trip duration between TAZs identified as within Montgomery County or as an Activity Center (there are 141 Activity Centers, 23 of which are in Montgomery County).

Goal 3: Creating Safety

Three draft objectives have been defined for Thrive Montgomery 2050's safety goal:

1) Reduce the number of motor vehicle severe injuries and fatalities per vehicle mile traveled.

[1] https://www.mwcog.org/community/planning-areas/land-use-and-activity-centers/activity-centers/
[2] https://www.mwcog.org/documents/2013/01/13/activity-centers-maps/

2) Reduce the number of pedestrian severe injuries and fatalities per the amount of walking.

3) Reduce the number of bicycling / e-scooter severe injuries and fatalities per the amount of bicycling / e-scooting.

Numeric Objectives

Objective 3.1 - By 2050, the number of severe injuries and fatalities per vehicle mile traveled for motor vehicle occupants will be less than or equal to:

- X1 in non-Equity Emphasis Areas
- X1 in Equity Emphasis Areas

Objective 3.2 - By 2050, the number of severe injuries and fatalities per XX for pedestrians will be less than or equal to:

- X2 in non-Equity Emphasis Areas
- X2 in Equity Emphasis Areas

Objective 3.3 - By 2050, the number of severe injuries and fatalities per XX for bicyclists / e-scooters will be less than or equal to:

- X3 in non-Equity Emphasis Areas
- X3 in Equity Emphasis Areas

Analysis Approach

These draft safety objectives aim to reduce the number of severe injuries and fatalities (herein referred to as KSI) per the amount of travel by mode. The metric here is a rate, the number of KSI relative to the exposure of that mode. As a result, the metric requires two datapoints in order to be calculated: the number of KSI as well as the number of miles traveled by each mode. **Table 2**, below, outlines an approach for calculating these metrics for Existing Conditions, in Baseline Futures, and for tracking progress prior to the horizon year.

Table 2. Safety Metrics Analysis Approach

Application	Crashes	Exposure
Existing Conditions	Observed KSI, recommend at least 3 years of data	*Vehicles* – apply countywide VMT from the Travel/4 *Bicyclists/Micromobility* – employ (and potentially tweak) approach used in Bicycle Master Plan (**Appendix A**) to extrapolate bicycle trip table from Travel/4 model; calculate average network distance between zones (assuming the bicycle network is LTS 1 and 2) to estimate exposure *Pedestrians* – same as bicyclists/micromobility but tweak approach for extrapolating bicycle trip table to apply to pedestrians (may then require subtracting the pedestrian trip table from the bicycle trip table, assuming some or all trips assumed to be walking are also included in the original bicycle trip table) Apply for the appropriate analysis year depending on the application. For tracking progress, may need to interpolate between two model years for appropriate analysis year
Baseline Futures	*Business as Usual Future* – develop KSI rates in Existing Conditions model year based on speed bin (either observed or posted) or roadway type; apply KSI rate by the selected roadway characteristic to Business as Usual Future exposure values and combine total crashes by roadway characteristic to develop weighted average crash rate *Alternative Futures* – same as above (except with Alternative Futures exposure values) and assume reduced crash rate as a result of AVs (e.g. 80% reduction)	
Tracking Progress	Observed crashes, recommend at least 3 years of data	

While the safety objectives can be measured using the analysis approach above, the proposed approach for bicyclists and pedestrians is a high level of effort while confidence in results may be low. There are a few considerations and alternative approaches worth raising here:

- The future year bicycle trip table developed outlined in the Bicycle Master Plan represents latent demand, rather than observed trips. Applying a similar approach to pedestrians would also yield a latent demand trip table rather than expected exposure. It is expected that latent demand exceeds actual demand, so this would result in a "better" safety score than is accurate.
- Most KSIs involving bicyclists or pedestrians involve a motor vehicle. The metric could be revised as a KSI rate for each mode of transportation relative to total VMT in the County.

- A rate-based metric provides the reader information about the relationship between the number of KSI and exposure. This is valuable, but, as evidenced above, complex to calculate. An alternative set of objectives seek to reduce the number of motor vehicle, pedestrian, and bicycle KSI. These objectives could be calculated for Existing Conditions and tracking progress as outlined in the table above. For Baseline Futures, a rate would still need to be calculated to forecast the number of future crashes.

Goal 4: Ensuring Reliability

Two draft objectives have been defined for Thrive Montgomery 2050's reliability goal:

1) Reduce the variation in daily travel times by private vehicle.
2) Increase the on-time performance of transit.

These draft objectives aim to make travel predictable on Montgomery County's roadway and transit network. To do so, metrics measure variation in travel time for those traveling by auto as well as transit on-time performance.

Objective 1: Auto Reliability

Numeric Objective

Daily trips within the same time period will be within XX% of the annual average trip travel time by roadway segment.

Analysis Approach

Table 3, below, outlines an approach for calculating auto reliability for Existing Conditions, in Baseline Futures, and for tracking progress prior to the horizon year. Auto reliability is calculated based on the distribution of travel times over an extended period. Without observed data, the ratio of peak period travel time to off-peak period travel time could be used as a proxy for reliability.

When applying observed data, average travel time would be calculated between key destinations in Montgomery County as well as between key destinations Montgomery County and key regional destinations. The same approach could be calculated for model data. However, the model is also capable of calculating the average travel time for all vehicle trips starting and/or ending in the County.

Table 3. Auto Reliability Metrics Analysis Approach

Application	Dataset	Average Travel Time	Congested/Daily Travel Time
Existing Conditions	Observed	*Peak Period over Time* - peak period Inrix data is averaged across an extended time period (e.g. one year) *Peak vs. Off-Peak* – Inrix data for off-peak period is used as a proxy for uncongested travel	*Peak Period over Time* - % of days of Inrix data included in average calculation that exceed the average travel time by X minutes* *Peak vs. Off-Peak* – peak period Inrix data is used as a proxy for congested travel
	Model	*Peak vs. Off-Peak* – off-peak travel time is used as a proxy for uncongested travel	*Peak vs. Off-Peak* – peak-period travel time is used as a proxy for congested travel
Baseline Futures	Model	*Peak vs. Off-Peak* – off-peak travel time is used as a proxy for uncongested travel	*Peak vs. Off-Peak* – peak-period travel time is used as a proxy for congested travel
Tracking Progress	Observed	*Peak Period over Time* - peak period Inrix data is averaged across an extended time period (e.g. one year) *Peak vs. Off-Peak* – Inrix data for off-peak period is used as a proxy for uncongested travel	*Peak Period over Time* - % of days of Inrix data included in average calculation that exceed the average travel time by X minutes* *Peak vs. Off-Peak* – peak period Inrix data is used as a proxy for congested travel
	Model	*Peak vs. Off-Peak* – off-peak travel time is used as a proxy for uncongested travel	*Peak vs. Off-Peak* – peak-period travel time is used as a proxy for congested travel

* number of minutes to be determined by Montgomery Planning

Objective 2: Transit Reliability

Numeric Objective

Red Line, Metrobus, Ride On, Purple Line, MARC, future BRT will meet an XX% on-time performance standard.

Analysis Approach

Transit operations are not managed by or reported on by Montgomery Planning. Instead, Montgomery Planning will compile on-time performance information from the appropriate agencies administering Metrorail Red Line, Metrobus, Ride On, Purple Line, MARC, and future bus rapid transit. On-time performance may be tracked for Existing Conditions and for tracking progress, but future on-time performance is difficult to calculate; nevertheless, there are a few proxies for transit reliability that can be applied:

- Average vehicle travel speeds along key transit corridors could be used as a qualitative proxy for understanding how transit reliability changes in Baseline Alternatives.
- The percentage of transit trips on uncongested or dedicated rights-of-way could represent the portion of transit trips considered "reliable".

These proxy measures address transit delays that can occur as a result of congestion, but they would not represent transit disruptions occurring as a result of a vehicle malfunction.

Goal 5: Building Resiliency

One draft objective has been defined for Montgomery Planning's resiliency goal:

1) Increase the percent of commute trips that will be able to be completed with a reasonable amount of travel time if key locations in the transportation network are unavailable for an extended period.

This draft objective aims to ensure that infrastructure closures as a result of man-made and environmental disasters do not result in a significant disruption to commuters. Impacted roadway locations could include the American Legion Bridge, I-270 north of the Beltway (I-495), Georgia Avenue, Connecticut Avenue, US-29 at the Anacostia River Northwest Branch. Impacted transit locations could include the entire WMATA Metrorail system, the Red Line (both branches individually), the Purple Line, and MARC.

Numeric Objective

By 2050, XX% of commute trips will be able to be completed with a [reasonable amount of travel time / travel time multiplier] if key locations in the transportation network are unavailable for an extended period.

Analysis Approach

Resiliency can most easily be calculated using the Travel/4 model:

- **Without Disruption:** The model would be run for the analysis year and scenario (e.g. Existing Conditions, Business as Usual Future, Alternative Futures) without an infrastructure disruption, and the distribution of travel times to and from Montgomery County would be calculated.
- **With Disruption(s):** One or more disruptions would be applied to the model by removing the associated roadway or transit links in each analysis year and scenario. The model would be run, and updated travel time distribution would be calculated. The "with disruption(s)" scenario could be run multiple times with different standalone disruptions or combinations of disruptions.

Given that the closures could impact mode choice, travel time should be calculated as a weighted average for transit and auto trips.

This metric would look at the difference in distribution between the two scenarios. There are two approaches that could be applied here:

1) Calculate the difference in the percent of commute trips completed within a designated travel time (e.g. 45 minutes) under the two scenarios.
2) Compare the percent of commute trips completed within a designated travel time (e.g. 45 minutes) under the "without disruption" scenario to the percent of commute trips completed within a certain multiplier (e.g. 120%) of the designated travel time under the "with disruption" scenarios.

This approach can effectively be calculated for all years where the model is available. If the interim year assessed for tracking progress is not assessed in the model, this metric cannot be calculated for that year.

Goal 6: Maintaining Infrastructure

Five draft objectives have been defined for Montgomery Planning's maintenance goal:

1) Improve the condition of County sidewalks.
2) Improve the condition of County bikeways.
3) Improve the condition of County transit vehicles.
4) Improve the condition of County bridges.
5) Improve the condition of County road pavement.

Numeric Objectives

Objective 6.1 - Improve the condition of County sidewalks.

- X1 in non-Equity Emphasis Areas
- X1 in Equity Emphasis Areas

Objective 6.2 - Improve the condition of County bikeways.

- X2 in non-Equity Emphasis Areas
- X2 in Equity Emphasis Areas

Objective 6.3 - Improve the condition of County transit vehicles.

- X3 in non-Equity Emphasis Areas
- X3 in Equity Emphasis Areas

Objective 6.4 - Improve the condition of County bridges.

- X4 in non-Equity Emphasis Areas
- X4 in Equity Emphasis Areas

Objective 6.5 - Improve the condition of County road pavement.

- X5 in non-Equity Emphasis Areas
- X5 in Equity Emphasis Areas

Analysis Approach

These draft objectives aim to improve the condition of County sidewalks, bikeways, transit vehicles, bridges, and roadway pavement. Infrastructure quality is not included in existing analysis tools, and requires observed data collected by the County. It is assumed that Montgomery County has pavement and bridge quality data for major roadways and bridges. It is our understanding that bikeway and sidewalk quality is currently being collected as well. Transit vehicle data is likely available through the various transit agencies serving Montgomery County.

While these recent and current data collection efforts serve to provide Existing Conditions, state of good repair is challenging to calculate for future years, given limited data or forecasting approaches. Construction and maintenance information is not available and/or digitized throughout the entire network, and year-over-year infrastructure quality has not been collected. As a result, this metric may be analyzed for Existing Conditions and for tracking progress

(assuming additional data is collected), but not for the Business as Usual Future or Alternative Futures.

However, state of good repair may be qualitatively assessed for these future conditions. It can be expected that Baseline Futures with more VMT or a higher percentage of freight trips, pavement quality would be worse than under futures with fewer vehicle and truck trips. This qualitative approach could be applied to the County's roadways, bridges, and on-street bikeways. Bikeways could be assumed to be all roadways designated low stress (LTS 1 or 2).

This qualitative approach would allow the County to rank different futures or understand their relative difference in VMT and truck trips. However, it should be noted that a linear relationship between VMT, truck trips, and pavement quality has not been established.

Alternative Futures Workshop

Montgomery Planning hosted an internal workshop on June 17, 2019, to develop the Alternative Futures to be analyzed in the Thrive Montgomery 2050, as well as to brainstorm how these Alternative Futures (and their associated Drivers of Change) would impact travel behavior and the transportation network.

The workshop included three activities, focused on developing Drivers of Change, Alternative Futures, and transportation assumptions associated with the identified Drivers of Change.

Drivers of Change

As discussed previously, Montgomery Planning has identified five Drivers of Change: economic disruptions, climate change, demographic changes, technological innovations, and changes in lifestyle. These Drivers of Change serve as the primary framework for identifying Individual Drivers and combining Individual Drivers to develop Alternative Futures.

In the workshop, the facilitators set up designated boards for each of the five Drivers of Change. Each board was "seeded" with some examples of Individual Drivers, generally based on those mentioned in the Thrive Montgomery 2050 scope of work. Participants were asked to rate the impact of each Individual Driver using stickers to indicate the likelihood that a Driver of Change will occur (very likely, likely, unlikely, very unlikely), expected direction (increase or decrease) and magnitude (large or small) of change. Participants were also encouraged to add new Individual

Drivers that were not "seeded" on the boards, even if those Individual Drivers may be voted unlikely to occur.

Participants in this activity including the Steering Committee and Working Group Leaders. The results from the Drivers of Change activity are included in **Appendix B**.

Alternative Futures

For the second workshop activity, Steering Committee Members and Working Group Leaders discussed how the Individual Drivers could be combined to develop Alternative Futures. The goal was building four alternatives based on different type, directions, and magnitude of change for each of the five Drivers of Change. Participants formed four groups to review feedback from the Drivers of Change discussion and develop Alternative Futures.

Following the Alternative Futures group discussion, each group reported out to the larger group of workshop participants. The four groups identified different ways in which the Individual Drivers could be combined to create Alternative Futures, but few groups were able to develop a clear, complete Alternative Futures framework.

Following the activity, a smaller group of Montgomery Planning and Fehr & Peers DC staff brainstormed how the previous discussions and draft Alternative Futures could be consolidated into an Alternative Futures framework. The small group's ideas were shared during a follow-up session with Steering Committee Members and Working Group Leaders. The discussion raised valuable points but failed to yield a consensus set of Alternative Futures. Following the workshop, Montgomery Planning staff and Fehr & Peers DC developed an Alternative Futures framework, which was then elaborated and refined by Fehr & Peers DC (and discussed in the next section, Alternative Futures, below).

Transportation Assumptions

The Transportation Assumptions activity was designed to brainstorm how the Drivers of Change included in the Alternative Futures would impact transportation inputs and behavior. Given that the Alternative Futures activity did not immediately result in draft Alternative Futures, the Transportation Assumptions activity was revised during the workshop to focus on Drivers of Change, absent of how they are incorporated into different Alternative Futures. Prior to the activity, a small group of Montgomery Planning and Fehr & Peers DC staff identified the top four to six Individual Drivers associated with each Driver of Change. These Individual Drivers were the focus of the Transportation Assumptions activity.

Transportation staff were divided into four groups, and each discussed the Individual Drivers associated with one Driver of Change (one group looked at both Demographic Changes and Changes in Lifestyle). Within each group, discussions identified how their designated Individual Drivers would impact the transportation network and travel behavior. To the extent possible, conversations were encouraged to focus on the inputs to transportation planning and modeling tools. For example, the purpose of the activity was not to develop an assumption that autonomous vehicles would increase VMT; instead, transportation staff were direct to develop assumptions that people may feel comfortable traveling in vehicles for longer periods of time, and that some portion of trips may be made with zero passengers in the vehicle. Some Individual Drivers were found to result in just one adjustment to travel behavior, while others drive multiple changes. **Appendix C** includes the notes from each group, outlining the assumptions associated with each Individual Driver.

Drivers of Change

Based on the workshop findings, around 20 Individual Drivers were identified as likely to occur in Montgomery County in 2050. Spanning the five Drivers of Change - economic disruptions, climate change, demographic changes, technological innovation, and changes in lifestyle - these Individual Drivers could impact the County's land use, employment, and travel patterns.

This section summarizes each Driver of Change and their associated Individual Drivers. For each Individual Driver, the summary describes how it could impact travel behavior, land use, and the transportation network; and how these impacts can be modeled using either the County's Travel/4 model or the regional travel demand model (**Table 4**). While the focus of the assumptions are the transportation impacts, land use changes are included throughout the list of assumptions below. This is because land use impacts transportation because where people start and end their trips impacts where they choose to go, what mode they use for travel, and what roadways or transit lines they travel on.

In the text, each modeling approach includes some highlighted text. These highlighted placeholders represent the magnitude of change implemented in the model. This value may change based on the Alternative Future evaluated. More information about the suggested values are included in the Alternative Futures Analysis Approach section below.

The assumptions listed below are highly speculative, based on Montgomery Planning and Fehr & Peers DC staff perception about the type, direction, and magnitude of change associated with each of the Individual Drivers. The purpose of making these assumptions is not to precisely model what 2050 will be like, but to identify the range of outcomes that could occur in different Alternative Futures. In some Alternative Futures, the Individual Drivers might move in the opposite direction to what's described here (e.g., shifts of jobs could be to or from Montgomery County).

In addition, the model may or may not be sensitive to the changes included below. It is recommended that changes are "tested" individually, prior to being combined into an Alternative Future, to understand how individual model adjustments impact key outcomes for the County.

Table 4. Drivers of Change

Individual Driver	Transportation Impact	Modeling Approach
Economic Disruption		
Automation of Work	Technology replaces jobs, reducing or shifting commute travel	1) Shift a portion of retail and industrial jobs to office jobs 2) Reduce the trip rate associated with retail and industrial employment
Increase in Global Trade	Global trade brings more merchandise and services	Increase the number of freight trips
Competition within Region	Montgomery County has more jobs and attractions, relative to other parts of the region	1) Shift jobs to Montgomery County from other parts of the region 2) Reduce jobs outside of Montgomery County
Competition outside the Region	More people commute into or out of the DC metropolitan region	Increase the number of internal-external and external-internal commute trips
Sharing Economy	Technology accelerates sharing information, space, and transportation	Increase shared rides (increased vehicle occupancy)
Climate Change		
Infrastructure Closures	Road closures require travelers to avoid obstructed routes	We will not model this due to the complexity and subjectivity of the issue.
Flooding	Residents and employers leave vulnerable areas in the County (and region) that are prone to flooding	1) Reduce households and employment in flood-prone areas and shift them to less vulnerable locations
Rising Temperatures/ Weather Variability	Erratic weather makes travel unsafe and/or uncomfortable	Reduce non-motorized mode share

Individual Driver	Transportation Impact	Modeling Approach
Demographic Changes		
Income Inequality	Housing prices push low-income residents to the exurbs or out of the County; auto ownership by low-income residents drops	Adjust income distribution, moving some middle-income residents to high or low-income brackets
Declining Birth Rates	Fewer children result in smaller household sizes and less school-related travel	1) Adjust household size distribution and reduce population accordingly 2) Reduce school trips and other related trips (e.g. daycare, after school programs)
Multi-Generational Homes	Cultural and economic factors change household types	Increase the household size while holding population constant
Aging Population	The population distribution shifts, with a larger portion of older adults (while holding population constant)	Adjust time of day factors to increase portion of trips in off-peak
Technological Innovation		
E-Commerce	Technology reduces in-person purchases and increases residential parcel delivery	1) Shift a portion of retail jobs to industrial jobs 3) Increase freight trips 4) Reduce home-based shopping trips
Virtual Reality	Virtual reality reduces the need for travel, including trips to work, school, and entertainment	Reduce trip generation
3D Printing	Products are made at home, or made by local retailers rather than imported or manufactured	1) Shift a portion of industrial jobs to retail jobs 2) Increase intra-county commercial vehicle trip generation
Vehicle Electrification	Electric vehicles increase fuel efficiency, reducing auto-operating costs	Reduce auto-operating costs
Autonomous Vehicles	Autonomous vehicles increase access to vehicle travel for youths and seniors, improve auto efficiency, and improve safety for all travelers	1) Decrease parking costs 2) Decrease access time 3) Increase non-work vehicle trips 4) Increase vehicle availability 5) Increase vehicle trips (zero-occupants) 6) Increase roadway capacity

Individual Driver	Transportation Impact	Modeling Approach
Change in Lifestyle		
Preference for Urban Living	Shift land uses to denser parts of the region and County	Increase households and jobs in high density TAZs or in specific area types by shifting households and jobs from other parts of the County
Flexible Work Hours	People travel to and from work outside of the peak period	Adjust time of day factors to increase portion of work trips in off-peak
Retirement Age	People stay longer in the workforce and therefore a larger portion of the population commutes to work	1) Increase the number of work-related trips 2) Adjust time-of-day factors for non-work-related trips
Preference for Walking and Biking	Residents prefer more non-auto modes	Adjust mode share to increase non-motorized trips

Economic Disruptions

Changes in regulation, technology, and international relations can each impact employment and quality of life. The strength of an individual geographic market, either as a locality or entire region, impacts the prosperity of surrounding localities and regions, as economic trends and impacts are not confined by geographic borders. During the workshop, five Individual Drivers emerged as the most likely and impactful associated with economic disruptions: automation of work, global trade, competition within the region, competition outside the region, and the sharing economy.

Automation of Work

In every generation, the nature of work has changed as new technology or tools have replaced the existing practice. In the coming decades, it is expected that technological advances, particularly through artificial intelligence, could automate a large portion of the jobs occupied by today's workforce. Automation results in task performance that is often cheaper, faster, and more efficient than what a human workforce can achieve. As the nature of work changes, those employed in newly automated industries may need to take other roles or face unemployment.

Transportation Impacts

Automation is assumed to result in two changes: shifting the type of employment and reducing commute travel. Automation can shift a portion of existing retail and industrial jobs to office employment and technical maintenance jobs. The new office jobs would be located where there is existing office employment, rather than where the previously retail or industrial jobs were housed, while technical maintenance jobs would likely remain in industrial areas. In addition, it is assumed that there will be fewer commute trips to the remaining retail and industrial land uses.

Modeling Approach

- In the Zone.dbf file, reduce the amount of retail and industrial employment by XX%. For any TAZs with more than 1,000 office jobs, increase the number of office jobs by the same number of jobs removed from retail and industrial employment in the same zone; For all TAZs with fewer than 1,000 office jobs, sum the number of removed retail and industrial jobs in these zones across the County, and reallocate proportionally to office employment in each of those TAZs with greater than 1,000 office jobs . Adjust total employment in the Zone.dbf file accordingly.
- In the Attrrates.dbf file, reduce the home-based work (HBW) attraction rate for retail employment by XX% (Note: Industrial employment is not included in this file).

Global Trade

Global or international trade is defined as an exchange of goods and services between countries, which can boost the world economy, affect patterns of supply-demand and be affected by global events. In general, global trade can increase revenues and enhance risk management. The United States, similar to other developed countries, usually benefits from global trade not only from meeting its needs with the resources of other countries (such as oil and gas), but also from currency exchange.[3] These trends could shift, should the United States fall behind China or other economic powers.

Transportation Impacts

From a transportation perspective, it is assumed that more global trade will result in an increase in freight movement. Some small parcel deliveries could be made by drones, reducing the overall increase in on-street truck traffic.

Modeling Approach

- In the Truck_Com_Trip_Rates.dbf, increase freight trip generation rates across all industries by XX%.

Competition within the Region

Competition within the region refers to how competitive Montgomery County is relative to other counties and cities within the greater Washington metropolitan area. For example, if Montgomery County is "winning" local competition, it may increase its relative share of the region's employment or housing. If Montgomery County is "losing" relative to its neighbors, it would have a smaller share of the regional employment or housing.

Transportation Impacts

Competition within the region is essentially about the distribution of employment. Competition within the region can be measured by adjusting regional employment, impacting Montgomery County's regional contribution relative to the rest of the metropolitan region.

Modeling Approach

- In the Zone.dbf file, increase or decrease employment in all Washington metropolitan area counties – excluding Montgomery County – by XX%. Distribute the increase or

[3] https://www.investopedia.com/insights/what-is-international-trade/

decrease in total employment proportional to the existing industries in each TAZ (office, retail, industrial, and other).

Competition outside the Region

Competition outside the region represents how competitive the Washington metropolitan region is relative to its neighbors, such as Baltimore, MD; Philadelphia, PA; and Richmond, VA. As one metropolitan area becomes more attractive, it could result in an increase in that area's employment or population or could lead to an influx of commuters from adjacent regions.

Transportation Impact

Regardless of whether the Washington metropolitan area is "winning" or "losing" this competition along the mid-Atlantic corridor, a rise in competition results in an increase in the number of people commuting across the regional border (either into or out of the region).

Modeling Approach

- In the i4_Trip_Gen_Attractions_Comp.dbf file, decrease the HBW motorized person-trip attractions by XX%.[4] Distribute the reduction proportionately across the different income groups. (These changes will require a modification in the Trip_Generation.s script to make the adjustment as part of the model flow.)

Sharing Economy

Sharing economy is defined as a peer-to-peer activity model for acquiring, providing, and sharing access to goods using an on-line platform where people can share information. Examples of sharing economy are carsharing and online hospitality services.[5] [6] The sharing economy refers to not only the sharing of goods, but also services. For example, strangers carpooling through use of UberPool and Lyft Line are examples of the sharing economy. In Virginia, "slugging" or "instant carpool" started occurring after implementation of the I-66 high-occupancy toll (HOT) lanes, particularly for eastbound I-66 travel in the morning. This trend could continue with implementation of HOT lanes on I-270 in Montgomery County.

[4] The decrease in intra-regional travel is a proxy for an increase in cross-border travel.
[5] https://www.investopedia.com/terms/s/sharing-economy.asp
[6] https://www.cleverism.com/introduction-to-sharing-economy/

Transportation Impact

As a result of the sharing economy, there would be a reduction in single-occupant vehicle trips and an increase in shared rides. Shared rides are more likely to occur in high- and medium-density areas. It is not expected that shared trips will replace single-occupancy vehicle trips one-to-one. Instead, the increase in shared trips will be greater than the decrease in single-occupancy vehicle trips.

Modeling Approach

- In the MC_Auto_Drivers.s script file, increase shared vehicle trips (HOV2 and HOV3+) originating and ending in Area Type 1, 2, and 3 by XX%.[7]. Decrease single-occupant vehicle trips in Area Type 1, 2, and 3 by 75% of the shared trip increase.

