Are we there yet? Smart growth, travel forecasting, and transportation adequacy in Montgomery County, Maryland

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Montgomery County, Maryland has an Adequate Public Facilities Ordinance (APFO) that requires the county’s Planning Board to determine that available or programmed transportation facilities can accommodate the peak-period trips that a proposed residential or commercial subdivision will generate before they can approve that subdivision. This requirement generates nearly continuous discussion among policy makers, residents, property developers, and other interest groups about what it means for a transportation system to be adequate. Since 2007, the county’s biennial growth policy has addressed this issue with a measure called Policy Area Mobility Review (PAMR). The review uses a regional travel-demand model to consider current and future system performance across 32 policy areas that range in size from ten to thirty square miles. The PAMR analysis integrates transit system and roadway system mobility measures, incorporating a county policy that transportation-system equity can be maintained by allowing more congestion in areas with better transit service. The regional nature of the PAMR analysis provides geographic and analytic capabilities beyond the typical traffic-impact study. The Montgomery County Planning Board (MCPB) uses PAMR for both near-term subdivision regulation for compliance with the APFO and long-term master-planning purposes. These characteristics of the PAMR application, plus context-sensitive development-mitigation approaches including peak-hour vehicle trip-reduction measures, additional public transit capacity, and nonautomobile-transportation facilities, help improve the sustainability of new development. This article describes how PAMR has worked and the issues its use has generated in integrating sustainability into the transportation-planning process.

KEYWORDS: regional planning, land use, metropolitan areas, transportation, travel, traffic management

Introduction

At what point does new development overburden a transportation system? How can new development best contribute to a sustainable network? These questions are addressed at different levels of scale and detail by planning and zoning practices around the world and require a careful synthesis of science and policy. The science aspect involves defining reliable, relevant, and consistent measures of effectiveness that can be forecasted. The policy aspect requires developing a system that is coherent and equitable, yet sensitive to judgments by elected officials.

Montgomery County is an urbanizing jurisdiction adjacent to Washington, DC with a long history of applying progressive growth-management strategies. Both the definition and achievement of transportation-system adequacy are topics of almost continuous debate among policy makers and county residents. The consideration of sustainability as part of the adequacy discussion has become increasingly important as the county matures from decades of active greenfield development to recognize that in the face of a growing population, housing stock, and economy, it retains little buildable raw land.

This article explores the state of practice in assessing the county’s transportation-system adequacy. At the heart of the matter is how travel-demand forecasting connects land-use and transportation planning in both near-term and long-term horizons, and how both measurement objectives and tools evolve under such circumstances and enhance sustainability. As an example, the Adequate Public Facilities Ordinance (APFO) provides an alternative review procedure for Policy Area Mobility Review (PAMR) within areas located in close proximity to Metro stations, based on incentives to direct growth to areas served by regular public transit that meets smart growth criteria. This procedure encourages infill development where transit service is plentiful, which reduces traffic congestion and vehicle-miles of travel. Relative to sprawled/automobile-oriented development, the resultant compact/transit-served development is much greener through less carbon emissions.

*The research reported in this article occurred while Dan Hardy was with the Montgomery County Planning Department.
With nearly one million residents, Montgomery County is the most populous jurisdiction in the state of Maryland. It continues to experience intensive growth, having added 200,000 residents since 1990 and is planning for another 200,000 new residents by the year 2030. At the same time, the county has a strong open space-preservation program. Nearly half of its 507 square miles is protected from development by a combination of approaches including agricultural zoning, parkland, and conservation easements. Only 4% of the county’s land area remains both zoned for development and undeveloped (M-NCPPC, 2009a).

Montgomery County has had an APFO since 1973. The APFO requires the Planning Board to determine that public facilities, including transportation and school capacity, will be adequate to support and serve any new subdivision that it approves. The APFO is implemented through the county’s Growth Policy, a resolution adopted biennially by the Montgomery County Council (2009). The APFO and the Growth Policy originated during the era of suburban expansion and were designed to stage development so that there was no gap between the creation of new business and residential communities and the facilities needed to serve them. This APFO was intended to prevent leapfrogging sprawl as vacant land was converted into new communities. The development of a biennial Growth Policy recognized that implementation rules would need to evolve as the county applied its land-use and transportation plans. The biennial review also provides opportunities to coordinate with adjacent municipalities with different development procedures.

Where Is Montgomery County Today?

Montgomery County’s current Growth Policy includes two tests of transportation-system adequacy (M-NCPPC, 2008). One assesses conditions in close proximity to the development site and the other considers the effects of secondary and cumulative development over a larger geographic area. Both tests require applicants for new development to mitigate unacceptable traffic impacts generated by their proposed development projects.