Climate Change

As a result of human action, the globe is warming, and the global climate is changing. Ongoing climate changes impact weather events, as well as the earth's diverse ecosystems. According to NASA, evidence of rapid climate change includes global temperature rise, decreased snow cover, sea level rise, and extreme weather events. More specifically the number of record high-temperature events in the US has been increasing as well as the number of intense rainfalls.[8] [9] Individual Drivers associated with climate change that will be assessed as part of Thrive Montgomery 2050 include infrastructure closures, flooding, and rising temperatures/weather variability.

Infrastructure Closures

One of the outcomes of extreme weather events could be infrastructure closures, impacting the roadway network, transit network, and other public facilities. The closures could be the result of flooding, downed trees, icy roadways, etc.

[7] The MWCOG and Travel/4 models include six Area Types, which range from dense urban centers (Area Type 1) to the region's exurbs (Area Type 6). Area Type is determined based on population and employment density. These area types do not correspond to Montgomery County's three planning areas.
[8] https://climate.nasa.gov/evidence/
[9] USGCRP, 2017: Climate Science Special Report: Fourth National Climate Assessment, Volume I [Wuebbles, D.J., D.W. Fahey, K.A. Hibbard, D.J. Dokken, B.C. Stewart, and T.K. Maycock (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 470 pp, doi: 10.7930/J0J964J6

Transportation Impact

This Individual Driver in itself is a transportation impact. Key links in the roadway and transit network could be closed as a result of extreme weather. Infrastructure closures, in turn, impact travel behavior. Travelers may choose to use different modes or routes as a result of the closures. This could lead to longer travel times or congestion on arterials not typically congested. As is common today, it is assumed travelers would use navigation apps (e.g. Google Maps, Waze) to identify the most convenient route and mode for travel.

Modeling Approach

Rather than modeling infrastructure closures as part of building the Alternative Futures, this Individual Driver will be assessed when calculating the metrics associated with each Alternative Future. See the subsection Building Resiliency (within Metrics) to review how infrastructure closures are addressed in Thrive Montgomery 2050.

Flooding

Some climate impacts include sea level rise and more extreme weather events. As a result, flooding is likely to increase in low-lying parts of the County and region.

Transportation Impacts

There are two likely transportation impacts associated with increased flooding: a shift in land use, and a reallocation of the roadway network. Families and employers may choose to relocate from low-lying locations to parts of the County less vulnerable to flooding. In addition, a portion of the roadway network may be reallocated for stormwater management (resulting in reduced capacity for motor vehicles).

Modeling Approach

- In the Zone.dbf file, reduce the number of households, population, and jobs in TAZs within the 100-year floodplain by XX%. Reallocate those households, population and jobs to other TAZs in the County proportional to those TAZs' total households, population and employment.

Rising Temperatures/Weather Variability

As a result of the changing climate, Montgomery County temperatures are expected to rise, and the region is expected to experience more extreme weather events.

Transportation Impact

As a result of hotter summers and more variable weather, the rate of non-motorized trips is expected to decrease, shifting more of these trips to auto or transit.

Modeling Approach

- In the Prepare_Trip_Tables_for_Assignment.s script file, increase O-D pairs in the pre-assignment vehicle trip tables for each time period (excluding night) for O-D pairs with a distance of three miles or fewer and where either the origin or destination is in Area Type 1, 2, or 3. The increase factor applied would represent XX% of nonmotorized trips generated by the TAZ.

Demographic Changes

Demographic changes encompass how the population changes. For example, the United States is more racially and ethnically diverse than in the past and is projected to be more diverse by 2065 to the point that there might not be a racial majority (one racial group with more than 50% of the population). Beyond ethnicity, demographic changes include political status, age, sex, household size, income level, and religion.[10]

The demographic makeup of Montgomery County has changed over the past several decades:

- Between 1990 and 2017, the population grew 38% from 765,476 to1,058,810 people.
- The County has grown increasingly diverse with people of color comprising more than 56% of the total population in 2016.
- Montgomery County continues to be one of the most highly educated counties in the United States and this characteristic correlates to relatively high incomes.[11]

These trends may continue, or they may shift as a result of other exogenous forces. As part of the Alternative Futures, four demographic changes will be evaluated: income inequality, declining birth rates, multi-generational homes, and aging populations.

Income Inequality

Income inequality is the difference in income between an area's highest- and lowest-income earners. Over the past 30 years, income inequality in the Unites States has increased, with income

[10] https://www.pewresearch.org/fact-tank/2016/03/31/10-demographic-trends-that-are-shaping-the-u-s-and-the-world/

[11] https://montgomeryplanning.org/wp-content/uploads/2019/01/MP_TrendsReport_final.pdf

flowing unequally toward the very high-income people. According to the World Economic Forum, the main causes of income inequality are technology and education, trade and globalization, and the institutional framework of deregulation, de-unionization, tax changes, and federal monetary policies.[12]

Transportation Impacts

Income impacts how people travel, and this plays out in a variety of different ways. From a land-use perspective, lower-income jobs may be located in different locations than higher-paying jobs, and affordable housing for low-income residents may be in a different part of the city, county, or region than more expensive market-rate or luxury housing. From a transportation perspective, low-income travelers are less likely to own a vehicle and generally prefer lower-cost forms of transportation (e.g. transit instead of a taxi). Low-income work is more likely to occur outside of conventional commute periods (traveling to work in the morning and home from work in the late afternoon), as some low-paying positions span early morning, late night, or overnight shifts. [13]

The model already accounts for differences in travel behavior as a result of income. As a result, the transportation impacts of income inequality are modeled by adjusting the income distribution in each TAZ, rather than adjusting the travel behavior of Montgomery County residents.

Modeling Approach

- In the Demo_Models.s script file, adjust the income distribution by shifting XX% of households in the second and third quartiles to the first quartile and fourth quartiles. The script update should modify the i4_Demo_Models_HHbyISV.dbf output file.

Declining Birth Rates

The fertility rate in the United States has dropped to the lowest rate since the Centers for Disease Control and Prevention started keeping records in 1909, and it continues to decline. Increasingly urban lifestyles as well as demographic and socioeconomic trends are some factors contributing to reduced birth rates in developed countries.[14] [15]

[12] https://www.weforum.org/agenda/2015/05/whats-caused-the-rise-in-income-inequality-in-the-us/
[13] https://www.apta.com/wp-content/uploads/APTA_Late-Shift_Report.pdf
[14] https://www.economist.com/democracy-in-america/2018/10/31/americas-fertility-rate-continues-its-deep-decline
[15] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4255510/

Transportation Impact

There are two ways in which declining birth rates impact transportation: changes in the number of travelers as well as changes in travel behavior due to changes in the sizes of specific age cohorts. With a lower birth rate, the overall population could decrease. In addition, the number school and school-related trips (e.g. daycare, after school programs) would decrease.

Modeling Approach

- In the Zone.dbf file, decrease the total population in all Montgomery County TAZs by XX% while maintaining the same number of households.
- In the i4_Trip_Gen_Attractions_Comp.dbf file, decrease HBO and NHO trips by XX% in all Montgomery County TAZs. (This change will require a modification in the Trip_Generation.s script to make the adjustment as part of the model flow.)
- In the schl.adr file, decrease trip generation by XX% in all Montgomery County TAZs.

Multigenerational Households

Pew defines a multigenerational household as one that includes two or more adult generations, such as Baby Boomer parents and their adult children. The number of multigenerational households continues to grow.[16] Today, 20% of American households are multigenerational. Several factors contribute to multigenerational households including later-in-life marriage, economic necessity, racial and cultural diversity in lifestyles, health and disability issues of elderly members of a family, and household expenses management.[17]

Transportation Impacts

This household type affects the driving behavior of a household. Multigenerational household members can share their assets including cars. They also can drive together so there will be more HOVs and multi-purpose trips for dropping children to schools, following by workplaces and non-work destination such as shopping or medical appointments. Given the number of people at each multigenerational house, a greater number of trips is generated per household.[18]

[16] https://www.nytimes.com/2016/08/12/your-money/multigenerational-households-financial-advice.html
[17] https://www.gu.org/explore-our-topics/multigenerational-households/
[18] https://www.nytimes.com/2012/11/30/us/building-homes-for-modern-multigenerational-families.html

Modeling Approach

- In the Zone.dbf file, decrease the number of households by XX%. No adjustments should be made to the population in each TAZ.

Aging Population

Baby Boomers, born between 1946 and 1965, are the largest population group in the United States. The leading edge of the boomer generation turned 65 in 2011 and by 2030, all will be 65 and older. The aging boomers will drive growth in the county's 65-plus population from about 120,000 residents, or 12% of the population, in 2010 to 19% in 2030 – an 82% increase over 20 years. By 2040 the number of seniors is expected to double from 2010.[19]

As Baby Boomers age and live longer than previous generations, the median age in the country rises. This means a larger portion of the population is living long into retirement, and that this population may continue to be mobile longer than their predecessors.

Transportation Assumptions

With a larger non-working population, the distribution of trips throughout the day may change toward more off-peak trips and fewer peak trips. Additional aging drivers could also result in lower travel speeds, reduced road capacity (as a result of lower travel speeds and conservative driving behaviors), and a higher probability of crashes.

Modeling Approach

- In the TODcomp_2008HTS.dbf, adjust the time-of-day factors for HBS, HBO, and NHO trips to shift an additional XX% of trips to the midday time period from the AM and PM peak periods. If the data is available at the time of this analysis, adjustment factors could be based on the updated MWCOG 2017/2018 household travel survey.

Technological Innovation

Technology has changed all aspects of our lives, from how we work, travel and receive medical care to how we socialize and consume entertainment. On a day-to-day basis, technology advancement such as wayfinding or GPS-based navigation, make driving more efficient. Thanks to web-based platforms and mobile apps, users are a few clicks away from making decisions for home furniture, planning their next vacation, or customizing a birthday gift. As part of the Thrive

[19] https://montgomeryplanning.org/wp-content/uploads/2019/01/MP_TrendsReport_final.pdf

Montgomery 2050, several technological innovations are assessed: e-commerce, virtual reality, 3D printing, vehicle electrification, and autonomous vehicles.

E-Commerce

E-commerce, or online shopping, is the activity of buying or selling products on online services or over the Internet.[20] E-commerce has heavily changed business-to-business and business-to-consumer patterns. In the past, customers had to make trips to stores to purchase goods or services during business hours. Over the past decade, e-commerce has shifted purchasing patterns towards more online shopping, which can occur at irregular hours and through a few clicks on smartphones or computers.[21]

Transportation Impact

The rise of online shopping has the potential to impact both land use and travel behavior. From a land use perspective, e-commerce is expected to lead to fewer retail jobs, as well as an increase in industrial employment; some retailers are closing, while distribution centers are growing to manage increased deliveries. For travel behavior, fewer shoppers physically travel to a store to complete their purchase; shopping trips decline while home deliveries grow. It is expected that retail that requires a separate vehicle trip will experience a greater decline, while retail that shoppers pass by during their commutes or other travel is less impacted.

Modeling Approach

- In the Zone.dbf file, reduce retail employment in by XX% in Area Types 1, 2, and 3 and by XX% in Area Types 4, 5, and 6 (larger decrease for Area Types 4, 5, and 6). Increase industrial employment to maintain the same number of total jobs in Montgomery County.
- In the Truck_Com_Trip_Rates.dbf, increase rates across all industries by XX%.
- In the i4_Trip_Gen_Attractions_Comp.dbf file, decrease the HBS motorized person-trip attractions by XX%. Distribute the reduction proportionately across the different income groups. (These changes will require a modification in the Trip_Generation.s script to make the adjustment as part of the model flow.)

[20] https://en.wikipedia.org/wiki/E-commerce
[21] https://www.supplychainquarterly.com/columns/scq201102monetarymatters/

Virtual Reality

Virtual Reality (VR) is a simulation-based experience with applications for work, entertainment, and education. A VR system includes a head-mounted display combined with 3D touch and audio options.[22] Applications of VR in the workplace include recruiting, staff training, collaboration, telecommuting, and sales interaction with consumers.[23] This Individual Driver represents an intensification of the teleworking trend already enabled by current technology. Virtual and augmented reality has the potential to improve the K-12 education system as well as higher education, new arts, and vocational training education.[24]

Transportation Impact

With simulated experiences, travelers no longer need to travel. It is not expected that all trips will be replaced by VR, but it is assumed that trip rates will be reduced with high-quality virtual experiences.

Modeling Approach

- In the Weighted_trip_rates.dbf file, reduce the HBW, HBO, and NHO trips for income levels 3 and 4 by XX% and for income levels 1 and 2 by XX% (lower than the level for 3 and 4).[25]

3D Printing

3D printing refers to a process in which material is joined to create a three-dimensional object using computer-based control systems. 3D printing can be completed in a residence or job center, but it is more likely to occur in industrial settings.

Transportation Impact

3D printing is expected to reduce industrial employment while increasing local commercial vehicle trip generation.

Modeling Approach

- In the Zone.dbf file, decrease industrial jobs by XX%, and shift the removed industrial jobs to retail jobs (in TAZs with existing retail employment).

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[22] https://en.wikipedia.org/wiki/Virtual_reality
[23] https://www.viar360.com/5-ways-can-use-virtual-reality-workplace/
[24] https://www.classvr.com/virtual-reality-in-education/
[25] The MWCOG and Travel/4 models include four household income segments: 1) less than $50,000, 2) $50,000-$100,000, 3) $100,000-$150,000, and 4) more than $150,000.

- In the Ver23_f_factors.dbf file, increase truck friction factors by XX%.

Vehicle Electrification

Electric vehicles (EVs) refer to several electricity technologies such as hybrid electric, plug-in hybrid, and battery electric vehicles. It is expected that EVs will make up an increasingly larger share of the vehicle fleet, comprising up to 35% of new car sales by 2040[26]. While EVs currently have a large up-front cost, they are expected to cost less to operate than gas-powered vehicles over the course of their lifetime. As a result, EVs have reduced operating costs relative to most of today's automobiles.

Transportation Impact

It is expected that EVs will reduce auto operating costs.

Modeling Approach

- In the control files associated with the nested-logit mode choice model (HBW_NL_MC.CTL, HBS_NL_MC.CTL, HBS_NL_MC.CTL, NHW_NL_MC.CTL, and NHO_NL_MC.CTL), reduce the auto operating costs by XX%.[27]

Autonomous Vehicles

There are several levels of automation, from no limited driver assistance (Level 1, human drivers monitor the driving environment) to full automation (Level 5, automated driving system monitors the driving environment). A Level 5 autonomous vehicle (AV) can sense its environment, perform driving tasks, take safety decisions and navigate without a driver. As a result, AVs have the potential to decrease road fatalities, improve mobility for people with disabilities and elderly people, and improve travel efficiency (improved merging, weaving, and following).

Transportation Impact

AVs have the potential to radically impact the way that people travel. For example, the door-to-door nature of AVs could reduce the time spent searching for parking and walking to and from one's vehicle. In addition, AVs could result in decreased parking costs, as the vehicle does not need to park near its occupant's destination; it can instead park somewhere with lower parking

[26] https://insideevs.com/news/341824/december-2018-us-plug-in-ev-sales-report-card/

[27] The auto operating costs in the mode choice model relate to out-of-pocket expenditures directly associated with an automobile trip, including fuel, oil, maintenance, tire wear, etc. (not including insurance, registration fees). It is 10 cents per mile (in 2007 dollars) and the rate is not varied over the years in MWCOG's current model.

expenses. These changes make the auto mode more appealing, which may result in a shift from other modes (e.g. transit). AVs can increase non-work trip making, as children, people with disabilities, and seniors are now able to travel independently. The number of trips could also increase as a result of "zero-occupant" trips, where the vehicle is traveling without any passengers on board.

Modeling Approach

- In the PrefarV23.s file, reduce auto access time by XX%.
- In the PrefarV23.s file, reduce parking costs by XX%.
- In the Equiv_Toll_Min_by_Inc.s file, decrease value-of-time in the vehicle by XX%.
- In the Demo_Models.s script file, adjust the vehicle ownership by shifting XX% of households with zero vehicles available to households with one vehicle available. The script update should modify the i4_Demo_Models_HHbyISV.dbf output file.
- In the Link.dbf file, increase freeway capacity (Facility Type 1) by XX%.
- In the i4_Trip_Gen_Productions_Comp.dbf file, increase HBS, HBO, and NHO trip generation by XX%. (These changes will require a modification in the Trip_Generation.s script to make the adjustment as part of the model flow.)

Change in Lifestyle

Changes in lifestyle include shifts in where people live, how they work, and how they travel based on shifting cultural and societal norms. Within this Driver of Change, four Individual Drivers will be assessed in Thrive Montgomery 2050: preference for urban living, flexible work hours, retirement age, and preference for bicycling and walking.

Preference for Urban Living

The United States is increasingly becoming more urbanized. The promise of jobs and prosperity pulls people to cities, as well as the concentration of amenities, such as entertainment options and restaurants, and alternatives to a drive-alone commute, such as transit service and bicycle and pedestrian infrastructure. Half of the global population already lives in cities, and by 2050 two-thirds of the world's people are expected to live in urban areas.[28]

[28] https://www.nationalgeographic.com/environment/habitats/urban-threats/

Transportation Impacts

Preference for urban living is essentially about the distribution of land use. Households in less dense TAZs are expected to move to denser TAZs. It is assumed that most shifts will come from high-income households with a relatively low household population (generally one or two people).

Modeling Approach

- In the Zone.dbf file, identify TAZs in Area Types 3, 4, 5, and 6 that have a median income of 50% higher than the median regional income. Remove XX% of households from these TAZs and move them to TAZs in Area Types 1 or 2, proportional to the number of households in the denser TAZs. Assume the households that have been moved will have the same household-to-population ratio as their destination TAZ. Reduce the population in original TAZs and correspondingly increase the same amount of population in their destination TAZs.

Flexible Work Hours

Flexible work hours are when an employer permits its employees to work outside of traditional 9 AM to 5 PM shifts. Employees may arrive and leave work early (e.g. 7 AM to 3 PM) or arrive late and leave late (e.g. 11 AM to 7 PM).

Transportation Impact

As a result of flexible work hours, some employees may choose to commute outside of the traditional commute periods.

Modeling Approach

- In the TODcomp_2008HTS.dbf, adjust the time-of-day factors for HBW trips to reduce the AM and PM peak period trips by XX%. For the percent reduction, allocate 67% of the removed trips to the midday period and 33% of trips to the other off-peak period.

Retirement Age

According to Montgomery County Trends report, workforce age is increasing as people increase their retirement age.[29] This could be because workers fear their savings are insufficient for

[29] https://montgomeryplanning.org/wp-content/uploads/2019/01/MP_TrendsReport_final.pdf

retirement or could be due to a trend towards more office employment and workers feeling capable of continuing work into their late 60s.

Transportation Impact

With workers staying employed later in life, the number of commute trips in the region are more likely to increase. Concurrently, the portion of discretionary trips during the peak periods could increase as workers trip-chain shopping or other errands on their way to and from work. It is expected that the increase in retirement age will be more prevalent among low-income workers than high-income workers.

Modeling Approach

- In the Weighted_trip_rates.dbf file, increase the HBW trips for income levels 3 and 4 by XX% and increase the HBW trips for income levels 1 and 2 by XX% (higher than the level for 3 and 4).
- In the TODcomp_2008HTS.dbf, adjust the time-of-day factors for HBS, HBO, and NHO trips to shift XX% of trips from the midday time period to the AM and PM peak periods.

Preference for Walking and Biking

As a result of shifting cultural preferences, more people may choose to walk or bike, either for work-related or discretionary trips.

Transportation Impact

The preference for walking and bicycling is, in itself, a transportation impact. It does not result in an increase or decrease in the total number of trips made, but rather is implemented by shifting some auto and transit trips to non-motorized modes.

Modeling Approach

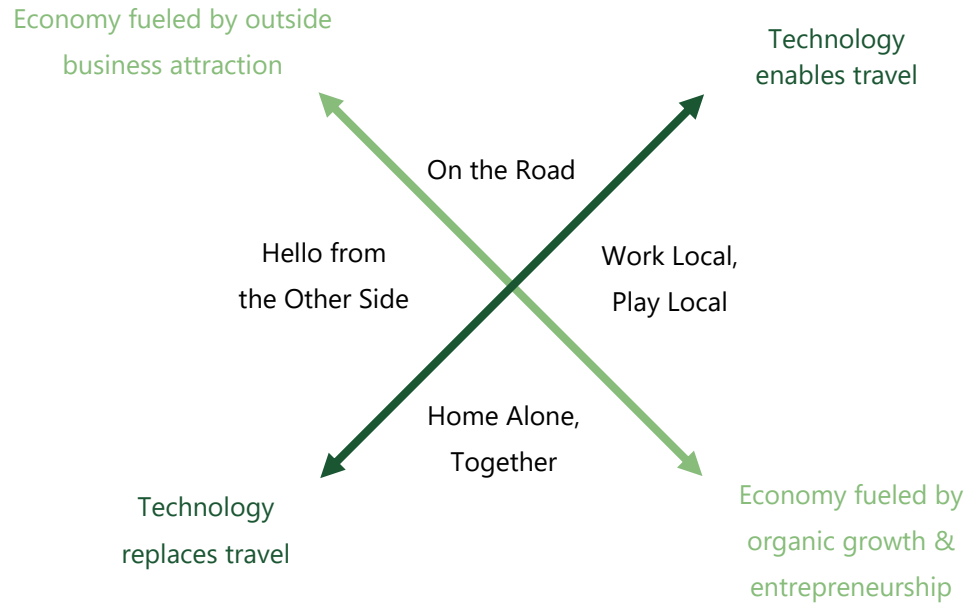
- In the Prepare_Trip_Tables_for_Assignment.s script file, reduce O-D pairs in the pre-assignment vehicle trip tables for each time period (excluding night) for O-D pairs with a distance of three miles or fewer and where either the origin or destination is in Area Type 1, 2, or 3. The reduction factor applied would represent XX% of nonmotorized trips generated by the TAZ.

Alternative Futures

Based on the discussions during the workshop, four Alternative Futures were created, based on a matrix framework with two axes:

- **Technology:** Technological innovation is inevitable. Several anticipated innovations are linked to travel. One end of the spectrum represents technology that encourage travel, such as autonomous and electric vehicles. The other end of the spectrum represents technology trends that replaces travel, such as e-commerce, virtual reality, and 3D printing.
- **Economy:** The economy is inextricably linked to the demographic, environmental, and equity outcomes for the region. One end of the spectrum represents a focus on existing Montgomery County industries and residents, encouraging local entrepreneurship, with no effort to attract outside businesses. The other end of the spectrum highlights Montgomery County as a regional leader in attracting global corporations to establish offices in the county.

The figure below depicts how these axes intersect to create four Alternative Futures.



Each Alternative Future is briefly summarized below. These narratives are not expected to be an exhaustive list of the Individual Drivers that make up each Alternative Future, but they are intended to paint a picture of life in Montgomery County. Each Alternative Future includes a location that loosely resembles the economic and technological conditions summarized in each Alternative Futures description.

- **On the Road -** Montgomery County, having further diversified its industries, attracts employees from throughout the region. Some of these new employees move to Montgomery County, while most commute from other parts of the region. Autonomous vehicles and transit transport these high-skill workers to the county's job centers. However, commutes are often unreliable, as extreme weather events regularly close key bridges and highways, requiring long detours. Housing demand continues to rise, exacerbating today's affordability challenges. The number of intergenerational homes increases across the county, both for affordability and cultural reasons. Income inequality and health disparities persist along economic and racial lines. *Resembles Silicon Valley.*
- **Work Local, Play Local -** The County's strategic focus on retaining and expanding existing industries and small businesses has removed the County from regional competition for employers. Growth industries have largely chosen to locate in other parts of the region. Montgomery County residents across the income spectrum are employed locally; nearly all residents work within the county borders and unemployment is at an all-time low. Local restaurants and entertainment are thriving. Residents can walk and bike to most of what they need, and shared autonomous vehicles support longer trips within the county. Rising temperatures make walking and bicycling uncomfortable in the summer, but health breakthroughs have eliminated the risk of skin cancer. *Resembles Portland, OR.*
- **Home Alone, Together** - Local biotech and hospitality companies are the major employers of highly educated Montgomery County residents, and virtual reality enables nearly all employees to work from home. Local companies prioritize local hires despite the pervasive telework culture. Residents teleworking for companies outside the county supplement local employment. Few errands need to be run in-person, as most goods and services can be rendered online. Grocery stores and retailers move from downtowns and shopping centers to more affordable, industrial areas, tapping into the growing distribution and delivery system. Digital sports and entertainment reign, with low user and membership fees accessible to all residents. Residential energy use skyrockets, eclipsing transportation energy use and exacerbating climate issues. *Resembles Vermont (the state pays remote workers to move to Vermont).*

- **Hello from the Other Side -** Successfully recruiting key digital service providers, there are more jobs in Montgomery County than any other jurisdiction in the region. However, given the remote nature of all work, these jobs –filled by residents throughout the region and the world – rarely require travel to the companies' minimalist campuses. Corporations require less commercial office space, resulting in significantly lower commercial property taxes and demand for commercial space. Urban streets are generally empty of vehicles, pedestrians, and bicyclists, as most socializing happens online. Obesity increases as physical activity declines, though exposure to air pollution is mitigated through limited time spent outdoors. There are limited employment opportunities for blue collar workers. As a last resort, they often work in service of the booming sharing economy, renting their personal goods, homes, and vehicles for income. *Resembles University of Phoenix*.

In addition to these Alternative Futures, Montgomery Planning aims to analyze a **Business as Usual Future**, a 2050 future that assumes the status quo with regards to the five Drivers of Change: economic disruptions, technological innovation, climate change, demographics, and changes in lifestyle.

Each Alternative Future includes a variety of assumptions regarding each of the Individual Drivers, grouped into their respective Drivers of Change. These assumptions have been developed based on feedback from Steering Committee and Working Group Leaders during the workshop.

Table 5. Alternative Futures Summary

Alternative Futures	On the Road	Work Local, Play Local	Home Alone, Together	Hello from the Other Side
Technology Condition	Tech enables travel	Tech enables travel	Tech replaces travel	Tech replaces travel
Economy Condition	Outside business attraction	Organic growth	Organic growth	Outside business attraction
Economic Disruptions				
Automation of work	large increase	large increase	large increase	large increase
Increase in global trade	slight decrease	no change	no change	slight increase
Competition within the region	large increase	slight decrease	slight decrease	large increase
Competition outside the region	large increase	slight increase	slight increase	large increase
Sharing economy	large increase	slight increase	slight increase	large increase
Climate Change				
Infrastructure closures	large increase	large increase	slight increase	slight increase
Flooding	large increase	slight increase	slight increase	large increase
Rising temps/weather variability	large increase	large increase	large increase	large increase
Demographic Changes				
Income inequality	large increase	slight increase	slight increase	large increase
Birth rates	slight decrease	slight decrease	slight decrease	slight decrease
Multigenerational Households	large increase	slight increase	slight increase	large increase
Aging population	slight increase	slight increase	slight increase	slight increase
Technological Innovation				
E-commerce	slight increase	slight increase	large increase	large increase
Virtual reality	slight increase	slight increase	large increase	large increase
3D printing	slight increase	slight increase	large increase	large increase
Vehicle electrification	large increase	large increase	slight increase	slight increase
Autonomous vehicles	large increase	large increase	slight increase	slight increase
Changes in Lifestyle				
Preference for urban living	large increase	slight increase	slight increase	slight increase
Flexible work hours	slight increase	slight increase	large increase	large increase
Retirement age	large increase	slight increase	slight increase	large increase
Pref. for walking and bicycling	no change	slight increase	no change	slight increase

Legend > large decrease | slight decrease | no change | slight increase | large increase

Alternative Futures Analysis Approach

The Alternatives Futures analysis operationalize the narratives included above. This Analysis is crucial, as it identifies the range of possible outcomes in the County, allowing Montgomery Planning to "bracket" what the future might look like and then develop a set of policy responses to steer the future towards its desired vision.

Table 6 (next page), summarizes each of the Alternative Futures based on how the changes in each Individual Driver associated with that future. The changes associated with the Individual Drivers are varied, addressing several different aspects of travel behavior, including trip generation, trip distribution, time of day distribution, and mode share. In addition, some Individual Drivers made adjustments to the underlying household and employment distribution throughout the County, which in turn impacts how people travel.

The table below also includes estimates for the adjustment values for each Individual Driver based on the Alternative Future. These assumptions are based on the direction and magnitude of change included in **Table 5**. These values should be considered as initial suggestions, rather than final modeling assumptions. During the next phase of work, Montgomery Planning may want to explore surveying experts or convening a Delphi panel to provide justification for the assumptions made in the Alternative Futures.

For additional information about the assumptions associated with the Individual Drivers cited below, refer to the specific Individual Driver subsection within Drivers of Change section.

Table 6. Modeling Adjustments by Alternative Futures

Individual Driver	Modeling Approach	Change Type[1]	On the Road	Work Local, Play Local	Home Alone, Together	Hello from the Other Side
Economic Disruptions						
Automation of work	Shift XX% of retail and industrial jobs to office jobs	LU	+50%	+50%	+50%	+50%
	Reduce the trip rate associated with retail and industrial employment by XX%	TG	-20%	-20%	-20%	-20%
Increase in global trade	Increase the number of freight trips by XX%	TG	-10%	0%	0%	+10%
Competition within the region	Increase jobs in Montgomery County by XX%	LU	+10%	-10%	-10%	+10%
	Reduce jobs outside of Montgomery County by XX%	LU	-2%	+2%	+2%	-2%
Competition outside the region	Increase the internal-external and external-internal commute trips by XX%	TD	+10%	+5%	+5%	+10%
Sharing economy	Increase shared rides by XX%	MS	+20%	+10%	+10%	+20%
Climate Change						
Infrastructure closures	Addressed through metrics analysis					
Flooding	Reduce households and employment in flood-prone areas by XX% and shift to less vulnerable locations	LU	+80%	+40%	+40%	+80%
Rising temps/ weather variability	Reduce non-motorized mode share by XX%	MS	-30%	-30%	-30%	-30%

1. LU = land use; TG = trip generation; TD = trip distribution; TOD = time of day; MS = mode share; OC = other change

Individual Driver	Modeling Approach	Change Type[1]	On the Road	Work Local, Play Local	Home Alone, Together	Hello from the Other Side
Demographic Changes						
Income inequality	Shift XX% of residents in the second- and third-income quartiles to first- and fourth-income quartiles	LU	+50%	+25%	+25%	+50%
Birth rates	Reduce population by XX% while maintaining the same number of households	LU	-10%	-10%	-10%	-10%
	Reduce school trips by XX%	TG	-5%	-5%	-5%	-5%
Multigenera-tional Households	Decrease the number of households by XX% while maintaining the population total	LU	-20%	-10%	-10%	-20%
Aging population	Increase portion of trips in off-peak by XX%	TOD	+20%	+20%	+20%	+20%
Technological Innovation						
E-commerce	Reduce retail jobs in Montgomery County by XX% in Area Types 1-3 and by XX in Area Types 4-6. Removed retail jobs will be added as industrial jobs to TAZs with industrial employment.	LU	-10%/ -20%	-10%/ -20%	-20%/ -40%	-20%/ -40%
	Increase freight trips by XX%	TG	+10%	+10%	+10%	+10%
	Reduce home-based shopping trips by XX%	TG	-20%	-20%	-40%	-40%
Virtual reality	Reduce trip generation by XX% for income levels 1-2 and by XX for income levels 3-4	TG	-20%/ -10%	-20%/ -10%	40%/ -20%	40%/ -20%
3D printing	Decrease industrial jobs by XX% and add as retail jobs in TAZs with retail employment	LU	-5%	-5%	-10%	-10%
	Increase intra-county commercial vehicle trips by XX%	TD	+10%	+10%	+20%	+20%
Vehicle electrification	Reduce auto-operating costs by XX%	OC	-50%	-50%	-25%	-25%
Autonomous vehicles	Decrease parking costs by XX%	OC	-50%	-50%	-25%	-25%
	Decrease access time by XX%	OC	-50%	-50%	-25%	-25%
	Increase non-work vehicle trips by XX%	TG	+20%	+20%	+10%	+10%
	Increase vehicle availability XX%	LU	+20%	+20%	+10%	+10%
	Increase vehicle trips by XX% to account or zero-occupant trips	TG	+20%	+20%	+10%	+10%
	Increase roadway capacity by XX% on freeways	OC	+20%	+20%	+10%	+10%

1. LU = land use; TG = trip generation; TD = trip distribution; TOD = time of day; MS = mode share; OC = other change

Individual Driver	Modeling Approach	Change Type[1]	On the Road	Work Local, Play Local	Home Alone, Together	Hello from the Other Side
Changes in Lifestyle						
Preference for urban living	Remove XX% of households from high-income sprawling areas and move to high-density areas	LU	-50%	-25%	-25%	-25%
Flexible work hours	Reduce the portion of work-related trips made during peak commute periods by XX%	TOD	-5%	-5%	-10%	-10%
Retirement age	Increase the number of work-related trips by XX%	TG	+20%	+10%	+10%	+20%
	Shift XX% of midday non-work-related trips to the peak commute periods	TOD	+20%	+10%	+10%	+20%
Pref. for walking and bicycling	Shift XX% of motorized trips to nonmotorized modes	MS	0%	+15%	0%	+15%

1. LU = land use; TG = trip generation; TD = trip distribution; TOD = time of day; MS = mode share; OC = other change

Model Selection & Horizon Year

MWCOG's regional travel demand forecasting model, known as the Version 2.3 Travel Model, is designed to represent the transportation supply and demand in the Washington, D.C. metropolitan area. The area represented by this model includes the District of Columbia, neighboring parts of Maryland, Virginia, and one county in West Virginia. The 6,800-square mile modeled area is divided into 3,722 transportation analysis zones (TAZs). The model was calibrated to year-2007 conditions, between 2008 and 2011, using the COG 2007/08 Household Travel Survey and onboard transit surveys. Revisions to the travel model are referred to as "builds," and is indicated as the third index in the model version number.

The Travel/4 model is based on the Version 2.3.52 travel demand forecast model. The Travel/4 model includes a more detailed set of zones within Montgomery County than the MWCOG model (466 zones vs. 376 zones), as well as a more detailed roadway and transit networks (300+ miles of highway). The Travel/4 model includes four analysis years: 2010, 2015, 2025, and 2040. Given the additional level of detail provided in the Travel/4 model, this model is recommended as the primary analysis tool for Thrive Montgomery 2050.

As mentioned above, the most distant horizon year in the Travel/4 model is 2040. MWCOG has released new model versions since Version 2.3.52 was used to develop the Travel/4 model; the most recent version is Version 2.3.75. The most distant horizon year for this version of the model is 2045.

In order to employ the Travel/4 model for the Thrive Montgomery 2050 analysis, the following steps are recommended:

- **Land Use Adjustments:** Calculate the population and employment growth rates for each TAZ between 2040 and 2045 in the MWCOG model (Version 2.3.75). Apply those five-year growth rates to the 2045 population and employment in order to calculate 2050 land uses for the region. Distribute the 2050 land use data to the more detailed TAZs in the Travel/4 model proportionately based on 2040 population and employment. Alternatively, Montgomery Planning could first distribute the 2045 MWCOG model land use to the Travel/4 TAZs prior to extrapolating growth in population and employment.
- **Transportation Network:** Identify what transportation projects, if any, should be added to the 2040 transportation network to more accurately reflect a 2050 condition.

Next Steps

This white paper provides an analytical approach for understanding the future of Montgomery County. It enables Montgomery Planning to assess how the County will be impacted by ongoing trends, as well as whether or not these trends are in support of Montgomery Planning's vision for the future.

Throughout this document, there are several recommendations for next steps for Montgomery Planning. This section compiles those recommendations and summarizes alternative approaches for moving forward with the Alternative Futures analysis.

Implementing the White Paper Approach

This white paper outlines the transportation approach to Thrive Montgomery 2050, and it provides an analysis framework for evaluating Baseline Futures (including a Business as Usual Future and four Alternative Futures). Prior to implementing the modeling approach detailed in the white paper, several recommendations were put forward to confirm the proposed assumptions are appropriate and help Montgomery Planning achieve its goals for Thrive Montgomery 2050.

- **Delphi Panel:** These adjustment values included in **Table 5** should be considered as initial suggestions, rather than final modeling assumptions. During the next phase of work, Montgomery Planning may want to explore surveying experts or convening a Delphi panel to provide justification for the assumptions made in the Alternative Futures.
- **Model Testing:** The model may or may not be sensitive to the changes included in **Table 4**. It is recommended that changes are "tested" individually, prior to being combined into an Alternative Future, to understand how individual model adjustments impact key outcomes for the County.
- **Metrics Revisions:** For some objectives, we recommend revising the current approach based on the level of effort needed to quantify the objective and the expected level of confidence in the resulting outcome. This recommendation specifically refers to the objectives related to bicycle and pedestrian safety (**Table 2**).

Simplifying the White Paper Approach

This white paper explores the how each Individual Driver would impact transportation, and it identifies a unique modeling for these Individual Drivers. We acknowledge that the future is

complex, but also the limited defensibility of the complex assumptions included in applying the modeling approach as written. As an alternative, the four Alternative Futures could be analyzed based on a simplified framework. Each Alternative Future is comprised of two axes – transportation and economy. The simplified framework would increase or decrease trip tables (adjusting trip generation) based on where the Alternative Future falls on the transportation axis. Trip distribution – either focused locally or regionally – would be adjusted based on where the Alternative Future falls on the economy axis. This option allows Montgomery Planning to still observe the range of outcomes from Alternative Futures, but with a framework that is less of a "black box".

After the Alternative Futures Analysis

Once that analysis is complete, the next steps for Montgomery Planning are to identify policy recommendations and future tasks in the agency's work program to bridge the differences between the County's vision and where it may end up without interventions.

Appendix A. Bicycle Master Plan – Appendix E: Bikeway Prioritization Methodology

APPENDIX E

BIKEWAY PRIORITIZATION METHODOLOGY

INTRODUCTION

The network of bikeways recommended in the Bicycle Master Plan is extensive and is likely to be only partially completed during the 25-year life of this plan. Such a large network is proposed so that opportunities to implement the preferred bicycling network are not lost when unforeseen circumstances arise. At the same time, it is important to identify priorities within the network, so the most important bikeways and facilities are constructed first.

The Bicycle Master Plan creates a new approach to understanding potential bicycle demand by converting the regional travel demand model to a potential demand model for bicycling. This analysis was a primary factor in prioritizing bikeway recommendations and is tied to the goals and objectives of the plan.

Specifically, Goal 2 and Goal 3 include five metrics that measure progress in increasing low-stress connectivity:

- Metric 2.1: Percentage of potential bicycle trips that can be made on a low-stress bicycling network.
- Metric 2.2: Percentage of dwelling units within 2 miles of each Red Line, Brunswick Line, Purple Line and Corridor Cities Transitway station that are connected to the transit station on a low-stress bicycling network.
- Metric 2.3: Percentage of dwelling units within one mile of elementary schools, 1.5 miles of middle schools and 2 miles of high schools that are connected to the schools on a very low-stress bicycling network.
- Metric 2.4: Percentage of dwelling units within 2 miles of public libraries, recreation centers and regional / recreational parks that are connected to the public facility on a low-stress bicycling network.
- Metric 3.1: Percentage of potential bicycle trips that can be made on a low-stress bicycling network in Census tracts where the median income is below 60 percent of the Montgomery County average median income.

DATA INPUTS

An evaluation of the connectivity metrics in the Bicycle Master Plan relies on three major inputs:

- The proposed low-stress bicycling network in Montgomery County.
- A 2040 matrix of all trips focused on areas that are likely to generate the most bicycling in Montgomery County.
- Refined geographic units of analysis by reducing the size of transportation analysis zones (TAZs) into smaller geographic areas.

Input 1: Low-Stress Bicycling Network

In order to attract the broadest segment of the population to bicycle, Montgomery County must create a bicycling network that does not exceed people's tolerance for traffic stress and does not require an excessive level of detour. While currently about 75 percent of street mileage in Montgomery County is low-stress, these streets largely represent "islands of connectivity" that are separated by arterial roads and environmental barriers such that only 18 percent of trips can be made by bicycle.

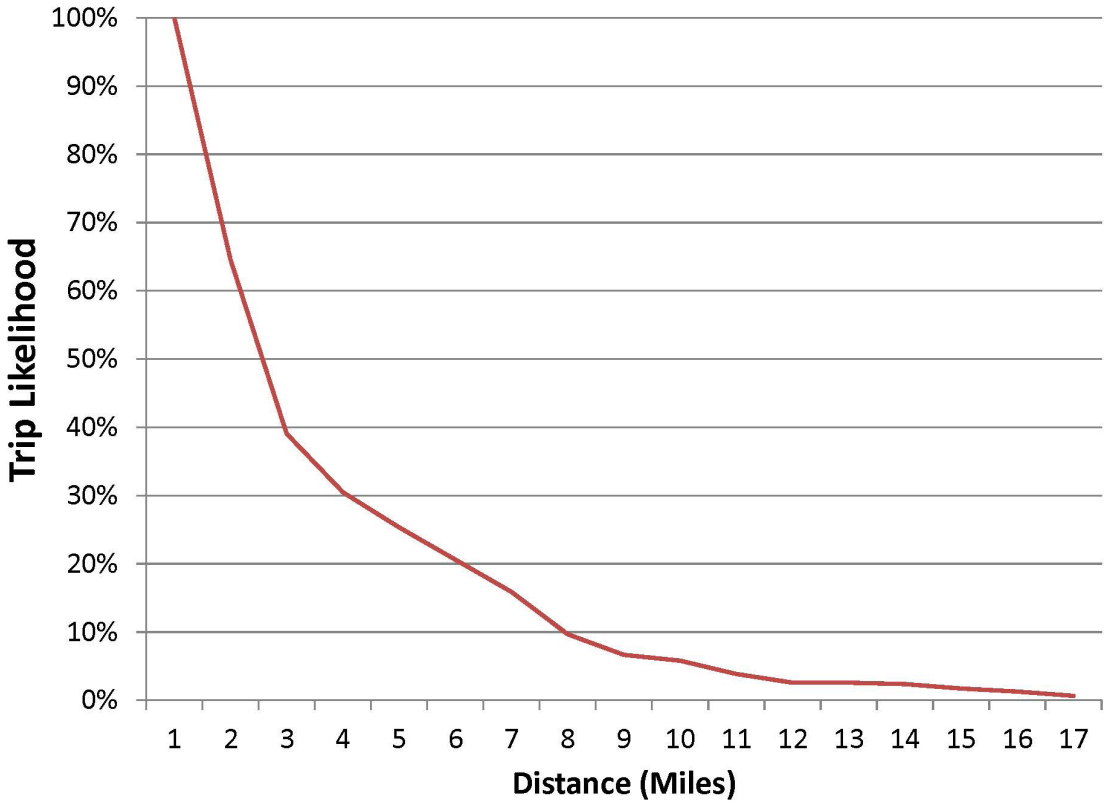
The Bicycle Master Plan recommends a network of low-stress bikeways to connect residential communities to the places in the county where people want to go, including transit stations, employment centers, retail destinations, public facilities and other activity centers. All roads were assigned a level of traffic stress using the methodology explained in Appendix D.

Input 2: 2040 Trip Table

A subset of the regional travel demand model was selected to be included in the connectivity analysis. While there are certainly some daily bike trips between Montgomery County and all jurisdictions in the region, the likelihood that a trip will be made by bicycle decreases with distance. It is therefore possible to remove many areas in the region from the analysis while still creating a useful representation of potential demand.

The likelihood that a trip will be made by bicycle can be approximated by a distance decay function using data from the 2007 – 2008 regional household survey conducted by the Metropolitan Washington Council of Governments. This chart shows that about 40 percent of bicycling trips are three miles or fewer and only 10 percent of bicycling trips are longer than 7 miles.

Distance Decay Function



The geographic areas included in the connectivity analysis include trips that are:

1. Within Montgomery County.
2. Between Montgomery County and the District of Columbia.
3. Between Montgomery County and Prince George's County north of MD 704.

Trips between Montgomery County and the District of Columbia are particularly important to capture because of the large number of transit trips between the two jurisdictions. Bicycling is an important way to expand the catchment area of transit stations without investing in expensive parking garages, and is an approach that WMATA is increasingly using at metrorail stations.

Trips south of MD 704 in Prince George's County were excluded because they are more than 7 miles from the nearest point in Montgomery County and so very few bicycling trips are likely between Montgomery County and these areas.

Similarly, TAZs from Frederick County, Howard County and Fairfax County were not included because their great distances from major activity centers in Montgomery County means that relatively few bicycling trips can be expected to occur between these counties and Montgomery County.

Input 3: Geographic Units for Measuring Bicycle Travel

Just as travel demand models are helpful at understanding future travel patterns via automobile or transit, they can also be used to understand future travel by bicycle. Since their geographic unit of measurement – TAZs – is too large to adequately distinguish areas where barriers to connectivity exist for bicycling, a smaller unit of geography is needed. Census blocks are ideal, since, typically, if people can bicycle to a Census block, they are able to access all of the attractions on that block.

Unfortunately, focusing on Census blocks in this plan would lead to a dataset that is unmanageably large. To keep the size of the dataset manageable, our analysis uses Census blocks in urban areas of Montgomery County, such as Downtown Silver Spring, Bethesda and Wheaton. In suburban and rural Montgomery County, Census blocks are combined into groups of about four to five contiguous blocks. TAZs are retained as units of geography for Washington, DC and Prince George's County.

ADJUSTMENTS TO TRIP TABLE

The 2040 trip table, showing travel patterns in the future, was adjusted to:

- Convert transit trips to potential bicycling trips.
- Disaggregate trip table from TAZs to smaller geographies.

Adjustment 1: Converting Transit Trips to Potential Bicycling Trips

Many trips in the travel demand model that are transit trips could include bicycle trips as the mode of access to the transit station. Since the travel demand model does not identify where transit was accessed, assumptions where made to determine which portion of the overall trip could be made by bicycle:

- For transit trips produced in Montgomery County where the attraction is in the District of Columbia or Prince George's County, the attraction location was converted to the Census block for the Montgomery County rail station that is closest to the production location. For example, for trips that are produced in Aspen Hill and attracted to Union Station in the District of Columbia, the production remains Aspen Hill and the attraction becomes the Glenmont Metrorail Station.

- For transit trips where the production is in the District of Columbia or Prince George's County and the attraction is in Montgomery County, the production location was converted to the Census block for the Montgomery County rail station that is closest to the attraction location. For example, for a trip that is produced in Georgetown and is attracted to Rock Spring area of Bethesda, the production becomes the Grosvenor Metrorail Station and the attraction remains Rock Spring.

What are Productions and Attractions?

For home-based trips, the production is always at the home end of the trip, whether home is the starting point or the ending point. In trips without a home end (non-home-based trips), productions are defined as the starting point of the trip. For home-based trips, the attraction end of the trip is the non-home end of the trip, whether that location is the starting or ending point of the trip. For non-home-based trips, attractions are defined as the ending point of the trip.

- For transit trips where both the production and attraction are in Montgomery County, the production and attraction were converted to the Census blocks for the closest rail stations in Montgomery County and became two potential bicycle trips. For example, for a trip that starts at Aspen Hill and ends at the Montgomery County Planning Department, one potential bicycling trip became from Aspen Hill to the Glenmont Metrorail Station and the second potential bicycling trip became from the Silver Spring Metrorail Station to the Montgomery County Planning Department.

Adjustment 2: Trip Table Disaggregation

The travel demand model was from TAZs to smaller geographic units within Montgomery County. Trips between TAZs were disaggregated based on the number of productions and attractions in each geographic unit.

A. Trip productions were distributed based on the forecast number of households in the geographic unit in the year 2040.
B. Trip attractions were distributed based on a summation of the following equations for different area types in the Metropolitan Washington Council of Governments Version 2.3 travel forecasting model calibration report:

HBW_Attr_1-2 = 1.118 x TOTEMP
HBW_Attr_3+ = 0.8546 x TOTEMP
HBS_Attr_1-2 = 1.995 x RETEMP + 0.301 x TOTPOP
HBS_Attr_3+ = 3.102 x RETEMP + 0.221 x TOTPOP
HBO_Atttr_1-2 = 0.425 x NONRETEMP + 1.012 x TOTPOP
HBO_Attr_3+ = 1.084 x NONRETEMP + 0.588 x RETEMP + 0.777 x TOTEMP
NHW_Attr_1-2 = 0.944 x RETEMP + 0.557 x OFFEMP + 0.656 x OTHEREMP
NHW_Attr_3+ = 0.807 x RETEMP + 0.522 x OFFEMP + 0.507 X OTHEREMP
NHO_Attr_1-2 = 0.097 x NONRETEMP + 1.498 x RETEMP + 0.300 x TOTPOP
NHO_Attr_3+ = 0.178 x NONRETEMP + 2.784 x RETEMP + 0.184 x TOTPOP

Total population (TOTPOP) is included in the MWCOG cooperative land use forecasts Round 8.3). Employment for retail (RETEMP), non-retail (NONRETEMP), office (OFFEMP) and other (OTHEREMP) was calculated by converting the square footage for each land use type in the Montgomery County Planning Department's parcel file to office, retail, industrial and other land use jobs using the following job factors:

a. Office: 250 square feet job
b. Retail: 400 square feet per job
c. Industrial: 450 square feet per job
d. Other: 500 square feet per job

The above equations also require assumptions about the area type, based on its population and employment densities. (For example, 1-2 refers to areas types 1 and 2; 3+ refers to area types 3, 4, 5 and 6.) Each block was assigned an area type from 1 to 6 using Table 24 from the MWCOG Version 2.3 travel forecasting model calibration report:

Table 24: Area Type Definitions (1-7) as a function of population and employment density

ONE-MILE "FLOATING" POPULATION DENSITY (POP/SQ MI)	ONE-MILE "FLOATING" EMPLOYMENT DENSITY (EMP/SQ MI)						
	0-100	101-350	351-1,500	1,501-3,550	3,551-13,750	13,751-15,000	15,001+
0-750	6	6	5	3	3	3	2
751-1,500	6	5	5	3	3	3	2
1,501-3,500	6	5	5	3	3	2	2
3,501-6,000	6	4	4	3	2	2	1
6,001-10,000	4	4	4	2	2	2	1
10,001-15,000	4	4	4	2	2	2	1
15,001+	2	2	2	2	2	1	1

Once productions and attractions were determined for each geographic unit in Montgomery County, they were disaggregated to better represent potential bicycle travel. For example, the Travel / 4[2] travel demand model shows that there will be approximately 21 trips produced in TAZ 3724 and attracted to TAZ 3726 in 2040:

PRODUCTION TAZ	PRODUCTION TAZ	TRIPS
3724	3726	20.73

TAZ 3724 and 3726 are each composed of two Census block groups. Within TAZ 3724, block group 240317047001 comprises 14.9 percent of productions and 14.7 percent of attractions, while block group 240317047002 comprises 85.1 percent of productions and 85.3 percent of attractions. All possible combinations of the block groups result in the following table:

BLOCK GROUP	TAZ	PRODUCTION %	ATTRACTION %
240317047001	3724	14.9%	14.7%
240317047002	3724	85.1%	85.3%
240317048041	3726	13.4%	95.0%
240317048052	3726	86.6%	5.0%

[2]Travel / 4 is an adaptation of the Metropolitan Washington Council of Governments (MWCOG) regional travel demand model used by Montgomery County.

To disaggregate the TAZ-to-TAZ trips to block group-to-block group trips, the production percentages and the attraction percentages for each block group were multiplied by the number of trips between TAZs using a query in Microsoft Access. For example, there were assumed to be 2.94 trips between 240317047001 and 240317048041. This total was calculated by multiplying 20.73 trips x 14.9 percent of productions and 95.0 percent of attractions.

PRODUCTION TAZ	ATTRACTION TAZ	TRIPS	PRODUCTION BLOCK GROUP	ATTRACTION BLOCK GROUP	PRODUCTION %	ATTRACTION %	TRIPS DISAGGREGATED
3724	3726	20.73	240317047001	240317048052	14.9%	5.0%	0.15
3724	3726	20.73	240317047002	240317048041	85.1%	95.0%	16.77
3724	3726	20.73	240317047002	240317048052	85.1%	5.0%	0.87
3724	3726	20.73	240317047001	240317048041	14.9%	95.0%	2.94
TOTAL							**20.73**

POTENTIAL DEMAND MODEL

The Montgomery County Planning Department created a GIS-based digital model to determine the potential for bicycling trips on all segments of the bicycling network using the three major inputs described above. The process assigns trips to the network based on the shortest distance between two points. Future versions could consider elevation change and delay at crossings.

Please note that the potential demand model is primarily intended to compare relative future bicycling among bikeway scenarios (existing, prioritized and full-build) and at comparing how well each bikeway project contributes to increasing connectivity. The model does not forecast actual demand.

The model includes two adjustments to the data:

- **Travel distance adjustments** on trails and breezeways.
- Travel flow adjustments based on trip distance using a **bicycle decay function.**

Travel Distance Adjustments on Trails and Breezeways

Two types of bikeways – trails and breezeways – are likely to be more attractive to bicyclists than other types of bikeways since they tend to allow faster travel (less delay due to crossings) and are much less stressful than other bikeways. As a proxy for these characteristics, travel distances on trails and breezeways were reduced to simulate the prioritized bicycling environment. The travel distances on bikeways classified as trails was reduced by 30 percent, since these bikeways feature few delays and are largely separated from traffic. The travel distance on bikeways classified as part of the Breezeway Network was reduced by 15 percent, since these routes will also prioritize bicycle travel, enabling faster speeds, though not as fast as trails, since trails typically have fewer road crossings. For example, if a bicycle trips is 3 miles long, including 1 mile on the Breezeway Network and 2 miles on a trail, the trip would be modeled as 2.25 miles. This includes 0.85 miles on the Breezeway Network (1 mile x 0.85) and 1.4 miles on the trail (2 miles x 0.70).