- The Local Area Transportation Review (LATR) test examines transportation impacts on intersections adjacent to, and substantially affected traffic generated by, a development site. The LATR test is similar to traffic-impact studies and statements required by many jurisdictions in the United States (ITE, 2010).
- The PAMR test examines transportation conditions for the 32 policy areas into which the county is divided including all approved (but unbuilt) development in Montgomery County and a six-year forecast of development and infrastructure in the Washington, DC region.

The PAMR process addresses secondary effects of development beyond the immediate site and the cumulative effects of all previously approved development. The process is typically considered part of the nonsite traffic-forecast evaluation described in the recommended practice for conducting transportation-impact analyses for site development by the Institute of Transportation Engineers (2010).

The traffic impact from a single new development is conceptually like the ripple effect from a pebble thrown into a pond. It spreads in all directions and diminishes with distance, as the shorter trips reach their destinations. The cumulative effects of multiple developments can be thought of as the ripple effects of a hailstorm in the same pond. Some of the impacts are additive, while others are offsetting; for instance, some of the trips generated by a new townhouse complex will be intercepted by a new office building nearby. The examination of thousands of simultaneous actions across the region is beyond the scope of any individual LATR study. The PAMR process provides a measure of these secondary and cumulative effects and establishes standards for mitigating them for all developments in a given policy area. This technical analysis provides the basis for regulations requiring appropriate levels of trip mitigation that take into account the need for fiscal sustainability in implementing the master-planned transportation system of an area concurrently with its development. Mitigation actions include trip reduction, transit, nonautomobile facilities, intersection improvements, and roadway construction. Because the PAMR analysis is conducted as a component of the Growth Policy, it does not require study by individual applicants, thus improving the efficiency and reducing the cost of review.

The Planning Department uses travel-demand forecasting to examine the effects of the entire hailstorm of development. The Department’s regional travel demand-forecasting model, TRAVEL/3, is used to develop forecasted travel-demand results for weekday travel and evening-peak periods. The TRAVEL/3 results are used to assess adequacy in the PAMR process. TRAVEL/3 is a traditional four-step model consisting of:

- Trip generation: person-trips generated by land-use type and density with each transportation-analysis zone (TAZ).
The PAMR process adds the incorporation of travel between TAZs.

- **Trip distribution:** person-trips generated in each TAZ that travel to each of the other TAZs within the metropolitan region.
- **Mode split:** travel mode of the person-trips, including single-occupant automobile, multiple-occupant automobile, transit, or nonmotorized mode, such as walking or bicycling.
- **Traffic assignment:** roadways used for vehicular travel between TAZs.

The TRAVEL/3 model incorporates land-use and transportation assumptions for the metropolitan Washington, DC region, using the same algorithms applied by the Metropolitan Washington Council of Governments (MWCOG) for air quality-conformity analysis. The MWCOG is a regional planning organization of Washington, DC area local governments and its transportation staff serve the Transportation Planning Board, the federally designated Metropolitan Planning Organization for the region. TRAVEL/3 provides system-level results that are used directly to obtain the metrics for the county’s PAMR process, described below.

The two-tiered system outlined above is akin to the local and regional concurrency tests proposed for Washington State (Hallenbeck et al. 2006, Samdahl & Pfundt, 2009) and the mitigation-payment system applied in King County (Washington State). Such fee-based systems apply a computer model to allocate the cost of planned or programmed transportation improvements to proposed development according to the relative forecasted traffic impacts of those developments. The PAMR process adds the incorporation of performance indicators for both transit and roadways, as described below.

The PAMR policy area-wide transportation test, introduced in 2007, evaluates two measures called relative arterial mobility (RAM) and relative transit mobility (RTM). The RAM is the speed by which automobile trips move during the evening-peak hour, relative to the free-flow speed. The RTM is the relative speed by which journey-to-work trips can be made by transit, compared to by car. For the purposes of the APFO, the RAM and RTM calculations are based on traffic generated by existing and unbuilt approved development on a transportation network anticipated to be on the ground within the timeframe of the capital program (typically four to six years in the future).

The use of PAMR represents a paradigm shift in measuring the adequacy of the local transportation network. Rather than using a congestion-based measure (i.e., volume-to-capacity ratios on a set of roadway-network links weighted by vehicle miles of travel), PAMR employs the relative travel time, mobility-based metrics of RAM and RTM. For example, RAM reflects the fact that effective roadway-travel time in a typical corridor between point A and point B is a function of travel conditions along links between intersections, as well as the delay experienced at intersections. The use of this metric is in keeping with the monitoring of observed travel times reported in the county’s biennial highway-mobility report (M-NCPPC, 2009b). Relative to the previous capacity-based metric, the mobility-related PAMR metrics are more intuitively consistent with how people generally perceive travel.