Bicycle Decay Function

As discussed previously, the likelihood that a trip will be made by bicycle decreases with distance. The following equation was fitted to the bicycle decay function mentioned previously and was used to convert travel flows into potential bicycling trips, where x is the distance between the centroids of two geographies.

$$y = 1.0747e-0.289x$$

Once the potential bicycling trips were determined for each pair of geographies, the trips were cumulatively assigned to the individual network segments comprising each route.

For example, each trip that is two miles in length would represent 0.60 potential bicycling trips and each trip that is five miles long would represent 0.25 potential bicycling trips. In other words, a two-mile long trip is 2.4 times as likely as a five-mile long trip.

Additionally, only trips that are 0.5 miles or greater could represent potential bicycling trips. Distances shorter than 0.5 miles were assumed to be walking trips.

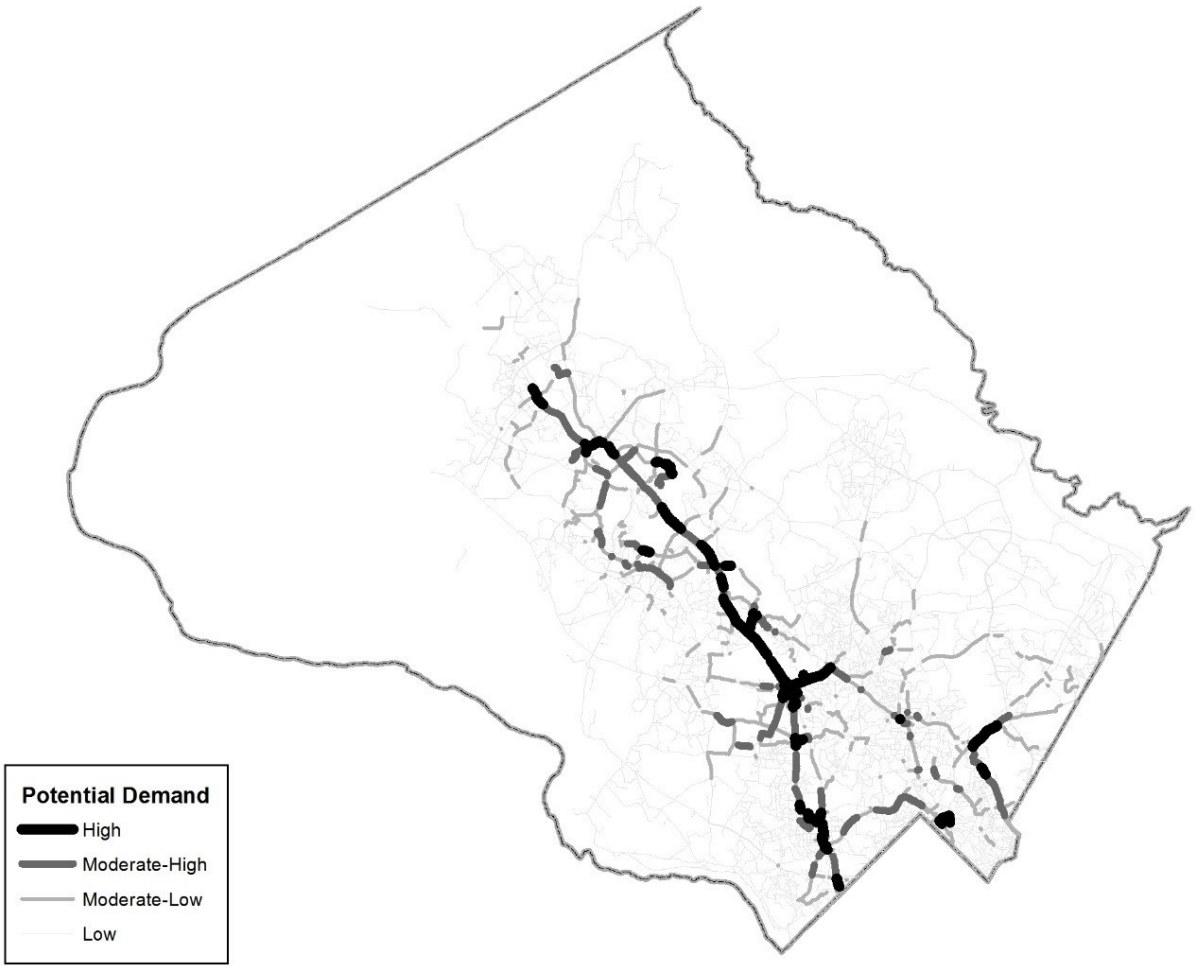
PRIORITIZATION OF BIKEWAYS

The network of bikeways recommended in the Bicycle Master Plan is extensive and is likely to be only partially completed during the 25-year life of this plan. The first step in the prioritization process is, therefore, to identify those bikeways that will be implemented within the life of the Bicycle Master Plan. To develop a list of prioritized bikeways, segments were grouped into potential projects. Those bikeways that are recommended to be implemented over the next 25 years include one or more of the following conditions:

1. Are in the top 25 percent of bikeways with the highest potential demand.
2. Located in one of the 31 locations in the county designated as Bicycle Pedestrian Priority Areas.
3. Fill in a gap within the existing bikeway network.
4. Are low in cost to construct, including most neighborhood greenways.

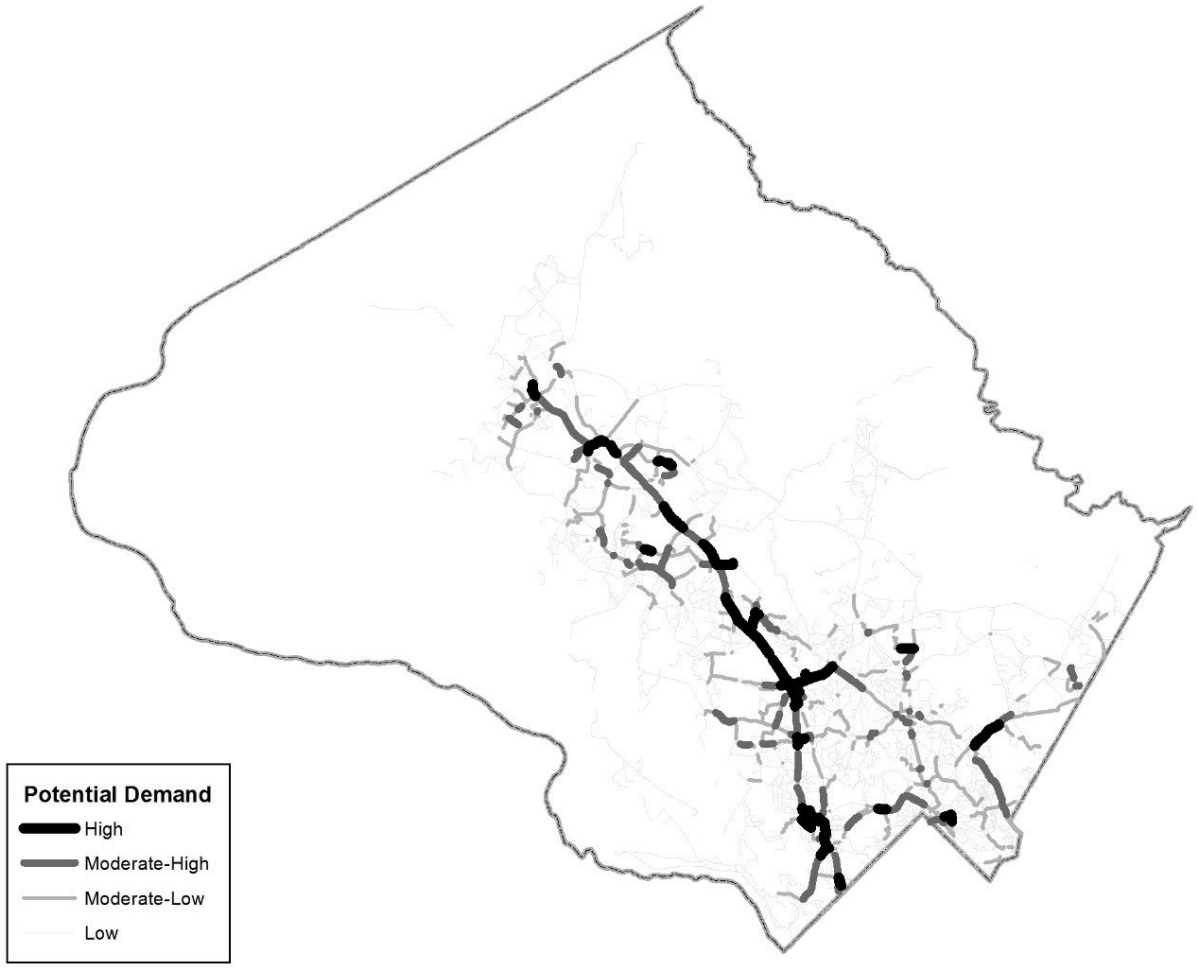
Potential Demand for the Full Build-Out Bicycling Network

The potential demand model was run to forecast future potential demand on the full build-out of the bicycling network. The figure below shows the results of the full build-out model and categorizes each road segment as having a high, moderate-high, moderate-low or low potential bicycling demand. The darker and thicker the line, the higher the potential bicycling demand. The bikeway recommendations that have the highest potential demand include segments of MD 355, Montrose Parkway, Woodmont Avenue, US 29 and several areas in downtown Silver Spring.



Potential Demand for the Prioritized Bicycling Network

The potential bikeway demand model was then analyzed with only those bikeways that are included in the list of projects to be implemented in the 25-year life of the Bicycle Master Plan. The figure below shows the results of the prioritized bikeway model and similarly categorizes each road segment as having a high, moderate-high, moderate-low or low potential bicycling demand.



Those bikeways recommended to be implemented within the 25-year life of the Bicycle Master Plan were categorized into four levels of priority: high, moderate-high, moderate-low and low.

Tier 1 includes:

- Bikeways located in seven Bicycle Pedestrian Priority Areas (Bethesda CBD, Friendship Heights CBD, Life Sciences Center, Silver Spring CBD, Wheaton CBD, White Flint and White Oak).
- Neighborhood greenways feeding into these BPPA areas (such as the Cornish Rd / Elm St neighborhood greenway).
- Bikeways with high demand that are included in the capital improvement program (such as the Montrose Parkway East project).
- Other county priorities (such as the Germantown – Grosvenor Breezeway, aka the PEPCO Trail).

Tier 2 includes:

- Bikeways located in the remaining Bicycle Pedestrian Priority Areas.

Tier 3 includes:

- Remaining neighborhood greenways.
- Highest demand bikeways located outside of the Bicycle Pedestrian Priority Areas.
- High demand recreational bicycling routes.

Tier 4 includes:

- All remaining bikeways that are recommended for completion within the 25-year life of the plan.
- Several heavily-used recreational bicycling routes.

The full build-out and prioritized bicycling networks were evaluated based on the connectivity metrics in the Bicycle Master Plan. The results are shown in the table below.

OBJECTIVE	METRIC		EXISTING	TARGET		FULL BUILD
			2018	2033	2043	
GOAL 2: CREATE A HIGHLY-CONNECTED, CONVENIENT AND LOW-STRESS BICYCLING NETWORK						
2.1	Percentage of potential bicycle trips that can be made on a low-stress bicycling network.		18%	TBD	TBD	TBD
2.2	Percentage of dwelling units within 2 miles of each Red Line, Brunswick Line, Purple Line and Corridor Cities Transitway station in Montgomery County that are connected to the transit station on a low-stress bicycling network.	Red Line	10%	37%	64%	80%
		Brunswick Line	12%	37%	62%	74%
		Purple Line	4%	37%	71%	77%
		Corridor Cities Transitway	0%	34%	69%	74%
2.3	Percentage of dwelling units within one mile of elementary schools, 1.5 miles of middle schools and 2 miles of high that are connected to the transit station on a very low-stress bicycling network.	Elementary Schools	26%	29%	32%	59%
		Middle Schools	11%	17%	22%	48%
		High Schools	6%	11%	16%	32%
2.4	Percentage of dwelling units within 2 miles of public libraries, recreation centers and regional / recreational parks that are connected to the transit station on a low-stress bicycling network.	Public Libraries	8%	34%	60%	84%
		Recreation Centers	13%	27%	40%	74%
		Recreational and Regional Parks	13%	27%	40%	74%
3.1	Percentage of potential bicycle trips that can be made on a low-stress bicycle network in areas where the median income is below 60 percent of the County average median income.		TBD	TBD	TBD	TBD

Appendix B. Drivers of Change Summary Tables

Economic Disruptions

Individual Drivers	Likelihood in 2050		Direction of Change		Respondents
	Unlikely	Likely	Decrease	Increase	
Global Trade	8%	92%	23%	77%	13
Competition within the Region	8%	92%	8%	92%	12
Competition outside the Region	0%	100%	13%	88%	9
Sharing Economy	20%	80%	10%	90%	10
Energy Prices	25%	75%	44%	56%	14
Federal/Regional/State Funding	10%	90%	75%	25%	9
Government Regulation	0%	100%	22%	78%	9
Automation	0%	100%	0%	100%	5
Interest rates	75%	25%	33%	67%	4
Bitcoin and Block Chain	60%	40%	40%	60%	5

Climate Change

Individual Drivers	Likelihood in 2050		Direction of Change		Respondents
	Unlikely	Likely	Decrease	Increase	
Rising Temperatures	7%	93%	7%	93%	14
Unsafe to be Outdoors	64%	36%	13%	88%	10
Flooding	0%	100%	0%	100%	12
Infrastructure Closures	18%	82%	9%	91%	11
Rail Heat Advisories	0%	100%	0%	100%	5
Variability in Water Availability	0%	100%	14%	86%	8
Environmental Degradation	8%	92%	23%	77%	13
Habitat for Wildlife	0%	100%	78%	22%	9

Demographic Changes

Individual Drivers	Likelihood in 2050		Direction of Change		Respondents
	Unlikely	Likely	Decrease	Increase	
International Migration	9%	91%	9%	91%	11
Income Inequality	8%	92%	8%	92%	13
Birth Rates	25%	75%	100%	0%	8
Average Age	0%	100%	25%	75%	9
Family Size	14%	86%	78%	22%	8
Education Level	11%	89%	22%	78%	9
Domestic Migration	0%	100%	8%	92%	12

Technological Innovations

Individual Drivers	Likelihood in 2050		Direction of Change		Respondents
	Unlikely	Likely	Decrease	Increase	
E-Commerce	0%	100%	0%	100%	9
Virtual Reality	0%	100%	0%	100%	11
3D printing	0%	100%	0%	100%	7
Internet of Things	11%	89%	11%	89%	9
Vehicle Electrification	0%	100%	0%	100%	12
Vehicle Automation	10%	90%	10%	90%	10
High Speed Rail	70%	30%	25%	75%	9
Artificial Intelligence	0%	100%	0%	100%	5
Automation of Work	25%	75%	0%	100%	7
Energy Generation & Distribution	0%	100%	0%	100%	9
5G Internet	0%	0%	0%	100%	1
Medical Break through	0%	100%	0%	100%	5

Changes in Lifestyle

Individual Drivers	Likelihood in 2050		Direction of Change		Respondents
	Unlikely	Likely	Decrease	Increase	
Preference for Urban Living	0%	100%	20%	80%	11
Flexible Work Hours	0%	100%	0%	100%	11
Retirement Age	22%	78%	0%	100%	9
Office Hoteling	0%	100%	17%	83%	7
Residential Hoteling	83%	17%	75%	25%	5
Preference for Outdoor Leisure	0%	100%	0%	100%	6
Preference for Air Travel	50%	50%	67%	33%	6
Level of Physical Activity	20%	80%	40%	60%	5
Pref. for Walking & Bicycling	25%	75%	0%	100%	7
Shifts in food preferences	25%	75%	0%	100%	7
Telework	29%	71%	10%	90%	12
Reduce/Reuse/Recycle	0%	100%	0%	100%	1
Prioritizing Health	33%	67%	0%	100%	2
Recreational Marijuana	0%	0%	0%	0%	0

Economic Disruptions

Individual Drivers	Likelihood in 2050				Direction & Magnitude of Change			
	Very Unlikely	Unlikely	Likely	Very Likely	Decrease from Today		Increase from Today	
					Large	Small	Large	Small
Global Trade		1	8	3		3	4	6
Competition within the Region		1	2	9	1		7	4
Competition outside the Region			3	6		1	5	2
Sharing Economy		2	6	2		1	3	6
Energy Prices		3	4	5	2	5	5	4
Federal/Regional/State Funding	1		7	2	3	3	1	1
Government Regulation			6	2		2	2	5
Automation			1	4			5	
Interest rates		3	1			1	1	1
Bitcoin and Block Chain		3	2		2			3

Climate Change

Individual Drivers	Likelihood in 2050				Direction & Magnitude of Change			
	Very Unlikely	Unlikely	Likely	Very Likely	Decrease from Today		Increase from Today	
					Large	Small	Small	Large
Rising Temperatures		1		13		1	3	10
Unsafe to be Outdoors	1	6	3	1		1	6	1
Flooding			5	7			4	7
Infrastructure Closures		2	5	4		1	5	5
Rail Heat Advisories			4				5	
Variability in Water Availability			7	2		1	3	3
Environmental Degradation		1	5	6		3	3	7
Habitat for Wildlife			4	5	4	3	2	

Demographic Changes

Individual Drivers	Likelihood in 2050				Direction & Magnitude of Change			
	Very Unlikely	Unlikely	Likely	Very Likely	Decrease from Today		Increase from Today	
					Large	Small	Small	Large
International Migration		1	3	7	1		6	4
Income Inequality		1	4	8		1	5	6
Birth Rates		2	5	1	2	6		
Average Age			9		1	1	5	1
Family Size		1	5	1	1	6	2	
Education Level		1	8			2	6	1
Domestic Migration			5	7		1	5	6

Technological Innovations

Individual Drivers	Likelihood in 2050				Direction & Magnitude of Change			
	Very Unlikely	Unlikely	Likely	Very Likely	Decrease from Today		Increase from Today	
					Large	Small	Small	Large
E-Commerce				10			3	5
Virtual Reality			6	5			6	5
3D printing			5	2			7	
Internet of Things		1	5	3		1	1	7
Vehicle Electrification			2	10			2	10
Vehicle Automation		1	4	5	1		2	7
High Speed Rail		7	3		1	1	5	1
Artificial Intelligence			1	4			2	3
Automation of Work		2	4	2			3	3
Energy Generation & Distribution			2	7			4	4
5 G Internet								1
Medical Break through			2	3			1	3

Changes in Lifestyle

Individual Drivers	Likelihood in 2050				Direction & Magnitude of Change			
	Very Unlikely	Unlikely	Likely	Very Likely	Decrease from Today		Increase from Today	
					Large	Small	Small	Large
Preference for Urban Living			6	5		2	4	4
Flexible Work Hours			3	8			3	7
Retirement Age		2		7			1	7
Office Hoteling			2	5		1	2	3
Residential Hoteling		5		1		3		1
Preference for Outdoor Leisure			2	4			3	3
Preference for Air Travel		3	3			4	2	
Level of Physical Activity		1	2	2		2	1	2
Pref. for Walking & Bicycling		2	2	4			3	3
Shifts in food preferences		2	2	4			1	4
Telework		4	4	6		1	1	8
Reduce/Reuse/Recycle				1				1
Prioritizing Health		1	1	1			1	
Recreational Marijuana								

Appendix C. Transportation Assumptions Summary Tables

Economic Disruptions

Individual Drivers	Changes in Travel Behavior	Changes to the Travelway	Changes to Parking	Changes to Pick Up / Drop Off	Changes to Auto Travel	Changes to Land Use
Automation of work	- less commuting - fewer work trips					- may need less industrial areas or employment
Increase in Global Trade	-increase in jobs will increase trips	-more freight capacity would be needed		-more loading space needed	-could mean increase in vehicle ownership	
Competition within the Region	-less trips to other jurisdictions -more trips from other jurisdiction -shorter trips -more non-auto trips		-more pressure to charge for parking -increased cost of parking			-need more residential capacity -greater intensity of commercial development in places
Competition Outside the Region	-fewer trips or				-could mean decrease in vehicle ownership	-continue trend of less commercial -underutilized commercial
Fed/State /Regional Funding	-would be fewer trips due to less federal/state/local employment	-would not increase capacity - road or transit				-reduction/closure of Fed facilities and -less commercial demand density
Energy Prices	- trips per capita would not increase - mode shift away from personal vehicle	-could see more efficient travel choices			-more shared rides -higher cost -less personal vehicle ownership	-more solar demand
Sharing Economy	-increase in trips - not peak hours -transit decrease		-reduces parking demand	-more need for pickup drop-off spaces	-less vehicle ownership	

Climate Change

Individual Drivers	Changes in Travel Behavior	Changes to the Travelway	Changes to Parking	Changes to Pick Up / Drop Off	Changes to Auto Travel	Changes to Land Use
Infrastructure Closures	-temporal changes	- emphasis on mobility redundancy -route choice -mode choice			-temporal	
Flooding		-new infrastructure spurred by regular disruptions - elevated transitway			-redefine auto capacity results in shift to next auto modes	-may not reinvest in areas that regularly flood -porous surface requirement
Variability in water availability		-storm water catchment				-limits development -increased … - expanded need for resources -expanded storm water catchment
Rising Temperatures/ Weather Variability	-less walk/bike -exposure to heat					

Demographic Change

Individual Drivers	Changes in Travel Behavior	Changes to the Travelway	Changes to Parking	Changes to Pick Up / Drop Off	Changes to Auto Travel	Changes to Land Use
Income Inequality	-trip generation: -trip distribution: longer trips because low income people live further from jobs -modes: high income leads to more cars, low income leads to more walk/bike /transit -time of day: more travel during off peak for low income	- adjust zone attributes (income quartiles) - changes to left < may be too outcome focused, aim to change inputs	- more surface for roads -more higher quality travel to serve low income people who travel greater distance -more point to point travel services (especially to north county) -more transit capacity	-more cost of parking because people driving are mostly higher income	-more demand for curb side pick up drop off	- less travel by low income
Declining Birth Rates	-less trip generation specially school trips - more transit/walk/bike because you don't have kids to drop off	- reduce home-based school trips (or HBO, NHB) - slight change to mode split (shared ride to drive alone)	-user cost per household decreases a little due to less travel -less traffic near school	- parking demand decreases a little	-less pick up drop-off for school	-less car per household -less user cost -smaller vehicle size -more speed due to fewer trip
Multi-Generational Homes	- more trip generation per household	- land use - shift HH size from smaller to larger - keep HH totals constant	-more user cost per household	- more parking per household	-no change	-more shared rides -less vehicle owned -both lead to shared
Aging Population	-less trips per person -less walk trips pp -more travel out of peak period -shorter trip distance	- shift trip purpose from HBW to HBO/NHB - adjust time of day factors - consider location-specific changes (based on Census)	-more demand for demand responsive services	-less parking demand -more ADA parking	-more pickup drop off	-less vehicle ownership -more shared rides

Technological Innovation

Individual Drivers	Changes in Travel Behavior	Changes to the Travelway	Changes to Parking	Changes to Pick Up / Drop Off	Changes to Auto Travel	Changes to Land Use
E-Commerce	-decrease in HBO/HBS and increase in deliveries -higher income	- reduction in HBO/HBS based on income - increase freight (NHB)		-less parking needed? -short term parking (flexible curb)	pricing the curb	autonomous trucking
Virtual Reality (work, education, social)	-decrease HBW and education more than other trip purposes -higher income (white collar) -most change in peak	- decrease HBW, HBSc, HBO (universities), NHB - apply to higher income quartiles - may not need to adjust time of day (doubling down)				
3D printing	-manufacturing close to home leads to shorter trucking trips -more US manufacturing short distance	- adjust freight table to have impedances to promote local trips				
Internet of Things	-link to Ecommerce -link to AVS		-increase capacity for connected vehicles -improve counts/demand -efficiency routing -signal priority	-more efficient parking		-more efficient - better maintenance - cost to user/ car dealer goes down - improve safety
Vehicle Electrification	- short trips of all types could be scooter/bike (less HBS)	- reduced cost per mile for auto	-dedicated travel way conductive driving - dedicated lanes for electric bus	- parking farms to charge cars		

Autonomous Vehicles	-relationship with VR -increase trip distance -decrease value of time	- previous AV model testing	-dedicated lanes	-lower parking demand -decrease parking cost	-more space required -increase demand -pricing the curb	-changes in ownership (depending on policy) - cost per ride decrease and less to maintain -improve safety for walk/bike/auto
Artificial Intelligence	-robots replace us -predictive travel	- model already optimizes				more efficient vehicle behavior

Changes in Lifestyle

Individual Drivers	Changes in Travel Behavior	Changes to the Travelway	Changes to Parking	Changes to Pick Up / Drop Off	Changes to Auto Travel	Changes to Land Use
Preference for Urban Living	-Shorter trips -more walk/bike -more shared rides -more trips	- land use shift (based on other designation for Activity Center/Urban Core)	-reallocation of road to transit lanes and protected bikeways -Bus stop Design	-less off-street parking -parking disturb (parking lot zones) -on street parking	-increase demand -designated space	-reduce auto travel -reduce VMT
Flexible Work Hours	-reduce peak travel demand -peak spreading	- "peak hour spreading", time of day factoring				-reduce peal travel demand -peal spreading
Retirement Age		- slight increase in HBW				
Preference for Walking and Biking		- change in mode split model	- reallocation of road to ped/bike uses	-reduce parking demand		-reduce auto travel - reduce VMT

Attachment B

FEHR PEERS DC

1003 K Street NW, Suite 209
Washington, DC 20001
202.854.2750

MEMORANDUM

Date: March 16, 2020 (Revised April 7, 2020)

To: Eric Graye – Montgomery County Planning Department

From: Alex Rixey, Kwasi Donkor, and Sogand Karbalaieali – Fehr & Peers DC

Subject: Montgomery County General Plan Update – Alternative Futures Transportation Analysis Methodology

DC19-0049.02

ALTERNATIVE FUTURES MODELING

Fehr & Peers DC will evaluate six scenarios, including existing conditions, business as usual (BAU), and four alternative futures for the Montgomery County General Plan Update. The Thrive Montgomery 2050 – Transportation Analysis Approach White Paper (October 28, 2019) presents descriptions of the four alternative futures. This memo describes how these alternative futures will be interpreted and translated into Montgomery County's regional travel forecasting model (Travel/4) for analysis in three categories: trip generation, trip distribution, and land use.

The White Paper presented two axes of "technology" and "economy" to define the four alternative futures as shown in **Figure 1**. These axes are reflected in model input adjustments through the **trip generation** and **trip distribution** steps, described in further detail below. On the technology axis, "technology enables travel" results in increased trip generation, while "technology replaces travel" results in decreased trip generation; similarly, on the economy axis "outside business attraction" results in a more regional trip distribution propensity (likely resulting in longer trips), while "organic growth" results in a more local trip distribution propensity.

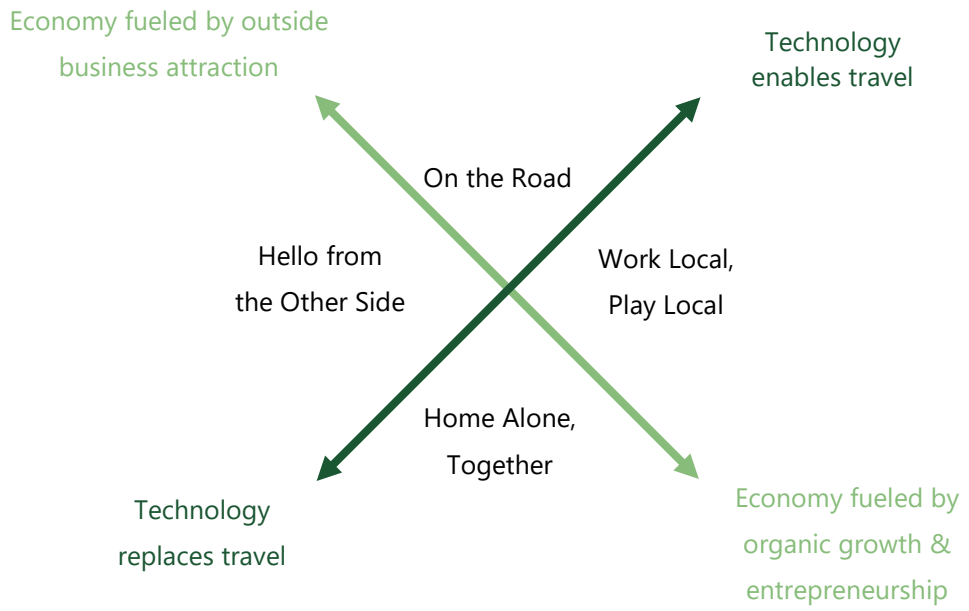


Figure 1 - Technology and Economy Axes

In this memo, we introduce two land use-related axes of "employment concentration" and "living preferences" to define corresponding land use distributions for each alternative future; these axes are intended to complement and be consistent with the narrative presented in the White Paper, but provide clearer definition of the corresponding **land use** adjustments (**Figure 2**). On the employment concentration axis, "more concentrated employment" reflects a relatively larger effect of automation, resulting in shifts in employment growth from retail and industrial employment into office and other employment, which itself is more densely concentrated, while "less concentrated employment" shifts less job growth into more concentrated categories; both alternative futures have more concentrated employment growth than the business as usual scenario. On the living preference axis, "preference for more urban living" results in relocating household growth from less dense areas into more dense areas, while "preference for less urban living" shifts household growth from more dense areas into less dense areas. In all four alternative futures, the effects of climate change are expected to result in flooding that over the long term will relocate land uses from flooded areas to unflooded areas.

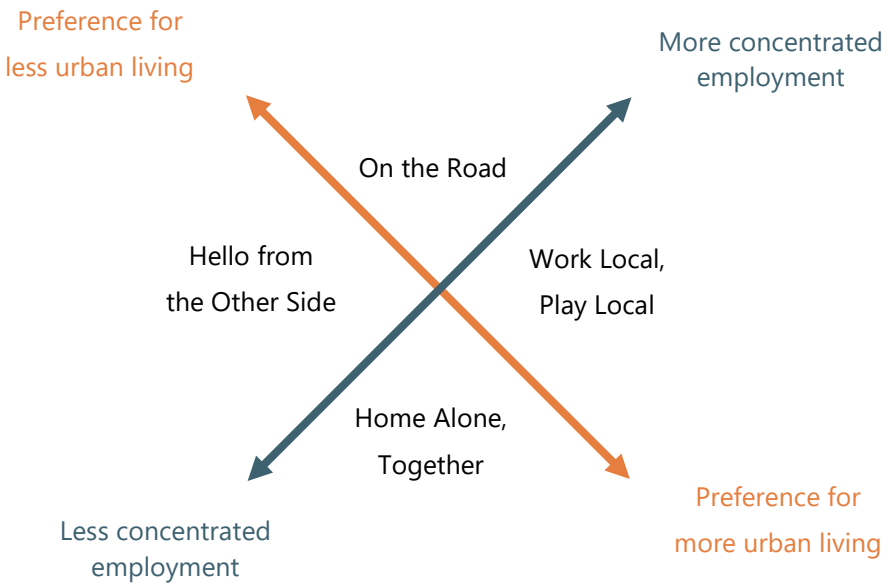


Figure 2 - Employment and Living Preference Axes

Combinations of the technology and economy axes, complemented by corresponding combinations of the employment concentration and living preference axes, lead to four alternative futures, as shown in **Table 1**.

In the On the Road scenario, Montgomery County residents live in less dense areas and commute long distances to work.

In the Work Local, Play Local scenario, Montgomery County residents live in more dense areas and work for local businesses.

In the Home Alone, Together scenario, Montgomery County residents live in more dense locations and can telework at increased rates, while shopping, enjoying entertainment, and eating locally.

In the Hello from the Other Side scenario, Montgomery County residents live in less dense areas, work at home, and prefer food delivery, online shopping, and home entertainment.

Table 1 summarizes the conceptual differences among the alternative futures and presents proposed adjustments to the trip generation, trip distribution, and land use components of the Travel/4 model.

Table 1 Alternative futures analysis approach

Alternative Futures		On the Road	Work Local, Play Local	Home Alone, Together	Hello from the Other Side
Technology Condition		Tech enables travel	Tech enables travel	Tech replaces travel	Tech replaces travel
Economy Condition		Outside business attraction	Organic growth	Organic growth	Outside business attraction
Employment Condition		More concentrated	More concentrated	Less concentrated	Less concentrated
Living Preference Condition		Less urban	More urban	More urban	Less urban
Analysis Approach					
Trip Generation		+25%	+25%	-25%	-25%
Trip Distribution*		-50%	+50%	+50%	-50%
Land Use	Employment Concentration**	+40%	+40%	+20%	+20%
	Flooding	Remove/ reallocate	Remove/ reallocate	Remove/ reallocate	Remove/ reallocate
	Preference for Urban Living***	-50%	+50%	+50%	-50%

**percentage to increase (+) or decrease (-) relative attractiveness of shorter-duration trips.*

***percentage of retail and industry jobs to remove and reallocate to office and other jobs in concentrated locations, reflecting automation of work*

****percentage of household growth to reallocate from less dense areas to more dense areas (+) or more dense areas to less dense areas (-) relative to Business as Usual (BAU)*

Fehr & Peers DC will use the Travel/4 model to investigate the impact of the alternative futures on transportation outcomes and compare them to the business-as-usual and existing conditions scenarios. The remainder of this memo describes the details of three types of adjustments in the Travel/4 modeling process: land use, trip generation, and trip distribution.

LAND USE ADJUSTMENTS

The intent of the land use adjustments is to apply a simplified analysis approach that combines the effects of multiple individual drivers, identified in the White Paper, into high-level effects on employment concentration and urban living preferences. The land use adjustments maintain the same countywide population and job totals, shifting population, households, and jobs within the county.

Employment Concentration

The Automation of Work driver is interpreted as reducing the amount of retail and industrial employment and compensating with a corresponding increase in the number of office and "other" jobs such that the county employment total across all categories remains unchanged. The land use adjustment process has two steps. The first step reduces the growth in retail and industrial jobs depending on the scenario: 40% for the On the Road and Work Local, Play Local scenarios, and 20% for the Home Alone, Together, and Hello from the Other Side scenarios. Then, the removed job growth is reallocated proportionally to office and other employment. If the transportation analysis zone (TAZ) from which retail and industrial job growth was removed has more than 1,000 office jobs, 20% of the removed jobs are converted to office and other employment within the same TAZ; the remaining removed jobs are converted to office and other jobs and are allocated proportionally to office and other jobs in other TAZs with more than 1,000 office jobs. For TAZs with fewer than 1,000 office jobs, the converted office and other jobs are reallocated proportionally to TAZs with more than 1,000 jobs throughout the county.

Preference for Urban Living

The land use adjustment process reflects varying degrees of Montgomery County residents' desires to live in more or less dense urban areas as a result of a combination of technological, demographic, and preference trends based on area types. In the Metropolitan Washington Council of Governments (MWCOG) regional travel demand model, area type codes range from 1 to 6 based on population and employment density (Figure 3); the Travel/4 model uses these same area types. Area types 1 and 2 have high employment density and/or high population density, while area types 5 and 6 have less dense population and/or employment levels. Area types 3 and 4 have moderate levels of employment and/or population density.

In Work Local, Play Local and Home Alone, Together scenarios, people are inclined to live in denser areas. The land use adjustment process for urban living preference reallocates household growth from only TAZs with a median income at or above the regional median income, reflecting the idea that those residents will have the most flexibility in their choice of residential location. 50% of the growth in households from 2015 to 2050 from area types 3 through 6 meeting the income criterion is removed and reallocated to area types 1 and 2, proportional to their numbers of households. In the On the Road and Hello From the Other Side scenarios, people prefer living in less urban areas. In this case, 50% of the growth from area types 1 and 2 meeting the income criterion is removed and reallocated to area types 3 through 6, proportionally.

One-Mile "Floating" Population Density (Pop/Sq mi)	One- mile "Floating" Employment Density (Emp/Sq mi)						
	0-100	101-350	351-1,500	1,501-3,550	3,551-13,750	13,751-15,000	15,001+
0-750	6	6	5	3	3	3	2
751-1,500	6	5	5	3	3	3	2
1,501-3,500	6	5	5	3	3	2	2
3,501-6,000	6	4	4	3	2	2	1
6,001-10,000	4	4	4	2	2	2	1
10,000-15,000	4	4	4	2	2	2	1
15,001+	2	2	2	2	2	1	1

Source: User's Guide for the COG/TPB Travel Forecasting Model, version 2.3.66; Table 28.

Figure 3 Area type codes based on population and employment density

Flooding

To reflect the possibility that residents and employees will leave areas vulnerable to flooding, households, population, and jobs are removed from the areas within the 500-year floodplain. Then, the flooded households, population, and jobs relocate to TAZs throughout the County proportional to the TAZs' unflooded households, population, and employment. This step applies to all scenarios in the same way.

TRIP GENERATION ADJUSTMENT

New technologies can encourage or discourage travel. The convenience of AVs may encourage people to take more trips while virtual reality and telework technologies may reduce the number of people commuting to work. A panel of 27 experts convened by Fehr & Peers in 2018 estimated that autonomous vehicles would increase non-work trip generation rates by a median value of 25%, with a range of increase between 10% and 80%. To reflect a range of possible outcomes, the person trip generation will be adjusted across all trip purposes, though not to the maximum extent estimated by the panel. The person trip table values will increase in the On the Road and Work Local, Play Local scenarios by 25% and decrease in the Home Alone, Together and Hello from the Other Side scenarios by 25%.

TRIP DISTRIBUTION ADJUSTMENT

Technology advancements may affect people's relative propensities for taking short or long trips. To model these potential outcomes, we will perform a trip distribution adjustment to change the relative attractiveness of short or long length trips in the friction factor input table.

Friction factors represent the effect travel time has on the number of trips between zones in the gravity model of the Travel/4 model. The friction factor table is an input to the trip distribution step. The values in the friction factor table are referenced in the gravity model for each trip purpose and four income categories. Since the values are relative, increasing the value of short trips will proportionally decrease the relative value for long trips and vice-versa.

The trip distribution adjustment process will have two steps. First, identify the current share of short trips in the BAU scenario; for each combination of trip purpose and income level, identify the travel time that represents the 25th percentile of trips by trip duration. Second, adjust the friction factors for the shortest 25th percentile of travel time bins. The adjustment process increases or decreases

the value of the friction factor for each bin by 50% of the difference between each bin's friction factor value and the friction factor value of the first bin above the 25th percentile travel time. The first friction factor value after the 25th percentile bin can vary by trip purpose and income level.

In the Work Local, Play Local and Home Alone, Together scenarios, the shortest 25th percentile of friction factor values increases, resulting in a relative decrease in the values for longer-duration trips. In the On the Road and Hello from the Other Side scenarios, the shortest 25th percentile of friction factor values decreases, resulting in a relative increase in the values for longer-duration trips. This adjustment comes before mode choice allowing for the propensity for shorter or longer trips to be reflected in a possible shift in mode. A graphical example of a hypothetical friction factor curve adjustment is depicted in **Figure 4**.

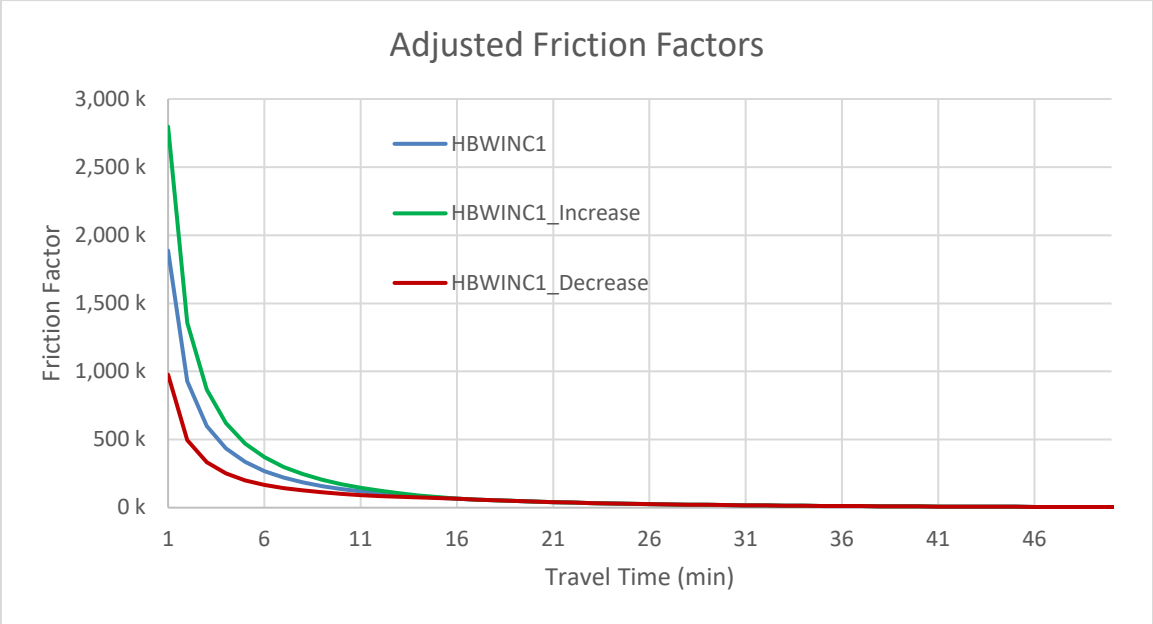


Figure 4 – Example Friction Factor Curve Adjustments

Attachment C

FEHR PEERS DC

1003 K Street NW, Suite 209
Washington, DC 20001
202.854.2750

MEMORANDUM

Date: June 9, 2020 *(Revised August 6, 2020)*

To: Eric Graye – Montgomery County Planning Department

From: Alex Rixey, Kwasi Donkor, Sogand Karbalaieali, and Zahra Khan – Fehr & Peers DC

Subject: Montgomery County General Plan Update – Evaluation Measure Methodology and Results

DC19-0049.02

After modifying and executing the Travel/4 Model as described in the "Montgomery County General Plan Update – Alternative Futures Transportation Analysis Methodology" memo (April 7, 2020) for Year 2015, Year 2050 Business As Usual, and the four Alternative Futures, nine transportation evaluation measures were calculated for each scenario. Evaluation measure results were then stratified by Equity Emphasis Areas (EEAs) and non-EEAs to identify disparate outcomes and explore whether the Alternative Futures reduce or expand disparities; EEAs identify locations with significant concentrations of low-income or minority population groups. This memo presents the methodology used to calculate each measure as well as each measure's results.

The On The Road and Work Local Play Local scenarios both include large increases in total travel, resulting in increased Vehicle Miles Traveled (VMT) and decreased auto access to regional jobs relative to Business As Usual, with the opposite pattern for Home Alone Together and Hello From The Other Side.

Across all scenarios, EEAs have higher Non-Auto Driver Mode Share and lower per-capita VMT than non-EEAs. Travelers to or from EEAs spend more time traveling by transit and less time traveling by auto than travelers to or from non-EEAs.

All Alternative Futures concentrate job growth in denser employment centers, many of which are proximate to transit, resulting in increased auto and transit accessibility to Montgomery County jobs in all Alternative Futures; access from Montgomery County to regional jobs by transit improves

in the Work Local Play Local and Home Alone Together scenarios in which residential land use is concentrated, but declines in the On The Road and Hello From The Other Side scenarios in which residential land use is dispersed relative to Business As Usual. Across all scenarios, EEAs, which are generally located in proximity to transit, have access to markedly more regional and Montgomery County jobs by transit on average than non-EEAs.

Finally, although the number of auto trips and total auto travel time increases in Work Local Play Local, auto travel time for each trip is reduced, reflecting a concentration of residential land use and a preference for shorter-distance, local trips. Conversely, Hello From The Other Side, despite fewer auto trips and less overall auto travel time than Business As Usual, has longer per-trip auto travel times, reflecting a dispersal of residential land use and a willingness to make longer trips.

TRANSPORTATION EVALUATION MEASURE METHODOLOGY

The following transportation evaluation measures were calculated for each scenario:

- Mode Split
    - Non-Auto Driver Mode Share
- Vehicle Miles Traveled
    - Vehicles Miles Traveled for Trips Beginning or Ending in Montgomery County
    - Vehicle Miles Traveled on Roads in Montgomery County
- Travel Times (Total, per-trip, and per-capita)
    - Auto Travel Time
    - Transit Travel Time
- Job Access
    - Regional Job Access
        - Regional Job Access by Auto
        - Regional Job Access by Transit
    - County Job Access
        - County Job Access by Auto
        - County Job Access by Transit

Results for each performance measure were then stratified by EEAs and non-EEAs. The remainder of this section describes the methodology for calculating each measure using a combination of Cube Catalog scripts and Excel spreadsheet analysis to post-process Travel/4 model results.

MODE SPLIT

Mode Split represents the share of person trips (trips completed by individual travelers) made by individual modes of travel. The following passenger modes are summarized from Travel/4 model outputs:

- Single Occupancy Vehicle (SOV)
- High Occupancy Vehicle with Two Occupants (HOV2)
- High Occupancy Vehicle with Three or More Occupants (HOV3+)
- Transit
- Nonmotorized[1]

Every trip has two trip ends representing its origin and destination. To calculate the mode split of trips to and from individual Transportation Analysis Zones (TAZs), only the trip end (or, in the case of intrazonal trips, both trip ends) located within the TAZ is/are included. The total number of person trip ends in the TAZ by each mode is divided by the total number of person trip ends in the TAZ by all modes to calculate Mode Split. To report individual person trips by mode, the trip end values are divided by two.

Non-Auto Driver Mode Share (NADMS)

Non-Auto Driver Mode Share is a summarization of mode split categories that reflects the share of person trips for which the individual traveler was not the driver of an automobile. The calculation includes nonmotorized (walk and bicycle) trips, transit trips, and trips by auto passengers in high-

[1] The Travel/4 model, like the MWCOG model, computes the share of nonmotorized trips as part of trip generation. Coefficients vary by trip purpose, Area Type, and productions vs. attractions, with the general form of the model being a linear combination of a constant term, one-mile floating population density, one-mile floating employment density, and half-mile floating block density. The model does not distribute or assign nonmotorized trips; however, nonmotorized trips are scaled along with motorized trips to ensure total productions and attractions are balanced. See https://www.mwcog.org/assets/1/6/mwcog_tpb_travel_model_v2.3.78_user_guide_v5_full.pdf p. 156. Because the Travel/4 model does not distribute nonmotorized trips, they cannot be said to have "origins" and "destinations." Instead, for purposes of the mode split calculation nonmotorized "origins" refers to adjusted nonmotorized productions and nonmotorized "destinations" refers to nonmotorized attractions.

occupancy vehicles (HOV); single-occupancy vehicle (SOV) trips are excluded. To account for HOV trips, HOV2 trips count as one auto driver trip and one non-auto driver trip; HOV3+ trips count as one auto driver trip and 2.5 non-auto driver trips, based on an assumed vehicle occupancy of 3.5 for HOV3+trips. Expressed another way, NADMS includes 50% of HOV2 trips and 71.43% of HOV3+ trips.

Because of the model's crude approach to calculating nonmotorized trips, it cannot provide precise nonmotorized trip values at the fine geographic scale of the TAZ; however, it can provide helpful information on the relative level of non-auto travel in the Alternative Futures.

VEHICLE MILES TRAVELED (VMT)

Vehicle Miles Traveled represents the total daily miles traveled by automobiles. Two VMT calculation approaches are applied: Vehicle Miles Traveled for Trips Beginning or Ending in Montgomery County, which attributes the miles traveled by automobiles to the land uses at the origins and destinations of their trips, and Vehicle Miles Traveled on Roads in Montgomery County, which tallies the total daily miles traveled by automobiles on roads in Montgomery County regardless of their origins or destinations.

Vehicle Miles Traveled for Trips Beginning or Ending in Montgomery County

Vehicle Miles Traveled per Service Population attributes the miles traveled by automobiles to the land uses at the origins and destinations of their trips and seeks to express the total amount of automobile travel relative to the number of people (residents and workers) who are served by that travel. This approach to VMT is useful for understanding the behavior of Montgomery County residents and workers, particularly the extent to which those people are traveling by automobile. Using Service Population, rather than population alone, as the denominator helps to avoid counterintuitive results in areas with more jobs than residents (or perhaps no residents at all, but a substantial number of jobs).

Service Population is defined as the sum of population and jobs for a given geography, e.g., a TAZ or a County. VMT per Service Population is calculated as the total VMT attributed to a geography divided by that geography's total population and jobs.

In this version of the VMT measure, the total number of miles traveled by automobile is calculated by multiplying the distance skim between each origin-destination TAZ pair by the number of auto

trips between each origin-destination TAZ pair; for trips internal to a single TAZ ("intrazonal trips"), the distance traveled is approximated by half the travel distance skim value to the nearest (by distance) adjacent TAZ. Every trip has two trip ends representing its origin and destination. To attribute the VMT of a trip that travels between two TAZs (as most do) to the TAZ level, half of the trip's mileage is attributed to the trip's origin TAZ and half of the trip's mileage is attributed to the trip's destination TAZ; for intrazonal trips, the entire trip distance is attributed to the trip's TAZ.

Vehicles Miles Traveled on Roads in Montgomery County

Vehicle Miles Traveled on Roads in Montgomery County reflects the total daily miles traveled by automobiles on roads inside Montgomery County, regardless of their origins or destinations; this approach to VMT is useful for understanding activity on roads in Montgomery County, which can be a proxy for global and local environmental impacts, like greenhouse gas emissions or particulate matter, or for exposure to vehicle-related safety risks.

In this version, VMT is calculated by multiplying the number of daily auto trips on each roadway link by the link's length. The VMT values for all roads within Montgomery County are then summed to a total county VMT value.

TRAVEL TIMES

Total Daily Travel Time

Auto Travel Time and Transit Travel Time reflect the total amount of time spent traveling by auto and transit, respectively. All modeled trips by all purposes are included in the calculation. For Auto Travel Times, the total amount of auto travel time (vehicle hours traveled or "VHT") is calculated by multiplying the travel time skim by occupancy (SOV, HOV2, or HOV3+) and time period (AM, midday, PM, and night)[2] between each origin-destination TAZ pair by the number of auto trips by occupancy (SOV, HOV2, or HOV3+) and period (AM, midday, PM, and night) between each origin-destination TAZ pair; for trips internal to a single TAZ ("intrazonal trips"), the travel time is approximated by half the travel time skim value to the nearest (by travel time) adjacent TAZ. The VHT total is then divided by the total number of vehicle trips to calculate an average Auto Travel Time per auto trip.

[2] Transposed AM peak period travel time skim is used for the PM peak period. The off-peak skim is used for midday and night periods.

A similar calculation is performed for Transit Travel Time, using the full transit travel time skim (including wait, transfer, and access times as described below) and the number of transit trips between each origin-destination TAZ pair for each combination of transit mode and access mode. The following combinations of transit mode and access mode are considered:

- Walk Access Commuter Rail
- Drive Access (Park & Ride) Commuter Rail
- Walk Access Bus
- Drive Access (Park & Ride) Bus
- Kiss & Ride Bus
- Walk Access Metro Rail
- Drive Access (Park & Ride) Metro Rail
- Kiss & Ride Metro Rail
- Walk Access Bus plus Metro Rail
- Drive Access (Park & Ride) Bus plus Metro Rail
- Kiss & Ride Bus plus Metro Rail

Travel time for each mode includes, where applicable:

- In-vehicle travel time
- Initial wait time
- Transfer wait time
- Walk access time or drive access time
- Other walk time
- Added transfer time

Average Per-Trip Travel Time

The total travel times by mode described above are normalized by the number of trips by each mode to produce an average travel time per trip.

Per-Capita Travel Time

Total travel times by mode are divided by total population, total employment, and total service population (population plus employment) to illustrate how much time on average a person spends traveling by each mode.

JOB ACCESS

Job Access reflects the number of jobs that can be reached from a given location within Montgomery County in a given amount of travel time. Both Regional Job Access and County Job Access are calculated separately for travel by auto and travel by transit.

Regional Job Access

Regional Job Access is calculated at the TAZ level and reflects the number of jobs that can be reached from each TAZ within a 45-minute travel time by either driving or transit, regardless of the jurisdiction in which the jobs are located; jobs both within and outside of Montgomery County are included in the calculation as long as they are accessible within 45 minutes (e.g., jobs in Frederick County, Prince George's County, the District of Columbia, etc. could be included).

The Travel/4 model provides travel time "skim" matrices that indicate the amount of time it takes to travel from each modeled TAZ to every other TAZ in the modeled region, with a separate matrix for each mode of travel. The Regional Job Access calculation references these skim matrices for the AM peak period for each origin TAZ to identify all of the TAZs that can be reached from that origin TAZ within a 45-minute travel time. For the auto mode, the single-occupant vehicle travel time skim is used to reflect congested commute travel times. For transit, multiple transit modes are considered:

- Metrorail Only
- Bus Only
- Metrorail and Bus

Travel time for each mode includes, where applicable:

- In-vehicle travel time
- Initial wait time
- Transfer wait time
- Walk access time or drive access time
- Other walk time
- Added transfer time

For transit, a TAZ is considered accessible within 45 minutes if it is accessible by Metrorail Only, Bus Only, or Metrorail and Bus (including corresponding walk or drive access time, wait time, and transfer time).