The RAM is based on the urban street-delay level of service (LOS) in the 2000 Highway Capacity Manual, published by the Transportation Research Board (2000). This concept suggests that for a trip along an urban street that has a free-flow speed (generally equal to posted speed) of 40 miles per hour (mph), LOS A conditions exist when the actual travel speed is at least 34 mph, including delays experienced at traffic signals. At the other end of the spectrum, LOS F conditions exist when the actual travel speed is below ten mph. These relationships are shown in Table 1.

The RTM is based on the transit-versus-automobile travel-time LOS concept in the 2003 Transit Capacity and Quality of Service Manual published by the Transportation Research Board (2003). This concept suggests that LOS A conditions exist for transit when a trip can be made more quickly by transit (including walk-access/drive-access and wait times) than by single-occupant automobile. This LOS condition is true in the Washington, DC region for certain rail-transit trips with short walk times at both ends and some bus trips in high-occupancy vehicle (HOV) corridors. LOS F conditions exist when a trip

| If the actual urban street travel speed is | PAMR Arterial Level of Service is |
|------------------------------------------|----------------------------------|
| At least 85% of the free-flow speed       | A                                |
| At least 70% of the free-flow speed       | B                                |
| At least 55% of the free-flow speed       | C                                |
| At least 40% of the free-flow speed       | D                                |
| At least 25% of the free-flow speed       | E                                |
| Less than 25% of the free-flow speed      | F                                |

Table 1 Relative arterial mobility (RAM) and arterial level of service (LOS).

Note: Speed ranges based on the 2000 Highway Capacity Manual (TRB, 2000).

1 “Planned” refers to projects recommended in master plans, but not funded in a capital improvement program (CIP). “Programmed” refers to master planned projects which are funded in a CIP or are otherwise the committed responsibility of a private sector entity.
takes more than an hour longer to make by transit than by single-occupant automobile. The RTM incorporates the shortest time path between points for both car and transit modes. The shortest transit-travel time may reflect transit vehicles traveling in mixed traffic (for which transit vehicle stops will result in a slower speed than for the automobile), transit vehicles traveling on a separate guideway (for which the travel time may be faster than automobile even considering station-dwell times), or a combination of the two.

This ratio between automobile and transit-travel times can also be expressed in an inverse relationship, defined by modal speed. If a trip can be made in less time by transit than by car, the effective transit speed is greater than the effective automobile speed. Based on the typical roadway-network speed during the peak period, RTM reflects the following relationship between car and transit trips as described in Table 2.

The PAMR transit LOS and the PAMR arterial LOS standards are inversely related, reflecting Montgomery County’s long-standing policy that greater levels of roadway congestion should be tolerated in areas where high-quality transit options are available. As adopted, PAMR uses the equivalency shown in Table 3.

This equivalency reflects the county’s current policy that any new development occurring in areas exhibiting RAM conditions at or below LOS D threshold must fully mitigate the trips generated by that development. By current policy, the maximum level of trip mitigation is 50% of the trip generated by new development.

The county is divided into 32 geographic policy areas, shown in Figure 1, for the purposes of transportation-system adequacy. Each policy area has a RAM and RTM score. Adequacy standards depicted in Table 3 are based on the relationship between RAM and RTM as depicted in Figure 2. Generally, the greater the RTM, the lower the acceptable RAM score.

### Table 2 Relative transit mobility (RTM) and transit level of service (LOS).

| If the effective transit speed is | PAMR Transit LOS is |
|----------------------------------|---------------------|
| 100% or more (e.g., faster) than the roadway speed | A |
| At least 75% of the roadway speed | B |
| At least 60% of the roadway speed | C |
| At least 50% of the roadway speed | D |
| At least 42.5% of the roadway speed | E |
| Less than 42.5% of the roadway speed | F |

Note: Speed ranges based on the 2003 Transit Capacity and Quality of Service Manual (TRB, 2003).

### Table 3 PAMR transit/arterial LOS equivalency.

| If the forecasted PAMR Transit LOS is | The PAMR Arterial LOS standard is |
|--------------------------------------|----------------------------------|
| A | D |
| B | D |
| C | D |
| D | C |
| E | B |
| F | A |

Source: Montgomery County Council, 2009

If the combined RAM/RTM score for a particular policy area falls “below” the stair-steps as outlined in Figure 2, then new development may receive subdivision approval only if the developer mitigates trip making at the fullest amount required by the County Council (currently defined as 50% of the trips the development would generate). Under current conditions, full mitigation is required in four policy areas: Germantown East, North Potomac, Fairland/White Oak and the nonmunicipal part of the Gaithersburg City policy area.

If the combined RAM/RTM score for a policy area falls into one of the triangular areas of the chart—that is, if it approaches the full mitigation threshold—then partial mitigation is required, depending on how close the combined scores are to either the diagonal line (as low as 5% mitigation) or the stair-step (as high as 45% mitigation).

Using the Aspen Hill Policy Area as an example, the year 2013 PAMR analysis forecasts RAM-related metrics of free-flow and congested evening-peak period arterial travel conditions as follows:

- 159,112 vehicle miles of travel (VMT)
- 4,748 “free-flow” vehicle hours of travel (VHT)
- 9,818 “congested” VHT
- 33.5 mph “free-flow” speed

![Figure 1 Montgomery County Policy Areas (Montgomery County Planning Department).](image-url)
The comparable RTM-related metrics for the Aspen Hill area, a forecast of morning-peak period (journey-to-work) travel-time conditions by automobile and transit combined with the number of work trips by car and transit from Aspen Hill to everywhere else in the region, are estimated to be:

- 36,796 trips to work
- 16% work trips by transit
- 52.7 minutes (average journey-to-work travel time by transit)
- 34.9 minutes (average journey-to-work travel time by automobile)
- 66% RTM

Plotting the combined RAM/RTM score for Aspen Hill (i.e., 48%/66%) results in this area falling into one of the triangular areas on the year 2013 PAMR chart (Figure 2). Given the relative location of this data point to the diagonal line on the PAMR chart, the percent trip-mitigation requirement for Aspen Hill is 20%. A developer of a new project in Aspen Hill would be required to reduce or otherwise mitigate 20% of trips generated by that project using some combination of the mitigation measures depicted in Figure 3. Both the LATR and PAMR tests are applied at the time an applicant seeks subdivision approval. Qualifying projects (those of a certain size that have greater than de minimis impacts—more than 30 peak hour-vehicle trips for LATR and more than three peak hour-vehicle trips for PAMR) must:

- Conduct an LATR study of nearby intersections and
- Address PAMR impacts by mitigating vehicle trips according to the current tabulation of mitigation requirements, which range from 0% of trips in policy areas on the PAMR chart found “adequate” to 50% of trips in policy areas on the PAMR chart found “adequate with full mitigation.”

Development that creates an adverse transportation-system impact is required to mitigate those effects. Figure 3 demonstrates the type and priority of mitigating actions required. The mitigation priority is to first seek mitigating actions that reduce vehicular demand or induce a modal shift to transit or nonmotorized travel. These exactions, described in Figure 3, are supplemented by a transportation-impact tax. This tax can be thought of as a “hookup” charge for development to contribute to the planned expansion of the countywide transportation system, regardless of the conditions in the vicinity of the development site. The transportation-impact tax is established by the Montgomery County Council and based on the estimated cost of master-planned transportation-system capacity. Development exactions based on the results of the LATR and PAMR tests can be thought of as an impact-mitigation ap-
Many exactions required by LATR and PAMR can be credited against the transportation-impact tax if they are used to build master-planned capacity (in other words, facilities included in the impact tax-establishment process).

The PAMR process blends scientific analyses developed by staff with policy decisions made by the County Council.

- The LOS D threshold reflects constituent concerns about vehicle delays. The Planning Board had supported the technical staff recommendation to allow LOS E in the most transit-served areas, recognizing that the maximum throughput of people and goods occurs at LOS E, even though delays to individual travelers are increased.
- The partial mitigation approach (from 5% to 45%) was a policy decision to move from a binary “pass/fail” system to a more finely graded scale. The previously proposed “pass/fail” system would have resulted in PAMR mitigation required in only two policy areas. The County Council determined that tougher standards were required to address constituent concerns about congestion.
- The cap of 50% for full mitigation was a policy decision to move from the 100% mitigation requirement initially implemented, reflecting concern from the development community that full mitigation was prohibitively costly.

**What is an APFO Intended to Do?**

A common misperception is that an APFO is primarily designed to direct growth to certain geographic areas where growth is intended, or to ensure that the development incorporates certain design standards or principles. Generally, this is not the case. In Montgomery County, as in most jurisdictions nationwide,

- *Where* growth should occur is determined by master plans that contain recommendations for the ultimate amount and type of land uses and the public facilities to accommodate those land uses at build out.
- *How* growth should occur is determined by zoning that describes in greater detail what uses are appropriate in given zones and what form the development can take.
- *When* growth should occur is governed by the APFO that ensures that public facilities will be in place concurrent with growth.