Once the TAZs accessible from the origin TAZ are identified, the total employment in all accessible TAZs is summed. That sum is the number of jobs accessible within 45 minutes. Thus, a jobs accessibility value is calculated by auto and transit for each TAZ in Montgomery County.

To aggregate the number of jobs accessible to the average resident of Montgomery County, the jobs accessibility value for each TAZ is weighted by the population of each TAZ, thereby placing more weight on TAZs with more residents.

County Job Access

County Job Access is similar to Regional Job Access but restricts accessible jobs to only those jobs located within Montgomery County; the calculation process is the same as described above, but once accessible TAZs are identified for each origin TAZ, the jobs from any accessible TAZs outside Montgomery County are excluded from the sum of accessible jobs. Thus, County Job Access reflects the number of jobs in Montgomery County accessible to a resident of Montgomery County.

EQUITY EMPHASIS AREAS

Equity Emphasis Areas (EEAs), developed by the Metropolitan Washington Council of Governments (MWCOG)[3] identify Census tracts with significant concentrations of low-income (less than one-and-a-half times the federal government's official poverty threshold) or minority population groups (African American, Asian, and Hispanic or Latino). Specifically, a Census tract is considered an EEA if it has:

1. a concentration of individuals identified as low-income that is more than one-and-a-half times the regional average or
2. high concentrations of two or more minority population groups and/or

[3] Equity Emphasis Area overview: https://www.mwcog.org/transportation/planning-areas/fairness-and-accessibility/environmental-justice/equity-emphasis-areas/

3. high concentrations of one or more minority population groups combined with low income concentration at or above the regional average.[4]

Because Census tracts do not precisely align with the Travel/4 model's TAZ boundaries, results for each of the metrics described above were spatially allocated to EEAs or non-EEAs by the proportion of their area overlapping with an EEA or non-EEA geography. Values were then allocated throughout Montgomery County to total EEA and non-EEA values. Figures presenting spatial performance measure results also depict EEA boundaries. Equity Emphasis Areas are defined using 2017 data and are not redefined in future years due to a lack of precise future year income and race demographic data; the Year 2050 EEA geographies remain the same as the EEA geographies used to analyze Year 2015, and can be interpreted in the Year 2050 scenarios as historical EEAs (i.e., locations that were EEAs as of Year 2015).

TRANSPORTATION EVALUATION RESULTS

Tables 1 through 5 summarize the transportation evaluation results for Year 2015, Year 2050 (Business As Usual), and the four Alternative Futures (On The Road, Work Local Play Local, Home Alone Together, and Hello From The Other Side) as follows:

- Table 1 – Mode Split
- Table 2 – Vehicle Miles Traveled
- Table 3 – Travel Time
- Table 4 – Per-Capita Travel Time
- Table 5 – Job Access

As shown on the bottom panel of Table 2, Between Year 2015 and Year 2050 Business As Usual, the population of Montgomery County increases 21% from approximately 1,020,000 residents to nearly 1,240,000 residents while employment in the county increases 36% from approximately 520,000 to 710,000 jobs. Service Population—the sum of population and employment—increases 27% from approximately 1,540,000 to 1,950,000.[5] EEAs comprise approximately one quarter of Montgomery County's population and employment and grow at a slightly faster rate (44%) than the Montgomery County average (36%) between Year 2015 and Year 2050 Business As Usual. The same Year 2050

[4] Additional details of the methodology are available at https://www.mwcog.org/assets/1/6/methodology.pdf
[5] Totals vary due to rounding.

population and employment totals are analyzed in all four Alternative Futures, but because of the reallocation of land use in different Alterative Futures, Work Local Play Local and Home Alone Together have slightly more growth in EEAs and On The Road and Hello From The Other Side have slightly less.

Table 1 – Alternative Futures Analysis
Mode Split
Montgomery County (Overall, EEA[1], non-EEA[1])

	Metric Values						*% Delta vs. Business As Usual*			
	2015	2050 Business As Usual (BAU)	On The Road	Work Local Play Local	Home Alone Together	Hello From The Other Side	On The Road	Work Local Play Local	Home Alone Together	Hello From The Other Side
Person Trips by Mode (Overall)	*Absolute Number of Person Trips*						*(Alternative divided by 2050 BAU)*			
SOV	1,334,500	1,493,740	1,817,792	1,807,409	1,143,789	1,147,138	21.7%	21.0%	-23.4%	-23.2%
HOV2	734,338	851,831	1,054,493	1,027,615	652,455	662,274	23.8%	20.6%	-23.4%	-22.3%
HOV3+	624,281	802,549	1,002,952	965,216	612,977	627,530	25.0%	20.3%	-23.6%	-21.8%
Transit	174,282	261,087	344,776	322,456	191,188	200,636	32.1%	23.5%	-26.8%	-23.2%
Nonmotorized	321,650	514,179	777,510	833,166	294,456	273,135	51.2%	62.0%	-42.7%	-46.9%
Total	***3,189,051***	***3,923,387***	***4,997,523***	***4,955,861***	***2,894,864***	***2,910,713***	27.4%	26.3%	-26.2%	-25.8%
Person Trips by Mode (EEA)										
SOV	302,038	351,216	417,096	424,017	275,219	269,961	18.8%	20.7%	-21.6%	-23.1%
HOV2	175,931	211,674	253,251	253,269	165,554	163,650	19.6%	19.7%	-21.8%	-22.7%
HOV3+	158,801	207,581	249,018	245,659	159,959	159,741	20.0%	18.3%	-22.9%	-23.0%
Transit	50,314	75,217	96,895	92,196	55,427	57,348	28.8%	22.6%	-26.3%	-23.8%
Nonmotorized	94,509	162,178	237,989	258,341	91,844	84,342	46.7%	59.3%	-43.4%	-48.0%
Total	***781,593***	***1,007,866***	***1,254,249***	***1,273,482***	***748,004***	***735,043***	24.4%	26.4%	-25.8%	-27.1%
Person Trips by Mode (non-EEA)										
SOV	*1,032,462*	*1,142,524*	*1,400,696*	*1,383,392*	*868,570*	*877,177*	22.6%	21.1%	-24.0%	-23.2%
HOV2	*558,407*	*640,157*	*801,242*	*774,346*	*486,900*	*498,624*	25.2%	21.0%	-23.9%	-22.1%
HOV3+	*465,480*	*594,968*	*753,934*	*719,557*	*453,017*	*467,788*	26.7%	20.9%	-23.9%	-21.4%
Transit	*123,968*	*185,870*	*247,881*	*230,260*	*135,761*	*143,288*	33.4%	23.9%	-27.0%	-22.9%
Nonmotorized	*227,141*	*352,001*	*539,521*	*574,824*	*202,612*	*188,793*	53.3%	63.3%	-42.4%	-46.4%
Total	***2,407,459***	***2,915,520***	***3,743,274***	***3,682,379***	***2,146,860***	***2,175,670***	28.4%	26.3%	-26.4%	-25.4%
Mode Split (Overall)	*Percentage of Total Person Trips*						*(Alternative minus 2050 BAU)*			
SOV	41.8%	38.1%	36.4%	36.5%	39.5%	39.4%	-1.7%	-1.6%	1.4%	1.3%
HOV2	23.0%	21.7%	21.1%	20.7%	22.5%	22.8%	-0.6%	-1.0%	0.8%	1.0%
HOV3+	19.6%	20.5%	20.1%	19.5%	21.2%	21.6%	-0.4%	-1.0%	0.7%	1.1%
Transit	5.5%	6.7%	6.9%	6.5%	6.6%	6.9%	0.2%	-0.1%	-0.1%	0.2%
Nonmotorized	10.1%	13.1%	15.6%	16.8%	10.2%	9.4%	2.5%	3.7%	-2.9%	-3.7%
NADMS[2]	**41.0%**	**45.2%**	**47.3%**	**47.6%**	**43.2%**	**43.1%**	2.1%	2.4%	-2.1%	-2.2%
Mode Split (EEA)										
SOV	38.6%	34.8%	33.3%	33.3%	36.8%	36.7%	-1.6%	-1.6%	1.9%	1.9%
HOV2	22.5%	21.0%	20.2%	19.9%	22.1%	22.3%	-0.8%	-1.1%	1.1%	1.3%
HOV3+	20.3%	20.6%	19.9%	19.3%	21.4%	21.7%	-0.7%	-1.3%	0.8%	1.1%
Transit	6.4%	7.5%	7.7%	7.2%	7.4%	7.8%	0.3%	-0.2%	-0.1%	0.3%
Nonmotorized	12.1%	16.1%	19.0%	20.3%	12.3%	11.5%	2.9%	4.2%	-3.8%	-4.6%
NADMS[2]	**44.3%**	**48.8%**	**51.0%**	**51.2%**	**46.0%**	**45.9%**	2.2%	2.5%	-2.7%	-2.8%
Mode Split (non-EEA)										
SOV	42.9%	39.2%	37.4%	37.6%	40.5%	40.3%	-1.8%	-1.6%	1.3%	1.1%
HOV2	23.2%	22.0%	21.4%	21.0%	22.7%	22.9%	-0.6%	-0.9%	0.7%	1.0%
HOV3+	19.3%	20.4%	20.1%	19.5%	21.1%	21.5%	-0.3%	-0.9%	0.7%	1.1%
Transit	5.1%	6.4%	6.6%	6.3%	6.3%	6.6%	0.2%	-0.1%	-0.1%	0.2%
Nonmotorized	9.4%	12.1%	14.4%	15.6%	9.4%	8.7%	2.3%	3.5%	-2.6%	-3.4%
NADMS[2]	**40.0%**	**44.0%**	**46.1%**	**46.3%**	**42.2%**	**42.1%**	2.1%	2.3%	-1.8%	-1.9%

Note:
[1] Equity Emphasis Area
[2] Non-Auto Driver Mode Share (NADMS) is the sum of all person trips made not as the driver of an automobile. This includes 50% of HOV2 trips and 71.4% of HOV3+ trips, assuming an HOV3+ occupancy of 3.5 travelers.

Table 2 – Alternative Futures Analysis
Vehicle Miles Traveled
Montgomery County (Overall, EEA[1], non-EEA[1])

	Metric Values						*% Delta vs. Business As Usual*			
	2015	2050 Business As Usual (BAU)	On The Road	Work Local Play Local	Home Alone Together	Hello From The Other Side	On The Road	Work Local Play Local	Home Alone Together	Hello From The Other Side
Daily Vehicle Miles Traveled (VMT) For Trips Beginning Or Ending In Montgomery County (Overall)							*(Alternative divided by 2050 BAU)*			
Total	**20,228,973**	**24,012,055**	**28,639,289**	**25,647,202**	**19,583,130**	**21,555,805**	19.3%	6.8%	-18.4%	-10.2%
Per Population	19.9	19.4	23.2	20.7	15.8	17.4	19.3%	6.8%	-18.4%	-10.2%
Per Employment	38.9	33.8	40.4	36.2	27.6	30.4	19.3%	6.8%	-18.4%	-10.2%
Per Service Population[2]	**13.2**	**12.3**	**14.7**	**13.2**	**10.1**	**11.1**	19.3%	6.8%	-18.4%	-10.2%
Daily Vehicle Miles Traveled (VMT) For Trips Beginning Or Ending In Montgomery County (EEA)										
Total	**4,545,807**	**5,603,427**	**6,476,213**	**5,917,542**	**4,647,992**	**5,009,308**	15.6%	5.6%	-17.1%	-10.6%
Per Population	18.6	18.2	21.4	18.9	14.8	16.5	17.5%	3.7%	-18.5%	-9.1%
Per Employment	35.4	30.3	35.3	32.3	25.2	27.2	16.6%	6.6%	-16.6%	-10.1%
Per Service Population[2]	**12.2**	**11.4**	**13.3**	**11.9**	**9.3**	**10.3**	17.2%	4.8%	-17.8%	-9.5%
Daily Vehicle Miles Traveled (VMT) For Trips Beginning Or Ending In Montgomery County (non-EEA)										
Total	**15,683,166**	**18,408,627**	**22,163,076**	**19,729,660**	**14,935,138**	**16,546,497**	20.4%	7.2%	-18.9%	-10.1%
Per Population	20.3	19.8	23.7	21.4	16.2	17.7	19.7%	7.8%	-18.4%	-10.6%
Per Employment	40.0	35.1	42.1	37.5	28.4	31.5	20.0%	6.8%	-19.0%	-10.3%
Per Service Population[2]	**13.5**	**12.7**	**15.2**	**13.6**	**10.3**	**11.3**	19.8%	7.5%	-18.6%	-10.5%
Daily Vehicle Miles Traveled (VMT) on Roads in Montgomery County (Overall)							*(Alternative divided by 2050 BAU)*			
Total	**24,139,544**	**29,091,294**	**33,204,115**	**30,560,390**	**24,752,575**	**26,554,764**	14.1%	5.0%	-14.9%	-8.7%
Per Sq Mi	47,613	57,379	65,491	60,277	48,822	52,376	14.1%	5.0%	-14.9%	-8.7%
Daily Vehicle Miles Traveled (VMT) on Roads in Montgomery County (EEA)										
Total	**5,476,627**	**6,798,192**	**7,905,457**	**7,234,815**	**5,679,067**	**6,149,141**	16.3%	6.4%	-16.5%	-9.5%
Per Sq Mi	152,129	188,839	219,596	200,967	157,752	170,809	16.3%	6.4%	-16.5%	-9.5%
Daily Vehicle Miles Traveled (VMT) on Roads in Montgomery County (non-EEA)										
Total	**18,662,917**	**22,293,102**	**25,298,658**	**23,325,574**	**19,073,508**	**20,405,623**	13.5%	4.6%	-14.4%	-8.5%
Per Sq Mi	39,624	47,331	53,713	49,524	40,496	43,324	13.5%	4.6%	-14.4%	-8.5%
Demographics (Overall)										
Population	1,015,273	1,236,998	1,236,998	1,236,998	1,236,998	1,236,998	0.0%	0.0%	0.0%	0.0%
Employment	520,172	709,452	709,452	709,452	709,452	709,452	0.0%	0.0%	0.0%	0.0%
Service Population	1,535,445	1,946,450	1,946,450	1,946,450	1,946,450	1,946,450	0.0%	0.0%	0.0%	0.0%
Demographics (EEA)										
Population	244,528	308,009	302,905	313,616	313,616	302,905	-1.7%	1.8%	1.8%	-1.7%
Employment	128,274	185,091	183,387	183,387	184,126	184,126	-0.9%	-0.9%	-0.5%	-0.5%
Service Population	372,802	493,100	486,292	497,003	497,742	487,032	-1.4%	0.8%	0.9%	-1.2%
Demographics (nonEEA)										
Population	770,745	928,989	934,093	923,382	923,382	934,093	0.5%	-0.6%	-0.6%	0.5%
Employment	391,898	524,361	526,065	526,065	525,326	525,326	0.3%	0.3%	0.2%	0.2%
Service Population	1,162,643	1,453,350	1,460,158	1,449,447	1,448,708	1,459,418	0.5%	-0.3%	-0.3%	0.4%

Note:
[1] Equity Emphasis Area
[2] Service Population equals the sum of population and total employment.

Table 3 – Alternative Futures Analysis
Travel Time
Montgomery County (Overall, EEA[1], non-EEA[1])

	Metric Values						*% Delta vs. Business As Usual*			
	2015	2050 Business As Usual (BAU)	On The Road	Work Local Play Local	Home Alone Together	Hello From The Other Side	On The Road	Work Local Play Local	Home Alone Together	Hello From The Other Side
Total Daily Travel Time (Overall)			*Travel Time In Hours*						*(Alternative divided by 2050 BAU)*	
...By Auto	686,941	924,007	1,201,869	1,034,981	679,563	766,910	30.1%	12.0%	-26.5%	-17.0%
...By Transit	145,790	216,676	294,126	265,861	154,137	168,585	35.7%	22.7%	-28.9%	-22.2%
Total	**832,731**	**1,140,683**	**1,495,996**	**1,300,842**	**833,700**	**935,495**	31.1%	14.0%	-26.9%	-18.0%
Total Daily Travel Time (EEA)										
...By Auto	157,035	218,707	276,187	242,102	162,835	180,201	26.3%	10.7%	-25.5%	-17.6%
...By Transit	42,341	61,983	81,633	74,995	44,553	48,091	31.7%	21.0%	-28.1%	-22.4%
Total	**199,376**	**280,690**	**357,820**	**317,097**	**207,388**	**228,291**	27.5%	13.0%	-26.1%	-18.7%
Total Daily Travel Time (non-EEA)										
...By Auto	529,906	705,300	925,683	792,879	516,728	586,709	31.2%	12.4%	-26.7%	-16.8%
...By Transit	103,449	154,693	212,493	190,866	109,584	120,495	37.4%	23.4%	-29.2%	-22.1%
Total	**633,355**	**859,993**	**1,138,176**	**983,745**	**626,312**	**707,204**	32.3%	14.4%	-27.2%	-17.8%
Average Per-Trip Travel Time (Overall)			*Travel Time In Minutes*						*(Alternative divided by 2050 BAU)*	
...By Auto	17.9	20.6	22.9	19.9	18.7	21.0	11.0%	-3.3%	-9.1%	2.1%
...By Transit	50.4	49.9	51.3	49.6	48.6	50.6	2.7%	-0.7%	-2.7%	1.4%
Average Per-Trip Travel Time (EEA)										
...By Auto	17.5	20.1	22.3	19.4	18.2	20.4	10.9%	-3.7%	-9.6%	1.5%
...By Transit	50.7	49.5	50.6	48.9	48.4	50.5	2.1%	-1.4%	-2.3%	1.9%
Average Per-Trip Travel Time (non-EEA)										
...By Auto	18.1	20.8	23.1	20.1	18.9	21.2	11.0%	-3.2%	-8.9%	2.2%
...By Transit	50.3	50.1	51.5	49.8	48.6	50.7	2.9%	-0.5%	-2.9%	1.2%

Note:
[1] Equity Emphasis Area

Table 4 – Alternative Futures Analysis
Per-Capita Travel Time
Montgomery County (Overall, EEA[1], non-EEA[1])

	Metric Values						*% Delta vs. Business As Usual*			
	2015	2050 Business As Usual (BAU)	On The Road	Work Local Play Local	Home Alone Together	Hello From The Other Side	On The Road	Work Local Play Local	Home Alone Together	Hello From The Other Side
Daily Travel Time (Overall)		*Travel Time In Minutes*					*(Alternative divided by 2050 BAU)*			
Per Population										
...By Auto	40.6	44.8	58.3	50.2	33.0	37.2	30.1%	12.0%	-26.5%	-17.0%
...By Transit	8.6	10.5	14.3	12.9	7.5	8.2	35.7%	22.7%	-28.9%	-22.2%
Total	**49.2**	**55.3**	**72.6**	**63.1**	**40.4**	**45.4**	31.1%	14.0%	-26.9%	-18.0%
Per Employment										
...By Auto	79.2	78.1	101.6	87.5	57.5	64.9	30.1%	12.0%	-26.5%	-17.0%
...By Transit	16.8	18.3	24.9	22.5	13.0	14.3	35.7%	22.7%	-28.9%	-22.2%
Total	**96.1**	**96.5**	**126.5**	**110.0**	**70.5**	**79.1**	31.1%	14.0%	-26.9%	-18.0%
Per Service Population[2]										
...By Auto	26.8	28.5	37.0	31.9	20.9	23.6	30.1%	12.0%	-26.5%	-17.0%
...By Transit	5.7	6.7	9.1	8.2	4.8	5.2	35.7%	22.7%	-28.9%	-22.2%
Total	**32.5**	**35.2**	**46.1**	**40.1**	**25.7**	**28.8**	31.1%	14.0%	-26.9%	-18.0%
Daily Travel Time (EEA)		*Travel Time In Minutes*					*(Alternative divided by 2050 BAU)*			
Per Population										
...By Auto	38.5	42.6	54.7	46.3	31.2	35.7	28.4%	8.7%	-26.9%	-16.2%
...By Transit	10.4	12.1	16.2	14.3	8.5	9.5	33.9%	18.8%	-29.4%	-21.1%
Total	**48.9**	**54.7**	**70.9**	**60.7**	**39.7**	**45.2**	29.6%	11.0%	-27.4%	-17.3%
Per Employment										
...By Auto	73.5	70.9	90.4	79.2	53.1	58.7	27.5%	11.7%	-25.2%	-17.2%
...By Transit	19.8	20.1	26.7	24.5	14.5	15.7	32.9%	22.1%	-27.7%	-22.0%
Total	**93.3**	**91.0**	**117.1**	**103.7**	**67.6**	**74.4**	28.7%	14.0%	-25.7%	-18.2%
Per Service Population[2]										
...By Auto	25.3	26.6	34.1	29.2	19.6	22.2	28.0%	9.8%	-26.2%	-16.6%
...By Transit	6.8	7.5	10.1	9.1	5.4	5.9	33.5%	20.0%	-28.8%	-21.4%
Total	**32.1**	**34.2**	**44.1**	**38.3**	**25.0**	**28.1**	29.3%	12.1%	-26.8%	-17.7%
Daily Travel Time (non-EEA)		*Travel Time In Minutes*					*(Alternative divided by 2050 BAU)*			
Per Population										
...By Auto	41.3	45.6	59.5	51.5	33.6	37.7	30.5%	13.1%	-26.3%	-17.3%
...By Transit	8.1	10.0	13.6	12.4	7.1	7.7	36.6%	24.1%	-28.7%	-22.5%
Total	**49.3**	**55.5**	**73.1**	**63.9**	**40.7**	**45.4**	31.6%	15.1%	-26.7%	-18.2%
Per Employment										
...By Auto	81.1	80.7	105.6	90.4	59.0	67.0	30.8%	12.1%	-26.9%	-17.0%
...By Transit	15.8	17.7	24.2	21.8	12.5	13.8	36.9%	23.0%	-29.3%	-22.3%
Total	**97.0**	**98.4**	**129.8**	**112.2**	**71.5**	**80.8**	31.9%	14.0%	-27.3%	-17.9%
Per Service Population[2]										
...By Auto	27.3	29.1	38.0	32.8	21.4	24.1	30.6%	12.7%	-26.5%	-17.2%
...By Transit	5.3	6.4	8.7	7.9	4.5	5.0	36.7%	23.7%	-28.9%	-22.4%
Total	**32.7**	**35.5**	**46.8**	**40.7**	**25.9**	**29.1**	31.7%	14.7%	-26.9%	-18.1%

Note:
[1] Equity Emphasis Area
[2] Service Population equals the sum of population and total employment.

Table 5 – Alternative Futures Analysis
Job Access
Montgomery County (Overall, EEA[1], non-EEA[1])

	Metric Values					*% Delta vs. Business As Usual*			
	2015	2050 Business As Usual (BAU)	On The Road	Work Local Play Local	Home Alone Together	Hello From The Other Side	On The Road	Work Local Play Local	Home Alone Together	Hello From The Other Side
Average Regional Jobs Accessible within 45 Minutes (Overall)							*(Alternative divided by 2050 BAU)*			
...By Auto	1,140,954	1,243,883	1,048,732	1,191,863	1,583,550	1,428,743	-15.7%	-4.2%	27.3%	14.9%
...By Transit	124,914	233,361	225,243	252,431	251,010	224,007	-3.5%	8.2%	7.6%	-4.0%
Average Regional Jobs Accessible within 45 Minutes (EEA)										
...By Auto	1,180,286	1,322,120	1,134,576	1,274,180	1,620,115	1,510,354	-14.2%	-3.6%	22.5%	14.2%
...By Transit	139,913	304,713	301,266	324,464	322,720	299,681	-1.1%	6.5%	5.9%	-1.7%
Average Regional Jobs Accessible within 45 Minutes (non-EEA)										
...By Auto	1,128,476	1,217,944	1,020,896	1,163,910	1,571,139	1,402,283	-16.2%	-4.4%	29.0%	15.1%
...By Transit	120,155	209,705	200,591	227,969	226,658	199,469	-4.3%	8.7%	8.1%	-4.9%
Average Montgomery County Jobs Accessible within 45 Minutes (Overall)							*(Alternative divided by 2050 BAU)*			
...By Auto	469,699	438,352	577,174	584,529	659,867	636,317	31.7%	33.3%	50.5%	45.2%
...By Transit	61,888	72,691	112,501	122,605	121,852	111,845	54.8%	68.7%	67.6%	53.9%
Average Montgomery County Jobs Accessible within 45 Minutes (EEA)										
...By Auto	493,508	466,868	623,492	635,246	689,692	672,366	33.5%	36.1%	47.7%	44.0%
...By Transit	73,244	92,862	142,810	148,286	147,586	142,181	53.8%	59.7%	58.9%	53.1%
Average Montgomery County Jobs Accessible within 45 Minutes (non-EEA)										
...By Auto	462,146	429,305	562,154	567,306	649,740	624,628	30.9%	32.1%	51.3%	45.5%
...By Transit	58,285	66,291	102,673	113,884	113,113	102,007	54.9%	71.8%	70.6%	53.9%

Note:
[1] Equity Emphasis Area

Business As Usual

As shown in **Table 1**, Between Year 2015 and Year 2050 Business As Usual, the total number of person trips increases by 23% from approximately 3.2 million to 3.9 million, with increases across all modes. The mode shares of transit and nonmotorized trips increase by 1.2 percentage points and 3.0 percentage points, respectively; overall Non-Auto Driver Mode Share (NADMS) increases by 4.2 percentage points from 41.0% to 45.2%. In Year 2015, NADMS is slightly higher in EEAs (44.3%) than non-EEAs (40.0%); this differential persists in Year 2050 Business As Usual with a 48.8% NADMS in EEAs and 44.0% NADMS in non-EEAs. **Figures 1a and 1b** illustrate NADMS by TAZ for 2015 and 2050 Business As Usual, indicating higher NADMS along the Metro Red Line and the I-270 corridor, the locations of most of Montgomery County's EEAs, than elsewhere in the county.

As shown in **Table 2**, VMT, measured both as attributed to trips beginning and ending in Montgomery County and as experienced on roads in Montgomery County, also increases by approximately 20%; however, because VMT does not grow as quickly as combined population and employment, VMT per Service Population decreases 6.4% from 13.2 to 12.3 VMT per Service Population. In both Year 2015 and Year 2050 Business As Usual, Trips beginning or ending in EEAs generate approximately 10% less VMT per Service Population than those beginning or ending in non-EEAs. The analysis also shows that, although trips to or from EEAs generate less VMT per service population, air quality will continue to be worse in EEAs in 2050 Business As Usual, as EEAs are exposed to about four times the emissions per square mile as non-EEAs. **Figures 2a and 2b** illustrate VMT per Service Population for 2015 and 2050 Business As Usual, indicating higher values of VMT per Service Population in less dense areas on the periphery of the county and lower values in the central and denser portions of the county, particularly Silver Spring and Bethesda.