Many jurisdictions, particularly in the western part of the United States, have growth-management laws that are termed “concurrency,” rather than APFO. This term reinforces the temporal nature of an APFO law. One concern is that if APFO or concurrency laws are too strict or inflexible, a long-term moratorium may ultimately influence where (i.e.,

![Figure 3 PAMR and LATR approaches to mitigating unacceptable impacts (M-NCPCC, 2008).](image-url)
“not here”) planned growth occurs. This concern is part of the reason that APFO regulations must blend science with policy to support the orderly implementation of planned development.

**How Does an APFO Relate to Sustainability?**

The term “sustainability,” like “smart growth,” is often defined by the user. The Montgomery County Planning Board (MCPB) proposed the following definition of sustainability as related to development in 2007 (M-NCPPC, 2007).

Sustainable development meets the needs of the present without compromising the ability of future generations to meet their own needs. It recognizes the fundamental inexorable interdependence between the economy, the environment, and social equity, and works to promote each to the benefit of all.

This definition is informed by the 1987 Brundtland Commission report that promoted the intergenerational nature of sustainability, as well as by the commonly accepted three pillars of economy, environment, and equity. While the county has not adopted a formal definition of sustainability, the county code reflects these three pillars of sustainability in the purpose clause of the Growth Policy as a “process by which the County Council can give policy guidance to agencies of government and the public on matters concerning land-use development, growth management; and related environmental, economic, and social issues.”

The identification of sustainable transportation-performance indicators continues to be an ongoing challenge, one made particularly daunting by the diverging objectives to be all-encompassing, pragmatic, and authoritative, as noted in current calls for additional research (Sustainable Transportation Indicators Subcommittee, 2009). Proposed sustainable transportation performance-indicator systems typically encompass several dozen diverse measures that are difficult to apply in practice due primarily to a combination of data limitations and complex relationships among the measures (Cormier & Gilbert, 2005). For instance, most planners agree that, all else being held constant, it is desirable to reduce vehicle miles of travel (VMT) to improve environmental sustainability. But the VMT reduction is neither sustainable nor desirable if it occurs because the economy is failing.

The three pillars of sustainability are reflected in the LATR and PAMR elements of the Growth Policy as follows:

- Economic considerations include both ensuring that mobility and accessibility support economic objectives and that mobility infrastructure is affordable. A key APFO concept is that new development pays for its fair share of planned infrastructure.
- Environmental considerations include pursuing travel-demand reduction, promoting transit-oriented and walkable solutions, and providing sufficient mobility to avoid true gridlock, all actions that support air-quality objectives and minimize other environmental impacts.
- Equity considerations include designing for all users and promoting alternative travel options for those who are unable or unwilling to drive.

An APFO can serve as a useful growth-management tool by ensuring that the public and private sectors work together to maintain a desired quality of life. Like most growth-management tools, however, a transportation APFO mechanism is the proverbial double-edged sword. Used appropriately, it ensures that growth that generates travel demand occurs concurrently with the transportation services planned to accommodate that demand. These services can be provided either by the public sector through a capital-improvements program or by the private sector. An APFO will incentivize private sector implementation of public facilities if the development community finds a fiscal rationale for providing the public facilities faster than the government can. An unintended consequence of an APFO, however, can be that growth is actually encouraged at a faster pace in areas where less growth is ultimately desired, based either on the presence of facilities with excess capacity or the lower cost of providing those facilities (TRB, 1998).

Montgomery County uses three mechanisms to match the APFO process with its goal of sustainable development:

- A context-sensitive definition of adequacy, in terms of both the conditions required to determine whether the transportation system is adequate as well as mitigating actions that the private sector can take to address determinations of inadequacy.
- A biennial review to align the definition of adequacy with the goals and objectives of the planning department’s constituency.
- An application of the APFO/PAMR approach to the development of master-plan amendments to ensure that new long-range land-use plans provide a balance between land use and transportation at their end-state.
How is the Measure of “Adequacy” Context-Sensitive?

Montgomery County’s policy areas constitute a transect ranging from urban to rural. Ten of the 32 policy areas are designated “Metro station policy areas”—communities generally within a half-mile radius of a Metro station. At the other end of the spectrum, the largest areas are “rural policy areas” in the county’s agricultural reserve where development is constrained by a wide range of planning and zoning tools.