As shown in **Table 3**, per-trip Auto travel times increase between 2015 and 2050 Business As Usual by 15% from an average of 17.9 minutes per trip to 20.6 minutes per trip, while transit travel times remain practically unchanged at approximately 50 minutes per trip. **Table 4** illustrates that total Daily Travel Time per Service Population increases by 8.1%, with a slightly larger increase in Non-EEAs (8.6%) than in EEAs (6.4%).

As shown in **Table 5**, Regional job access by both auto and transit improves between 2015 and 2050 Business As Usual. The average number of jobs accessible within a 45-minute drive increases 9% from approximately 1,140,000 to 1,240,000, while the average number of jobs accessible within a 45-minute transit trip increases 87% from approximately 120,000 to 230,000. Regional job access by transit increases more in EEAs (118%) than in non-EEAs (75%). **Figures 3a and 3b** illustrate

regional jobs accessible by auto for 2015 and 2050 Business As Usual and **Figures 4a and 4b** illustrate regional jobs accessible by transit. Access to regional jobs by auto is higher in areas closer to job centers in Washington, D.C. and Northern Virginia; access to regional jobs by transit is higher along the Metro Red Line. When considering only jobs within Montgomery County, the average number of jobs accessible within a 45-minute drive decreases 7% from approximately 470,000 to 440,000, while the average number of jobs accessible within a 45 minute transit trip increases 17% from approximately 62,000 to 73,000. Again, transit job accessibility gains for EEAs (27%) outpace those for non-EEAs (14%). **Figures 5a and 5b** illustrate Montgomery County jobs accessible by auto for 2015 and 2050 Business As Usual and **Figures 6a and 6b** illustrate Montgomery County jobs accessible by transit. Access to Montgomery County jobs by auto is higher in the southern portion of the county where job centers are located and jobs along the I-270 corridor are relatively accessible by auto travel in the non-peak direction; conversely, the northern portion of the county has fewer jobs and auto access to jobs in the southern portion of the county is more limited by peak period congestion. Similar to access to regional jobs by transit, access to Montgomery County jobs by transit is higher along the Metro Red Line, but since jobs in Washington D.C. are no longer included in the analysis, the Metro Red Line becomes relatively less important compared to local transit service around the I-270 corridor beyond the reach of the Metro Red Line.

Alternative Futures

The Alternative Futures are each compared with Year 2050 Business As Usual, with percent changes (% Delta) between the values for each Alternative Future and the values for Business As Usual presented in **Tables 1 through 5**. Additional discussion of the Alternative Futures results and maps illustrating the spatial distribution of selected results are presented in the following sections.

Mode Split

As shown in **Table 1**, On The Road includes the largest overall increase in travel by all modes, followed closely by Work Local Play Local, while Home Alone Together includes the largest overall decrease in travel by all modes, followed closely by Hello From The Other Side.

Nonmotorized travel increases more than travel by other modes in On The Road and Work Local Play Local, resulting in an increase in NADMS for those Alternative Futures, while nonmotorized travel decreases more than travel by other modes in Home Alone Together and Hello From The Other Side, resulting in a decrease in NADMS. EEAs have a higher NADMS than non-EEAs by 4 to 5

percentage points (or approximately 10 percent) in all scenarios. **Figures 1c through 1f** illustrate changes in NADMS by TAZ from 2050 Business As Usual to each of the four Alternative Futures.

Vehicle Miles Traveled

As shown in **Table 2**, VMT, both as attributed to trips beginning and ending in Montgomery County and as experienced on roads in Montgomery County, increases for On The Road and Work Local Play Local and decreases for Home Alone Together and Hello From The Other Side. Because the county population and employment totals are the same across Business As Usual and the four Alternative Futures, changes in VMT per Service Population follow the same trend. EEAs generate less VMT per service population in all scenarios, widening from an 11% gap in 2015 and 2050 Business As Usual to a 14% gap in On The Road and Work Local Play Local, and narrowing slightly to a 10% gap in Home Alone Together and Hello From The Other Side. The disparity in air quality, as measured by VMT per square mile, continues among the four Alternative Futures, though Home Alone Together reduces this disparity more than the other futures. **Figures 2c through 2f** illustrate changes in NADMS by TAZ from 2050 Business As Usual to each of the four Alternative Futures.

Travel Times

As shown on **Table 3**, Total auto and transit travel times increase in On The Road and Work Local Play Local and decrease in Home Alone Together and Hello From The Other Side, paralleling the changes in VMT. However, the pattern of per-trip travel time results varies across Alternative Futures, and is more reflective of willingness to take longer trips than the total number of trips: both per-trip auto travel times and per-trip transit travel times increase for On The Road and, to a lesser extent, Hello From The Other Side; in the case of On The Road, longer per-trip travel times also represent increased congestion as a result of increased VMT. Per-trip auto and transit travel times decrease for Work Local Play Local and Home Alone Together, reflecting the focus on local travel; the decrease for Work Local Play Local is smaller than for Home Alone Together, again reflecting increased VMT and congestion in Work Local Play Local relative to Home Alone Together. **Table 4** details the total per-capita travel times by auto and transit, which again follow the trends in total travel time and VMT. Travelers to or from EEAs spend on average between 8% and 10% less time traveling by auto and between 15% and 28% more time traveling by transit than travelers to or from non-EEAs.

Job Access

A shown in **Table** 5, access to regional jobs by auto increases for Home Alone Together and Hello From The Other Side, the two Alternative Futures with decreased VMT and congestion; conversely, access to regional jobs by auto decreases for On The Road and Work Local Play Local, the two Alternative Futures with increased VMT and congestion. **Figures 3c through 3f** illustrate changes in regional job access by auto by TAZ from 2050 Business As Usual to each of the four Alternative Futures. In On The Road and a lesser extent Work Local Play Local, concentration of jobs along the I-270 corridor improves auto access to jobs in limited locations, but increases in congestion throughout the county reduce auto access to jobs in most locations; in Home Alone Together and Hello From The Other Side, widespread reductions result in relatively uniform increases in auto access to regional jobs, with marked improvements along the Beltway, which is heavily congested under 2050 Business As Usual conditions. Across all scenarios, EEAs, which are generally centrally located, have access to between 3% and 11% more regional jobs by auto on average than non-EEAs.

When considering only jobs within Montgomery County, job accessibility by auto improves for all Alternative Futures, with larger accessibility gains for Home Alone Together and Hello From The Other Side than for On The Road and Work Local Play Local; all Alternative Futures concentrate job growth in denser employment centers with a relatively greater concentration in On The Road and Work Local Play Local offset by relatively higher levels of VMT and congestion. **Figures 5c through 5f** illustrate changes in Montgomery County job access by auto by TAZ from 2050 Business As Usual to each of the four Alternative Futures. In On The Road and Work Local Play Local, the concentration of jobs along the I-270 corridor has a much larger relative effect when considering only Montgomery County jobs; congestion on routes into downtown Washington D.C. and Northern Virginia via the American Legion Memorial Bridge are not relevant. In Home Alone Together and Hello From The Other Side, widespread congestion reduction results in improved auto access to Montgomery County jobs throughout the County. Across all scenarios, EEAs, which are generally centrally located, have access to between 6% and 11% more Montgomery County jobs by auto on average than non-EEAs.

Access to regional jobs by transit increases for Work Local Play Local and Home Alone Together, both of which concentrate both employment and housing growth more densely, bringing more growth into closer proximity to transit service; access to regional jobs by transit decreases for On The Road and Hello From The Other Side, which do concentrate employment growth but also

disperse housing growth to less dense areas. **Figures 4c through 4f** illustrate changes in regional job access by transit by TAZ from 2050 Business As Usual to each of the four Alternative Futures. Based on location, improvements in transit access to regional jobs are similar for all four Alternative Futures; transit travel times are relatively less affected by auto congestion and all four Alternative Futures concentrate employment growth in denser areas to varying degrees. However, in Work Local Play Local and Home Alone Together, more residential growth is concentrated in denser, more transit-accessible areas, so more Montgomery County residents experience the increased transit access to jobs. Across all scenarios, EEAs, which are generally located in proximity to transit, have access to markedly more regional jobs by transit on average (40% to 50% more) than non-EEAs.

When considering only jobs within Montgomery County, job accessibility by transit improves for all Alternative Futures, with larger accessibility gains for Work Local Play Local and Home Alone Together, both of which concentrate both housing and job growth in denser locations that tend to be near transit. **Figures 6c through 6f** illustrate changes in Montgomery County job access by transit by TAZ from 2050 Business As Usual to each of the four Alternative Futures. The similar visual pattern in across all four Alternative Futures is consistent with the trend for regional transit access to jobs described above. Across all scenarios, EEAs, which are generally located in proximity to transit, have access to markedly more Montgomery County jobs by transit on average (30% to 40% more) than non-EEAs.

Attachment D

FEHR PEERS DC

1003 K Street NW, Suite 209
Washington, DC 20001
202.854.2750

MEMORANDUM

Date: October 23, 2020 (Revised December 4, 2020)

To: Eric Graye, David Anspacher, and Jesse Cohn – Montgomery County Planning Dept.

From: Alex Rixey, Kwasi Donkor, and Zahra Khan – Fehr & Peers DC

Subject: Montgomery County General Plan Update – Policy Evaluation

DC19-0049.02

Fehr & Peers DC has evaluated scenarios reflecting Year 2015, Year 2050 Business As Usual, and four Alternative Futures (Work Local Play Local, Home Alone Together, On The Road, and Hello From The Other Side). These scenarios reflect the effects of exogenous changes and trends that may occur between year 2015 and 2050. Results of this analysis are presented in the "General Plan Update – Evaluation Measure Methodology and Results" memo (August 6, 2020).

Following that analysis, Fehr & Peers DC modeled the effects of a suite of eight desired policy measures, envisioned as part of the Montgomery County General Plan Update, in the regional travel demand model to measure their effects on transportation performance measures for a range of scenarios. To examine the range of potential transportation outcomes, the policy measures were evaluated in the context of three scenarios: Business as Usual, On The Road, and Home Alone Together. The On The Road and Home Alone Together Alternative Futures were selected for analysis because they represent the futures with the highest and lowest total Vehicle Miles Traveled (VMT), respectively.

This memo describes the policy measures evaluated, the approach to modeling the policy measures in the regional travel demand model, and the results of applying the full suite of policy measures to Business as Usual, On The Road, and Home Alone Together, allowing a comparison of the transportation outcomes for those three scenarios with both exogenous factors and policy measures applied to the transportation outcomes for those three scenarios with the effects of exogenous factors only.

The policy measures are successful to varying degrees in all scenarios in both modestly reducing VMT and substantially increasing transit travel and improving transit access to jobs; the effects of the policy measures are greatest on the Business As Usual scenario.

Parking and congestion pricing policies, coupled with improved transit service and an increased concentration of land uses in downtowns, town centers, and along transit corridors, were helpful in increasing carpooling and transit ridership. The combined effect of the policy measures decreased the number of vehicle trips by between 2 and 9 percent. Policy measures increased vehicle trip distances by 4 percent in the Business as Usual scenario, and held vehicle trip distances nearly constant or decreased them by 2 percent in the On The Road and Home Alone Together alternative futures, respectively. The net effect of the policy measures on VMT was a decrease of between 4 and 5 percent. Policy measure effects on transit outcomes were much larger, increasing transit ridership by between 22 and 36 percent and increasing the number of jobs accessible within 45 minutes by transit by between 21 and 30 percent; Montgomery County jobs accessible within 45 minutes by transit increased by between 28 and 110 percent, more than doubling the number of transit-accessible jobs in the Business As Usual scenario.

Although the policy measures are effective in reducing VMT, the effect magnitude of the technology and behavior changes evaluated in the Alternative Futures is far larger: for example, applying policy measures to the Business As Usual scenario reduces VMT by 5 percent compared to Business As Usual without policy measures, whereas the technology and behavioral changes of the Home Alone Together Alternative Future result in 18 percent less VMT than the Business As Usual scenario without policy measures. Because studied land use policy changes apply only to new population and employment growth and much of the county's growth was already anticipated in downtowns, town centers, and transit corridors, the effect of the land use policy measures is limited—the analyzed land use policies impact only about 4 percent of the total Montgomery County population and jobs anticipated by 2050. By contrast, technology and behavioral changes analyzed in the Alternative Futures influence all travelers.

As observed during 2020, technology and behavioral changes have the potential for even larger changes to transportation outcomes than those modeled in this study. Increased telework, reduced commute, shopping, and personal travel, and other travel behavioral responses to the COVID-19 pandemic have had a large effect on vehicular travel, reducing traffic in the Inner Jurisdictions of

the Transportation Planning Board Modeled Region by between 20 and 50 percent.[1] While these behavioral changes are accompanied by negative social and economic impacts and were made out of necessity for the sake of public health, lessons drawn from this experience could be applied to a future that encourages technology to replace travel where possible to further reduce VMT.

1. POLICY MEASURES

Eight policy measures were evaluated in the analysis described in this memo:

1. Restrict Through Travel Lanes on Selected Transit Corridors
2. Complete Communities
3. Concentrate Growth in Existing Commercial Areas and Transit Areas
4. Implement Premium Transit
5. Improve Local Bus Service
6. Increase Parking Pricing
7. Increase Auto Travel Pricing
8. Improve Local Street Network

1. Restrict Through Travel Lanes on Selected Transit Corridors and Reduce Target Speeds

Restrict through travel lanes to a total of four (two in each direction) for transit corridors in the downtowns, town centers and the transit corridors identified below:

- Corridor Cities Transitway from Shady Grove to Clarksburg
- Georgia Avenue from Silver Spring Transit Center to Montgomery General Hospital
- MD 355 from Bethesda Purple Line Station to Clarksburg
- New Hampshire Ave from DC to Colesville
- North Bethesda Transitway (White Flint alignment)
- Randolph Rd from White Oak to White Flint
- University Blvd from Wheaton to Takoma Langley
- US 29 from Silver Spring Transit Center to Burtonsville Park and Ride

[1] https://www.mwcog.org/documents/2020/10/27/covid-19-travel-monitoring-snapshot/ p. 4

- Veirs Mill Road from Rockville Metro Station to Wheaton Metro Station

Additionally, to reflect the target speeds envisioned in the Complete Streets Design Guide, modify free-flow speed assumptions for the street types in each area type highlighted in Table 1. Unmodified speeds are followed by speeds in parentheses, where modified:

Table 1. Free-Flow Highway Link Speeds (Miles per Hour)

		Area Type					
		1	2	3	4	5	6
Street Type		Downtown	Downtown/ Town Center	Suburban	Suburban	Suburban	Country
0	Centroid Connectors	15	15	20	25	30	35
1	Freeways	55	55	60	60	65	65
2	Major Arterials	35 (25)	35 (30)	45 (35)	45 (35)	50 (35)	50 (40)
3	Minor Arterials	35 (20)	35 (25)	40 (25)	40 (25)	40 (25)	45 (35)
4	Collectors	30 (20)	30 (25)	30 (25)	35 (25)	35 (25)	35
5	Expressways	45	45	50	50	50	55
6	Ramps	20	20	30	30	35	50

Source: https://www.mwcog.org/assets/1/6/mwcog_tpb_travel_model_v2.3.78_user_guide_v5_full.pdf Table 92

2. Complete Communities

Create Complete Communities by introducing a mix of uses throughout the county by adding jobs (e.g. corner stores, daycares, cleaners) locally. There is an inherent tradeoff between distributing and concentrating retail job growth. To distribute a portion of retail job growth evenly throughout the county, disperse 1,000 retail jobs to TAZs in areas beyond transit areas, Downtowns, and Town Centers in proportion to the area of those TAZs.

3. Concentrate Growth in Existing Commercial Areas and Transit Areas

This policy would concentrate all new population and employment growth between 2015 and 2050 in existing Downtowns and Town Centers; Metrorail, LRT, and MARC station areas; as well as four BRT corridors (Georgia Ave, MD 355, US 29 and Veirs Mill Road).

Of the 220,000 new residents anticipated by 2050, roughly 50,000 (or 22%) would be shifted to downtowns, town centers, and transit corridors from other areas of the county. That is because over

half of new residents are already expected to reside in areas currently designated as downtowns, town centers and transit corridors under Business As Usual conditions and one quarter are expected to reside in municipalities outside of Montgomery County's planning authority (including the cities of Rockville and Gaithersburg). Overall, this policy would affect about 4% of the total 1.2 million Montgomery County residents anticipated by 2050.

Similarly, of the 190,000 new jobs anticipated by 2050, roughly 26,000 (or 14%) would be shifted to downtowns, town centers, and transit corridors from other areas of the county. Overall, this policy would impact about 4% of the 710,000 total jobs anticipated by 2050.

4. Implement Premium Transit

Implement premium transit improvements to Metrorail, BRT, Purple Line, and MARC:

- Metrorail
    - Reduce headways on Red Line from 6 minutes to 5 minutes during peak periods and from 12 minutes to 10 minutes during off-peak periods.
    - No changes to end-to-end run times.
- MARC
    - 30-minute headways during peak and off-peak periods for the MARC Brunswick Line.
    - Implement two-way service throughout the day.
    - No changes to end-to-end run times.
    - Extend two-way MARC Brunswick Line service to the Alexandria VRE station via Union Station, L'Enfant, and Crystal City VRE stations with the same 30-minute headways applied to the Brunswick line service.
- Purple Line
    - Reduce headways to 3 minutes during peak periods and 6 minutes during off-peak periods.
    - No changes to end-to-end run times.
- BRT

- Implement all BRT corridors with 5-minute headways (exception on US 29 and MD 355 BRT, where the service patterns in the regional travel demand model will result in slightly different headways).
- Reduce end-to-end run times by 25% during peak periods and by 10% during off-peak periods.

5. Improve Local Bus Service

Improve WMATA Local Bus, WMATA Express Bus, and RideOn Local Bus service by reducing headways by 50%.

6. Increase Parking Pricing

Increase the price of paid parking in Montgomery County by 100%.

7. Increase Auto Travel Pricing; Reduce Auto Travel Costs for Travelers in the Lowest Income Quartile

- Increase the cost of automobile travel on all roadways in Montgomery County by 50% by instituting a per-mile charge for travel on roadways in Montgomery County that are not already tolled.
- Exempt travelers in the lowest income quartile from the increased per-mile charge.

8. Improve Local Street Network

Build out the local street network in Downtowns, Town Centers, and BRT station areas:

- Increase the block density in Downtowns and Town Centers to 150 blocks per square mile, equivalent to the dense street grid in King Farm.
- Increase the block density in BRT station areas not in Downtowns or Town Centers to 100 blocks per square mile.

2. POLICY MEASURE MODELING APPROACHES

1. Restrict Through Travel Lanes on Selected Transit Corridors and Reduce Target Speeds

Model links in the link.dbf input file representing corridors selected for lane reductions were identified in the regional travel demand model through a combination of visual inspection and a boundary shapefile representing the corridors. AMLANE, PMLANE, and OPLANE values in the link.dbf file were reduced to 4 in cases where the original value was greater than 4.

Montgomery County free-flow specific lookups were added to the in the AM_SPD_LKP.txt and MD_SPD_LKP.txt speed lookup files; the new speed lookups were calculated as a percent reduction from the original unmodified free flow highway link speeds reflected in Table 1. V2.3_Highway_Build.s script in the section below was then modified to call values based on links that fall within the county. Montgomery County links were identified via the "JUR" link attribute in the link.dbf file.

```
lookup name = amspd,              ; AM Initial Speeds Atype x Ftype
       lookup[1] = 1,result=2,    ; AM CentConn Speeds (mph)
       lookup[2] = 1,result=3,    ; AM Freeway  Speeds (mph)
       lookup[3] = 1,result=4,    ; AM Maj Art  Speeds (mph)
       lookup[4] = 1,result=5,    ; AM Min Art  Speeds (mph)
       lookup[5] = 1,result=6,    ; AM Collect  Speeds (mph)
       lookup[6] = 1,result=7,    ; AM Exprway  Speeds (mph)
       lookup[7] = 1,result=8,    ; AM Ramp     Speeds (mph)
       lookup[8] = 1,result=9,    ; AM CentConn Speeds (mph) for Mongomery County
       lookup[9] = 1,result=10,   ; AM Freeway  Speeds (mph) for Mongomery County
       lookup[10] = 1,result=11,  ; AM Maj Art  Speeds (mph) for Mongomery County
       lookup[11] = 1,result=12,  ; AM Min Art  Speeds (mph) for Mongomery County
       lookup[12] = 1,result=13,  ; AM Collect  Speeds (mph) for Mongomery County
       lookup[13] = 1,result=14,  ; AM Exprway  Speeds (mph) for Mongomery County
       lookup[14] = 1,result=15,  ; AM Ramp     Speeds (mph) for Mongomery County
       interpolate=N,fail=0,0,0,file=@AMSPD@

lookup name = opspd,              ; Off-Pk Initial Speeds Atype x Ftype
       lookup[1] = 1,result=2,    ; Off-pk CentConn Speeds (mph)
       lookup[2] = 1,result=3,    ; Off-pk Freeway  Speeds (mph)
       lookup[3] = 1,result=4,    ; Off-pk Maj Art  Speeds (mph)
       lookup[4] = 1,result=5,    ; Off-pk Min Art  Speeds (mph)
       lookup[5] = 1,result=6,    ; Off-pk Collect  Speeds (mph)
       lookup[6] = 1,result=7,    ; Off-pk Exprway  Speeds (mph)
       lookup[7] = 1,result=8,    ; Off-pk Ramp     Speeds (mph)
       lookup[8] = 1,result=9,    ; Off-pk CentConn Speeds (mph) for Mongomery County
       lookup[9] = 1,result=10,   ; Off-pk Freeway  Speeds (mph) for Mongomery County
       lookup[10] = 1,result=11,  ; Off-pk Maj Art  Speeds (mph) for Mongomery County
       lookup[11] = 1,result=12,  ; Off-pk Min Art  Speeds (mph) for Mongomery County
       lookup[12] = 1,result=13,  ; AM Collect  Speeds (mph) for Mongomery County
       lookup[13] = 1,result=14,  ; AM Exprway  Speeds (mph) for Mongomery County
       lookup[14] = 1,result=15,  ; AM Ramp     Speeds (mph) for Mongomery County
       interpolate=N,fail=0,0,0,file=@MDSPD@

       IF (JUR=1)
          _IDX    =  FTYPE + 8
          PPAMSPD= AMSPD(_IDX,AType)
          PPOPSPD= OPSPD(_IDX,AType)
       ELSE
          _IDX    =  FTYPE + 1
          PPAMSPD= AMSPD(_IDX,AType)
          PPOPSPD= OPSPD(_IDX,AType)
       ENDIF
```

2. Complete Communities

1,000 retail jobs out of the total growth of 10,540 retail jobs between year 2015 and year 2050 Business as Usual were allocated to TAZs in "No Growth" areas outside of Downtowns, Town Centers, and transit (i.e., Metrorail, Light Rail Transit [LRT], Bus Rapid Transit [BRT] and MARC) station areas in proportion to their total area. For each of the three scenarios, the land use adjustments to reflect complete communities were applied to the Zone.dbf files for the respective scenario without policy adjustments.

3. Concentrate Growth in Existing Commercial Areas and Transit Areas

Excluding the growth of 1,000 retail jobs allocated for the Complete Communities policy, growth between year 2015 and year 2050 Business as Usual of approximately 189,000 jobs and 222,000 residents were allocated according to the areas and percentages defined in Table 2 below. Within each area defined in Table 2, population and employment growth are allocated to each Transportation Analysis Zone (TAZ) according to the area of the TAZ relative to the total area of the location defined in Table 2. The land uses allocated according to this process are reflected in a revised Zone.dbf file for each scenario, based on the Zone.dbf file for the respective scenario without policy adjustments.

Table 2. Growth Percentage by Area Type

Area Type	Location Names	% of Population Growth	% of Employment Growth
Metro + Downtown	Bethesda, Wheaton, Silver Spring, Friendship Heights, White Flint	25.0%	27.5%
Metro + Town Center	Glenmont, Montgomery Hills, Grosvenor, Shady Grove, Takoma Park, Twinbrook	10.0%	15.0%
Metro Station Area	Stations: Bethesda, Forest Glen, Friendship Heights, Glenmont, Grosvenor-Strathmore, Shady Grove, Silver Spring, Takoma, Twinbrook, Wheaton, White Flint	2.5%	2.5%
LRT + Town Center	16th Street Station, Chevy Chase Lake, Long Branch, Lyttonsville, Takoma Langley	7.5%	20.0%
LRT Station Area	Stations: Connecticut Avenue, Dale Drive, Long Branch, Lyttonsville, Manchester Place, Piney Branch Road, Silver Spring Library, Takoma/Langley, Woodside	5.0%	5.0%
BRT + Downtown	Viva White Oak	12.5%	15.0%
BRT + Town Center	Aspen Hill, Briggs Chaney, Burnt Mills, Burtonsville, Cabin Branch, Clarksburg, Four Corners, Foxchapel, Germantown, Milestown, Montgomery Village, New Hampshire, Olney, Parklawn, Veris Mill/Randolph, White Oak	10.0%	10.0%

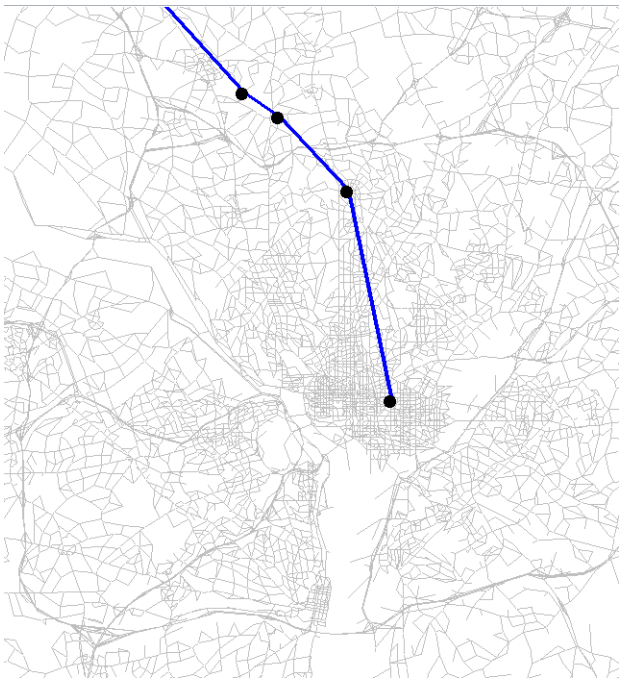
BRT Station Area	27 stations along MD 355, Georgia Ave, Veirs Mill Road, and US 29	25.0%	2.5%
MARC + Town Center	Kensington	1.0%	1.0%
MARC Station Area	Stations: Garrett Park, Germantown, Kensington, Shady Grove, Washington Gove, White Flint	1.0%	0.5%
No Transit + Downtown	Rock Spring, Life Sciences Center	0.5%	1.0%
No Transit + Town Center	Ashton, Cloverly, Coleville, Damascus, Hillandale, Hyattstown, Layhill, Norbeck, Park Potomac, Redland, Sandy Spring, USG/Traville, Washingtonian, Westbard	0.0%	0.0%
Municipalities	Gaithersburg, Rockville, Washington Grove, Laytonsville	0.0%	0.0%
No Growth	All other areas	0.0%	0.0%*
*The "No Growth" area is allocated 1,000 retail jobs as part of the Complete Communities policy; these jobs are not included in the percentages expressed in the table and the No Growth area receives no other additional job growth.			

4. Implement Premium Transit

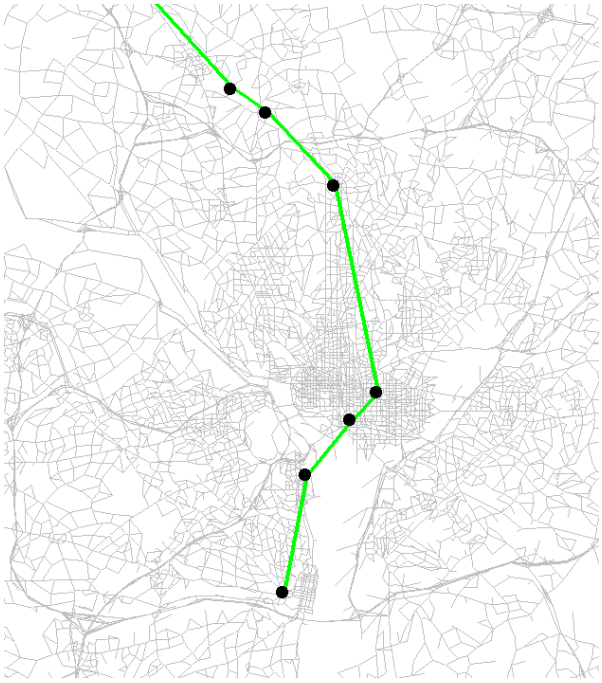
The following regional travel demand model files were modified to adjust headways, travel times, and two-way service as described in the Policy Measures section above:

- Metrorail – MODE3AM.TB, MODE3OP.TB
- MARC – MODE4AM.TB, MODE4OP.TB
- Purple Line – MODE5AM.TB, MODE5OP.TB
- BRT – MODE10AM.TB, MODE10OP.TB

In addition, the MODE4AM.TB, MODE4OP.TB files were modified to extend the MARC Brunswick Line service to include the L'Enfant, Crystal City, and Alexandria VRE stations. The line extension can be seen below:



Before



After

5. Improve Local Bus Service

The following regional travel demand model files were modified to reduce headways by 50%:

- WMATA Local Bus – MODE1AM.TB, MODE1OP.TB
- WMATA Express Bus – MODE2AM.TB, MODE2OP.TB
- RideOn Local Bus – MODE6AM.TB, MODE6OP.TB

6. Increase Parking Pricing

Non-transit related parking costs were increased in the prefarV23.s script by adding conditional statements to double the values of the following cost variables for all TAZs within Montgomery County:

- HBWParkCost – The daily parking rate for home-based work trips is a function of employment density for Area Types 1, 2, and 3. Unmodified values range from $0 per day in areas with low employment density, to approximately $10 per day in areas with high employment density.

- HBSParkCost, HBOParkCost, and NHBParkCost – The unmodified hourly parking rate for home-based shopping trips, other home-based trips, and non-home based trips is $2 per hour in Area Type 1, $1 per hour in Area Type 2, and $0.25 per hour in Area Type 3. The regional travel demand model assumes each home-based shopping trip requires one hour of parking and each home-based other and non-home based trip requires two hours of parking.

```
357 *
358 !>          IF (I=@MOCOZONES@)
359 !>            HBWParkCost = (HBWPkCost)*2
360 !>            HBSParkCost = (HrNonWkPkCost)*2        ; Assume 1-Hour parking duration for HBS trips
361 !>            HBOParkCost = (HrNonWkPkCost * 2.0)*2  ; Assume 2-Hour parking duration for HBO trips
362 !>            NHBParkCost = (HrNonWkPkCost * 2.0)*2  ; Assume 2-Hour parking duration for NHB trips
363 !>          ELSE
364 !>            HBWParkCost = HBWPkCost
365              HBSParkCost = HrNonWkPkCost        ; Assume 1-Hour parking duration for HBS trips
366              HBOParkCost = HrNonWkPkCost * 2.0  ; Assume 2-Hour parking duration for HBO trips
367              NHBParkCost = HrNonWkPkCost * 2.0  ; Assume 2-Hour parking duration for NHB trips
368 *          ENDIF
369
```

7. Increase Auto Travel Pricing

All regional travel demand model links in Montgomery County that do not have an existing toll were identified in the link.dbf file and assigned a toll group code of 1. Because the default assumed auto operating cost in the regional travel demand model is $0.10 per mile, a flat toll equivalent to $0.05 per mile was then calculated for each link according to its length, effectively increasing the cost of auto travel on roadways in Montgomery County by 50%.

To exempt travelers in the lowest income quartile from this toll, the Trip_Distribution_External.s script was modified to add tolls only to income quartiles 2, 3, and 4.

```
; add equivalent 'tolled' AM/OP highway time to normal times by income level
; AM pk normal + equivalent hwy time in work tables 61-64
; Offpk normal + equivalent hwy time in work tables 71-74

 ;TRAFFIC ON MIXED-FLOW LANES
JLOOP
      IF (I=@MOCOZONES@)   ; I-I  & I-X

      MW[61] = Round(MW[1] + ((MI.7.3/100.0) * i1PKEQM)*0) ;i1 AM hwy time w/eqv I-I
<!
<!
<!
<!
      MW[71] = Round(MW[2] + ((MI.8.3/100.0) * i1MDEQM)*0) ;i1 MD hwy time w/eqv I-I

      ELSEIF (I=@OTHERZONES@ && J=@MOCOZONES@)   ; X-I

      MW[61] = Round(MW[1] + ((MI.7.3/100.0) * i1PKEQM)*0)  ;i1 AM hwy time w/eqv X-I
      MW[71] = Round(MW[2] + ((MI.8.3/100.0) * i1MDEQM)*0)  ;i1 MD hwy time w/eqv X-I

      ELSE

      MW[61] = Round(MW[1] + ((MI.7.3/100.0) * i1PKEQM)) ;i1 AM hwy time w/eqv  X-X
      MW[71] = Round(MW[2] + ((MI.8.3/100.0) * i1MDEQM)) ;i1 MD hwy time w/eqv  X-X

      ENDIF
ENDJLOOP

      MW[62] = Round(MW[1] + ((MI.7.3/100.0) * i2PKEQM)) ;i2 AM hwy time w/eqv  X-X
      MW[63] = Round(MW[1] + ((MI.7.3/100.0) * i3PKEQM)) ;i3 AM hwy time w/eqv  X-X
      MW[64] = Round(MW[1] + ((MI.7.3/100.0) * i4PKEQM)) ;i4 AM hwy time w/eqv  X-X

      MW[72] = Round(MW[2] + ((MI.8.3/100.0) * i2MDEQM)) ;i2 MD hwy time w/eqv  X-X
      MW[73] = Round(MW[2] + ((MI.8.3/100.0) * i3MDEQM)) ;i3 MD hwy time w/eqv  X-X
      MW[74] = Round(MW[2] + ((MI.8.3/100.0) * i4MDEQM)) ;i4 MD hwy time w/eqv  X-X
```

8. Improve Local Street Network

The regional travel demand model converts the number of blocks in a TAZ (BLOCKS as presented in GIS_variables.dbf) to a floating half-mile average block density in Trip_Generation.s. To adjust this block density calculation, the TAZ-specific block density was calculated by dividing the value of BLOCKS from GIS_variables.dbf by LANDAREA in Zone.dbf. For TAZs in the following areas, the value of BLOCKS was modified such that the TAZ-specific block density calculation results in the desired block density:

- Downtowns and Town Centers – TAZ-specific block density of at least 150 blocks per square mile.
- BRT station areas not in Downtowns and Town Centers – TAZ-specific block density of at least 100 blocks per square mile.

These BLOCKS values were saved to a modified GIS_variables.dbf file.

3. POLICY MEASURE EVALUATION MODELING RESULTS

Tables 2 through 6 summarize the transportation evaluation results for the Year 2015, Year 2050 (Business As Usual), On The Road, and Home Alone Together scenarios. For Business as Usual, On The Road, and Home Alone Together, results without the aforementioned policy adjustments (labeled "Baseline") are presented for comparison alongside results with the policy adjustments (labeled "Policy Adjusted"). The contents of the tables are as follows:

- Table 2 – Mode Split
- Table 3 – Vehicle Miles Traveled
- Table 4 – Travel Time
- Table 5 – Per-Capita Travel Time
- Table 6 – Job Access

As shown on the bottom panel of Table 3, Between Year 2015 and Year 2050 Business As Usual, the population of Montgomery County increases 21% from approximately 1,020,000 residents to nearly 1,240,000 residents while employment in the county increases 36% from approximately 520,000 to 710,000 jobs. Service Population—the sum of population and employment—increases 27% from approximately 1,540,000 to 1,950,000.[2] The same Year 2050 population and employment totals are analyzed in all future scenarios, though the distribution of those land uses varies based on the specification of the particular Alternative Future and the land use policies applied.

Discussion of the transportation results with and without policy measures applied for Business As Usual, On The Road, and Home Alone Together follows the tables.

[2] Totals vary due to rounding.

Table 2 – Alternative Futures Analysis
Mode Split
Montgomery County (Policy Adjusted, non-Policy Adjusted)

	Metric Values							*% Delta: Policy Adjusted vs. Non-Policy Adjusted (Baseline)*			*% Delta: Alternative Future vs. Business As Usual (Baseline)*		*% Delta: Alternative Future vs. Business As Usual (Policy-Adjusted)*	
	2015	**2050 Business As Usual** (Baseline)	**Business As Usual** (Policy Adjusted)	**On The Road** (Baseline)	**On The Road** (Policy Adjusted)	**Home Alone Together** (Baseline)	**Home Alone Together** (Policy Adjusted)	**Business As Usual**	**On The Road**	**Home Alone Together**	**On The Road** (Baseline)	**Home Alone Together** (Baseline)	**On The Road** (Policy Adjusted)	**Home Alone Together** (Policy Adjusted)
Person Trips by Mode (Overall)				*Absolute Number of Person Trips*				*(Alternative with policy adjustment divided by baseline)*			*(Baseline Alternative Future divided by Baseline Business As Usual)*		*(Policy-Adjusted Alternative Future divided by Policy-Adjusted Business As Usual)*	
SOV	1,334,500	1,493,740	1,463,586	1,817,792	1,945,850	1,143,789	1,292,845	-2.0%	7.0%	13.0%	21.7%	-23.4%	33.0%	-11.7%
HOV2	734,338	851,831	872,008	1,054,493	1,087,576	652,455	721,052	2.4%	3.1%	10.5%	23.8%	-23.4%	24.7%	-17.3%
HOV3+	624,281	802,549	1,050,213	1,002,952	1,188,622	612,977	805,725	30.9%	18.5%	31.4%	25.0%	-23.6%	13.2%	-23.3%
Transit	174,282	261,087	356,209	344,776	421,950	191,188	237,596	36.4%	22.4%	24.3%	32.1%	-26.8%	18.5%	-33.3%
Nonmotorized	321,650	514,179	602,724	777,510	769,727	294,456	278,531	17.2%	-1.0%	-5.4%	51.2%	-42.7%	27.7%	-53.8%
Total	***3,189,051***	***3,923,387***	***4,344,740***	***4,997,523***	***5,413,726***	***2,894,864***	***3,335,750***	10.7%	8.3%	15.2%	27.4%	-26.2%	24.6%	-23.2%
Vehicle Trips[1]	**2,296,915**	**2,690,599**	**2,456,940**	**3,152,454**	**3,051,522**	**2,175,802**	**2,126,410**	-8.7%	-3.2%	-2.3%	17.2%	-19.1%	24.2%	-13.5%
Mode Split (Overall)				*Percentage of Total Person Trips*				*(Alternative with policy adjustment minus baseline)*			*(Baseline Alternative Future minus Baseline Business As Usual)*		*(Policy-Adjusted Alternative Future minus Policy-Adjusted Business As Usual)*	
SOV	41.8%	38.1%	33.7%	36.4%	35.9%	39.5%	38.8%	-4.4%	-0.4%	-0.8%	-1.7%	1.4%	2.3%	5.1%
HOV2	23.0%	21.7%	20.1%	21.1%	20.1%	22.5%	21.6%	-1.6%	-1.0%	-0.9%	-0.6%	0.8%	0.0%	1.5%
HOV3+	19.6%	20.5%	24.2%	20.1%	22.0%	21.2%	24.2%	3.7%	1.9%	3.0%	-0.4%	0.7%	-2.2%	0.0%
Transit	5.5%	6.7%	8.2%	6.9%	7.8%	6.6%	7.1%	1.5%	0.9%	0.5%	0.2%	-0.1%	-0.4%	-1.1%
Nonmotorized	10.1%	13.1%	13.9%	15.6%	14.2%	10.2%	8.3%	0.8%	-1.3%	-1.8%	2.5%	-2.9%	0.3%	-5.5%
NADMS[2]	**41.0%**	**45.2%**	**49.4%**	**47.3%**	**47.7%**	**43.2%**	**43.5%**	4.1%	0.4%	0.4%	2.1%	-2.1%	-1.6%	-5.8%

Note:

[1] Vehicle trips include truck trips, which are not included in Person Trips by Mode.

[2] Non-Auto Driver Mode Share (NADMS) is the sum of all person trips made not as the driver of an automobile. This includes 50% of HOV2 trips and 71.4% of HOV3+ trips, assuming an HOV3+ occupancy of 3.5 travelers.

Table 3 – Alternative Futures Analysis
Vehicle Miles Traveled
Montgomery County

	Metric Values							*% Delta: Policy Adjusted vs. Non-Policy Adjusted (Baseline)*			*% Delta: Alternative Future vs. Business As Usual (Baseline)*		*% Delta: Alternative Future vs. Business As Usual (Policy-Adjusted)*	
	2015	**2050 Business As Usual** (Baseline)	**Business As Usual** (Policy Adjusted)	**On The Road** (Baseline)	**On The Road** (Policy Adjusted)	**Home Alone Together** (Baseline)	**Home Alone Together** (Policy Adjusted)	**Business As Usual**	**On The Road**	**Home Alone Together**	**On The Road** (Baseline)	**Home Alone Together** (Baseline)	**On The Road** (Policy Adjusted)	**Home Alone Together** (Policy Adjusted)
Daily Vehicle Miles Traveled (VMT) For Trips Beginning Or Ending In Montgomery County								*(Alternative with policy adjustment divided by baseline)*			*(Baseline Alternative Future divided by Baseline Business As Usual)*		*(Policy-Adjusted Alternative Future divided by Policy-Adjusted Business As Usual)*	
Total	**20,228,973**	**24,012,055**	**22,808,430**	**28,639,289**	**27,604,428**	**19,583,130**	**18,827,231**	-5.0%	-3.6%	-3.9%	19.3%	-18.4%	21.0%	-17.5%
Per Population	19.9	19.4	18.4	23.2	22.3	15.8	15.2	-5.0%	-3.6%	-3.9%	19.3%	-18.4%	21.0%	-17.5%
Per Employment	38.9	33.8	32.1	40.4	38.9	27.6	26.5	-5.0%	-3.6%	-3.9%	19.3%	-18.4%	21.0%	-17.5%
Per Service Population[1]	**13.2**	**12.3**	**11.7**	**14.7**	**14.2**	**10.1**	**9.7**	-5.0%	-3.6%	-3.9%	19.3%	-18.4%	21.0%	-17.5%
Average Vehicle Trip Distance (mi.)	**8.8**	**8.9**	**9.3**	**9.1**	**9.0**	**9.0**	**8.9**	4.0%	-0.4%	-1.6%	1.8%	0.9%	-2.6%	-4.6%
Daily Vehicle Miles Traveled (VMT) on Roads in Montgomery County								*(Alternative with policy adjustment minus baseline)*			*(Baseline Alternative Future divided by Baseline Business As Usual)*		*(Policy-Adjusted Alternative Future divided by Policy-Adjusted Business As Usual)*	
Total	**24,139,544**	**29,091,294**	**27,541,938**	**33,204,115**	**31,715,926**	**24,752,575**	**23,864,394**	-5.3%	-4.5%	-3.6%	14.1%	-14.9%	15.2%	-13.4%
Per Sq Mi	47,613	57,379	54,323	65,491	62,556	48,822	47,070	-5.3%	-4.5%	-3.6%	14.1%	-14.9%	15.2%	-13.4%
Demographics (Overall)														
Population	1,015,273	1,236,998	1,236,998	1,236,998	1,236,998	1,236,998	1,236,998	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Employment	520,172	709,452	709,452	709,452	709,452	709,452	709,452	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Service Population	1,535,445	1,946,450	1,946,450	1,946,450	1,946,450	1,946,450	1,946,450	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Note:
[1] Service Population equals the sum of population and total employment.

Table 4 – Alternative Futures Analysis
Travel Time
Montgomery County

	Metric Values							*% Delta: Policy Adjusted vs. Non-Policy Adjusted (Baseline)*			*Future vs. Business As Usual (Baseline)*		*vs. Business As Usual (Policy-Adjusted)*	
	2015	**2050 Business As Usual** (Baseline)	**Business As Usual** (Policy Adjusted)	**On The Road** (Baseline)	**On The Road** (Policy Adjusted)	**Home Alone Together** (Baseline)	**Home Alone Together** (Policy Adjusted)	**Business As Usual**	**On The Road**	**Home Alone Together**	**On The Road** (Baseline)	**Home Alone Together** (Baseline)	**On The Road** (Policy Adjusted)	**Home Alone Together** (Policy Adjusted)
Total Daily Travel Time	*Travel Time In Hours*							*(Alternative with policy adjustment divided by baseline)*			*(Baseline Alternative Future divided by Baseline Business As Usual)*		*(Policy-Adjusted Alternative Future divided by Policy-Adjusted Business As Usual)*	
...By Vehicle	686,941	924,007	884,867	1,201,869	1,157,869	679,563	657,874	-4.2%	-3.7%	-3.2%	30.1%	-26.5%	30.9%	-25.7%
...By Transit	145,790	216,676	283,261	294,126	350,778	154,137	183,989	30.7%	19.3%	19.4%	35.7%	-28.9%	23.8%	-35.0%
Total	**832,731**	**1,140,683**	**1,168,127**	**1,495,996**	**1,508,647**	**833,700**	**841,863**	2.4%	0.8%	1.0%	31.1%	-26.9%	29.2%	-27.9%
Average Per-Trip Travel Time	*Travel Time In Minutes*							*(Alternative with policy adjustment minus baseline)*			*(Baseline Alternative Future divided by Baseline Business As Usual)*		*(Policy-Adjusted Alternative Future divided by Policy-Adjusted Business As Usual)*	
...By Vehicle	17.9	20.6	21.6	22.9	22.8	18.7	18.6	4.9%	-0.5%	-0.9%	11.0%	-9.1%	5.4%	-14.1%
...By Transit	50.4	49.9	47.8	51.3	49.9	48.6	46.6	-4.3%	-2.6%	-4.0%	2.7%	-2.7%	4.5%	-2.5%

Table 5 – Alternative Futures Analysis
Per-Capita Travel Time
Montgomery County

	Metric Values							*% Delta: Policy Adjusted vs. Non-Policy Adjusted (Baseline)*			*% Delta: Alternative Future vs. Business As Usual (Baseline)*		*% Delta: Alternative Future vs. Business As Usual (Policy-Adjusted)*	
	2015	**2050 Business As Usual** (Baseline)	**Business As Usual** (Policy Adjusted)	**On The Road** (Baseline)	**On The Road** (Policy Adjusted)	**Home Alone Together** (Baseline)	**Home Alone Together** (Policy Adjusted)	**Business As Usual**	**On The Road**	**Home Alone Together**	**On The Road** (Baseline)	**Home Alone Together** (Baseline)	**On The Road** (Policy Adjusted)	**Home Alone Together** (Policy Adjusted)
Daily Travel Time (Overall)		*Travel Time In Minutes*						*(Alternative with policy adjustment divided by baseline)*			*(Baseline Alternative Future divided by Baseline Business As Usual)*		*(Policy-Adjusted Alternative Future divided by Policy-Adjusted Business As Usual)*	
Per Population														
...By Vehicle	40.6	44.8	42.9	58.3	56.2	33.0	31.9	-4.2%	-3.7%	-3.2%	30.1%	-26.5%	30.9%	-25.7%
...By Transit	8.6	10.5	13.7	14.3	17.0	7.5	8.9	30.7%	19.3%	19.4%	35.7%	-28.9%	23.8%	-35.0%
Total	**49.2**	**55.3**	**56.7**	**72.6**	**73.2**	**40.4**	**40.8**	2.4%	0.8%	1.0%	31.1%	-26.9%	29.2%	-27.9%
Per Employment														
...By Vehicle	79.2	78.1	74.8	101.6	97.9	57.5	55.6	-4.2%	-3.7%	-3.2%	30.1%	-26.5%	30.9%	-25.7%
...By Transit	16.8	18.3	24.0	24.9	29.7	13.0	15.6	30.7%	19.3%	19.4%	35.7%	-28.9%	23.8%	-35.0%
Total	**96.1**	**96.5**	**98.8**	**126.5**	**127.6**	**70.5**	**71.2**	2.4%	0.8%	1.0%	31.1%	-26.9%	29.2%	-27.9%
Per Service Population[1]														
...By Vehicle	26.8	28.5	27.3	37.0	35.7	20.9	20.3	-4.2%	-3.7%	-3.2%	30.1%	-26.5%	30.9%	-25.7%
...By Transit	5.7	6.7	8.7	9.1	10.8	4.8	5.7	30.7%	19.3%	19.4%	35.7%	-28.9%	23.8%	-35.0%
Total	**32.5**	**35.2**	**36.0**	**46.1**	**46.5**	**25.7**	**26.0**	2.4%	0.8%	1.0%	31.1%	-26.9%	29.2%	-27.9%

Note:
[1] Service Population equals the sum of population and total employment.

Table 6 – Alternative Futures Analysis
Job Access
Montgomery County

	Metric Values							*% Delta: Policy Adjusted vs. Non-Policy Adjusted (Baseline)*			*% Delta: Alternative Future vs. Business As Usual (Baseline)*		*% Delta: Alternative Future vs. Business As Usual (Policy-Adjusted)*	
	2015	**2050 Business As Usual** (Baseline)	**Business As Usual** (Policy Adjusted)	**On The Road** (Baseline)	**On The Road** (Policy Adjusted)	**Home Alone Together** (Baseline)	**Home Alone Together** (Policy Adjusted)	**Business As Usual**	**On The Road**	**Home Alone Together**	**On The Road** (Baseline)	**Home Alone Together** (Baseline)	**On The Road** (Policy Adjusted)	**Home Alone Together** (Policy Adjusted)
Average Regional Jobs Accessible within 45 Minutes (Overall)								*(Alternative with policy adjustment divided by baseline)*			*(Baseline Alternative Future divided by Baseline Business As Usual)*		*(Policy-Adjusted Alternative Future divided by Policy-Adjusted Business As Usual)*	
...By Auto	1,140,954	1,243,883	1,214,939	1,048,732	1,031,885	1,583,550	1,555,792	-2.3%	-1.6%	-1.8%	-15.7%	27.3%	-15.1%	28.1%
...By Transit	124,914	233,361	290,997	225,243	292,711	251,010	303,689	24.7%	30.0%	21.0%	-3.5%	7.6%	0.6%	4.4%
Average Montgomery County Jobs Accessible within 45 Minutes (Overall)								*(Alternative with policy adjustment divided by baseline)*			*(Baseline Alternative Future divided by Baseline Business As Usual)*		*(Policy-Adjusted Alternative Future divided by Policy-Adjusted Business As Usual)*	
...By Auto	469,699	438,352	583,434	577,174	530,028	659,867	647,624	33.1%	-8.2%	-1.9%	31.7%	50.5%	-9.2%	11.0%
...By Transit	61,888	72,691	152,341	112,501	152,869	121,852	156,354	109.6%	35.9%	28.3%	54.8%	67.6%	0.3%	2.6%

Mode Split

As shown in **Table 2**, the application of the policy measures increases the total number of person trips in all three scenarios: approximately 11% for Business As Usual, 8% for On The Road, and 15% for Home Alone Together. Trips by the HOV3+ and Transit modes increase more than trips by other modes, resulting in an increase in NADMS across all scenarios. The policy measures have the largest effect on increasing NADMS in the Business As Usual scenario (4% increase), while increasing NADMS for On The Road and Home Alone Together by 0.4% each.

Vehicle Miles Traveled

Despite the increase in person trips in the policy adjusted scenarios, as shown in **Table 3**, the policy measures decrease total VMT, both as attributed to trips beginning and ending in Montgomery County and as experienced on roads in Montgomery County. The VMT reduction effect is largest on Business As Usual followed by On The Road and Home Alone Together. Because the county population and employment totals are the same across Business As Usual, On The Road, and Home Alone Together, changes in VMT per Service Population follow the same trend.

Travel Times

As shown in **Table 4**, average per-trip travel times for transit trips decrease for all policy adjusted scenarios. Per-trip travel time results for vehicle trips are mixed depending on scenario, with the policy adjustments resulting in 4.9% longer per-trip vehicle travel times under the Business As Usual scenario in the policy adjusted scenarios and 0.5% and 0.9% shorter per-trip auto travel times under On The Road and Home Alone Together, respectively.

The policy adjustments decrease total time spent traveling by vehicle in all scenarios, generally following the trend in reduced VMT, while they increase total time spent traveling by transit, following the increased number of transit trips. **Table 5** details the total per-capita travel times by auto and transit, which follow the trends in total travel time.

Job Access

As shown in **Table 6**, the policy adjustments modestly decrease access to regional jobs by auto (by between 1.6% and 2.3%); meanwhile the policy adjustments substantially increase access to regional jobs by transit (by between 21% and 24.7%). The policy adjustments' effect on access to Montgomery County jobs is similar for the On The Road and Home Alone Together scenarios; for

Business As Usual, the policy adjustments substantially increase access to jobs by both auto and transit, owing to the relocation of jobs and housing growth related to the policy of concentrating growth in existing commercial areas and transit areas (this policy also applies to On The Road and Home Alone Together, but those Alternative Futures already represent substantial land use growth relocations in their non-policy adjusted versions).