The context-sensitive definition of adequacy recognizes that equitable transportation service includes all modes of transport, but that all modes will not be developed in equal proportion countywide. High-quality transit and pedestrian connections are not economically or environmentally sustainable in the agricultural reserve. Similarly, high automobile speeds are not feasible or safe in the Metro station policy areas where land values (economics) and a walkable environment (equity) dictate solutions that move a higher number of people (person-throughput) most efficiently, but at slower speeds. In these areas, quality transit service is more practical and effective. Therefore, PAMR defines a relationship between transit-service levels and roadway-service levels; in areas with better transit service, greater levels of roadway congestion are considered acceptable.

This concept is also recognized in application of the LATR process and is illustrated in Figure 4 in terms of the level of intersection congestion allowed in different policy areas. The LATR metric applies intersection critical lane volume (CLV), a measurement of the number of vehicles competing for space at an intersection during the busiest hour (a subset of the total number of vehicles entering the intersection). A CLV of 1600 represents the boundary between LOS E and LOS F, which is generally the point at which the intersection is processing the greatest amount of vehicular throughput. In the agricultural preserve, intersections must operate in the LOS D range (a CLV of 1350), as transit and non-motorized transport options are scarce. Conversely, in Metro station policy areas, a CLV less than 1800 (and perhaps higher if more detailed analysis confirms spillback to upstream intersections is not a problem) is considered acceptable. The CLV LOS standards are set by policy as referenced in the county’s LATR and Policy Area Transportation Review Guidelines (M-NCPPC, 2008).

Finally, the planning department seeks context-sensitivity and sustainability in applying transportation impact-mitigation approaches. From the perspective of sustainability, the priority for mitigation approaches is to:

![LATR congestion levels](image-url)
- Reduce vehicle trips with travel demand-management measures.
- Provide public transit capacity.
- Invest in nonautomobile facilities, such as offsite sidewalks.
- Construct automobile-capacity improvements.

Transit-oriented development and the presence of nonautomobile facilities are well-documented means of reducing vehicle trip-generation rates and improving the internal capture of activity centers (Kuzmyak et al. 2006; ABAG, 2008; Arrington & Cervero, 2008). More research is needed to quantify these values in the context of a subregional travel model, however, where intrazonal trips are typically not loaded onto the network and benefits may therefore not be measured.

These priorities need to be context-sensitive to both land use and the community. While reducing vehicle trips may be the most sustainable approach from a fiscal perspective (reducing the amount of infrastructure and maintenance required), it is not always feasible from the perspective of an applicant. For retail properties in particular, a reduction in vehicle trips is (not necessarily, but usually) an indication of economic failure.

Often the most time-consuming aspect of the mitigation process is developing consensus on an appropriate offsite-mitigation solution given the civic and legal environments. A new turn lane, for instance, may solve a quantitative APFO problem but draw constituent concerns about pedestrian-crosswalk length, or require right-of-way for which eminent domain powers are needed. To streamline the development-review process, smaller-scale projects can mitigate trips through a payment-in-lieu process at which trips are valued at a one-time cost of US$11,000 for each daily peak hour-vehicle trip generated. This value is based on the estimate of Montgomery County’s US$1.1 billion construction cost to accommodate the additional 101,000 peak hour-vehicle trips anticipated by 2030, using a typical impact fee-study process such as described by Wallstedt (1999).

How Do APFO Rules Evolve?

Montgomery County’s APFO policies recognize that times change, and with them public perceptions of the adequacy or acceptability of travel conditions. A biennial review was built into the growth-policy law, requiring the county to examine the APFO rules in light of recent growth, supporting policies, and constituent and stakeholder attitudes. The County Council recently changed the review period to every four years, finding that too little change occurred in the shorter period to justify the amount of time and effort required in the review.

How PAMR Supports Master Planning

As previously described, the APFO is designed as a concurrency test—it prohibits development where master-planned infrastructure necessary to support it does not exist and is not scheduled for timely construction. The master plan itself defines the balance of land uses and transportation facilities considered adequate at the end-state of a master plan. The term of art for this condition in Montgomery County is “balance.” A plan may also contain a staging element that requires certain facilities to be in place and/or mobility-performance standards to have been achieved before a next level of development can proceed. For instance, the Great Seneca Science Corridor Master Plan requires the Planning Board to have found that implementation milestones for the Corridor Cities Transitway and measured progress toward the plan area’s end-state nonautomobile driver-mode share are met before opening any of the master plan’s four stages of development (MNCPPC, 2010).

Community-master plans typically have a useful life span of about two decades, and several throughout Montgomery County are in the process of being amended at any given time. As each plan is amended, the current APFO rules are applied over a 25-year horizon to ensure that the land-use and transportation systems are balanced. By applying a regional travel-demand model, this assessment of balance not only considers new planning and zoning proposals for the community that is the subject of the master-plan amendment, but also the current thinking on land-use and transportation planning for the rest of the county and region.

Where Have We Been?

As Montgomery County has grown over the past four decades, it has nearly completed its greenfield-development phase and is shifting into a mode of promoting more urbanized, infill development. Growing up, rather than growing out, reduces per-capita carbon footprint and provides development densities needed to support the transit components of the county’s planned transportation system. The Growth Policy has evolved as well, shifting from a focus on transportation-system capacity to an emphasis on the resulting mobility. During that time, the county has struggled with some basic questions on growth policy as it relates to transportation-system adequacy:
● How should adequacy be defined? What should be measured, and for each measurement metric, at what point is success defined? In considering these definitions, what is the appropriate balance between mechanical tools and policy judgment? Or between precision and transparency?

● What is the fair share for new development to contribute to either the construction or operation of the county’s transportation system? How should this nexus be defined?

● When conditions are found to be less than adequate, how should impacts be mitigated?

The introduction of a policy area transportation metric in 1986 included the land-use transect; six different area types were defined and LOS standards (ranging from LOS C to LOS E) were assigned to them. The county was still primarily in a greenfield-development mode and the principal objective of growth policy was to ensure that the master-planned highway system was constructed concurrently with development. Therefore, the primary measurement of automobile performance for the policy areas was the volume-to-capacity ratio (weighted by VMT). The transit component was qualitative; the Silver Spring Metro Station, located adjacent to the Washington, DC boundary and served by a multimodal connection to high-quality bus service in the US29 corridor, provided the greatest transit-system accessibility and all other locations in the county were judged relative to this location. By estimating remaining capacity in the system, staging ceilings for jobs and housing levels in each policy area were established using an interactive allocation process.

This approach had two primary limitations. First, the use of a relative transit-system metric based on a comparison to Silver Spring was counterproductive; any improvement to the Silver Spring station would have the unintended consequence of downgrading the performance of every other transit center in the county. Second, the establishment of jobs and housing ceilings reflected an unstable combination of technical analysis and policy judgment; policy makers exercised a greater level of control than ultimately could be justified by technical analysis. For instance, the two sizeable incorporated municipalities (Rockville and Gaithersburg) represent about one-fifth of the county’s development but have independent planning and zoning authority. It was undesirable for county policy makers to cede development potential (as measured by staging ceilings) in unincorporated parts of the county to the two municipalities. So by 2002, the combined remaining staging ceiling capacity of the two municipalities was assumed to be less than zero: ~8,500 households and ~32,900 jobs. An upgrade to a new regional travel demand-forecasting model in 2002 demonstrated that the policy area review process being used was, itself, unsustainable and led to its repeal in the 2003 Growth Policy.

From 2003 to 2007, the county’s APFO test consisted solely of LATR. Many constituents were dissatisfied with the removal of the policy-area test, primarily because of the recognition that even the smartest growth in transit-served Metro station policy areas creates some adverse mobility impacts beyond the boundaries of those areas. In 2007, the policy-area test was reinstated, following substantial discussion of alternative methods and metrics that are described in the following section.

Where Else Could We Have Gone?

In the context of considering alternative area-wide transportation tests to supplement LATR in 2007, planning department staff considered a variety of approaches. The PAMR methodology described above was ultimately selected. Among the approaches considered are those briefly summarized below. A more detailed discussion describing the strengths and weaknesses of each approach follows this summary.

- Proportional Staging: Allow development based on the proportion of the transportation system as a percentage of the master-planned development potential.
- Jobs/Housing Accessibility: Measure opportunities to match available employment locations with available employment locations within a given (and generally acceptable) travel-time budget.
- Travel-Time Variability/Reliability: Consider the consistency of expected travel times from one day to the next with particular concern for “travel-time reliability,” a measure of increasing importance to many transportation-service providers, particularly for transit service and goods movement, as well as for most travelers in private vehicles.
- Refined Policy Area Transportation Review (PATR): Use volume-to-capacity ratios (weighted by VMT) as the metric to assess policy area automobile performance. This congestion-based approach is similar to what was used prior to 2003 in the application of PATR with some refinements in accounting for the quality of transit service and allocations of land use.

As with PAMR, each of these potential alternative methods was rated according to how well it satisfied several characteristics that planning department staff judged relevant to decision makers, as well as to the broader stakeholder community. These characteristics included the following:
Table 4 Characteristics of alternative area-wide transportation tests.

| Alternative Approaches                          | Importance | Relevance | Coherence | Reliability | Availability |
|-----------------------------------------------|------------|-----------|-----------|-------------|--------------|
| Policy Area Mobility Review                   | Good       | Excellent | Fair      | Excellent   | Good         | Good         |
| Proportional Staging                          | Fair       | Poor      | Excellent | Poor        | Good         | Good         |
| Jobs/Housing Accessibility                     | Fair       | Excellent | Poor      | Good        | Good         | Good         |
| Travel-Time Variability/Reliability           | Good       | Poor      | Excellent | Good        | Fair         | Poor         |
| Refined Policy Area Transportation Review      | Fair       | Excellent | Poor      | Fair        | Good         | Good         |

- **Importance**: Are the factors measured of interest to constituents (e.g., residents, business interests, and decision makers)?
- **Relevance**: Are the factors measured appropriate for considering the transportation effects on growth?
- **Coherence**: Are the test results understandable to constituents and are the results of different scenarios intuitive to the decision makers and stakeholders?
- **Reliability**: Does the test measure what it says it does, and can the results be replicated?
- **Availability**: Are the data observable and available today for current conditions and can measures reasonably be forecasted to represent future conditions?

Table 4 contrasts the various alternative approaches based on these characteristics.

Proportional Staging was analyzed in detail twice during the past decade by planning department staff and the methodology continues to spark interest among some stakeholders. Proportional staging is attractive because its basic premise—providing planned transportation capacity at the same time as planned development—closely meets the definition of the APFO. However, the proportional staging process exhibits a fatal flaw in that there is truly no fixed “end-state” condition for either development or transportation service in the county. Adding new projects to master plans increases overall potential system capacity, but concurrently reduces the amount of the master-planned transportation system that is “complete” since the overall system becomes larger.

A compelling example of this fatal flaw is that the addition of a major new transportation project in a master plan, such as the adoption of the Purple Line transitway extension east of the Silver Spring area of Montgomery County, would have exactly the opposite effect of that desired. The Purple Line is a fourteen-mile east-west light-rail line planned to link Bethesda, in Montgomery County, with New Carrollton, in adjacent Prince George’s County. The portion between Bethesda and Silver Spring was added to the Montgomery County master plan in 1990, and the eastward extension to New Carrollton was added in 2010. Because the Purple Line extension would increase the master-planned transportation capacity in the area, the current and programmed transportation capacity would immediately be a lower proportion of master-planned capacity. Therefore, the application of the proportional staging method would result in the Purple Line actually reducing the current staging capacity of any area affected by the project. While this tool is inappropriate for regulatory work, it may be useful as an indicator of progress in capital programming.

Jobs/Housing Accessibility measures how many opportunities for matching housing with jobs exist within a given travel-time budget (such as a 45-minute trip from any given starting point). From a planning perspective, this may be one of the purest measures of the balance between transportation and land use. Jobs/housing accessibility is attractive because it can be improved substantially by either providing additional transportation-system capacity (i.e., achieving greater accessibility by increasing the geographic coverage area within the travel-time budget) or by reallocating land uses (i.e., achieving greater accessibility by increasing the number of destination points within a smaller geographic coverage area). This technique has frequently been used as a means to depict the relative performance of alternative land-use/transportation-system scenarios (see Figures 5 and 6).

A primary concern with the accessibility measure, however, is that it is not particularly meaningful to constituents, as not all jobs are created equal. When planners reallocate theoretical job/housing totals, the jobs that locate in traditionally residential suburban areas may not have the same value to those residents as jobs that locate in a traditional central business district area. A secondary concern is that the measure is not easily understood. For example, a typical worker may currently reach many thousands of potential jobs within a 45-minute trip. But most workers only want to reach one job, and that job is defined by the type of work it entails, as well as many other issues unrelated to transportation. There-
fore, the value of increasing the number of potential jobs within a 45-minute trip by 20,000 or 40,000 with a new transportation project appears to be of limited relevance to most people.

Travel-Time Variability/Reliability considers the consistency of expected travel times from one day to the next. The transportation-system travel-time reliability, also called the travel-time index, is a measure of increasing importance to many transportation-service providers (particularly for transit service and goods movement) and for all travelers (Schrank et al. 2010). Travel time varies based on many external factors. Nonrecurring delay is a term frequently used to describe these factors, where vehicle crashes and other incidents are perhaps the most notable, but other variables of equal importance in determining variability include weather conditions, special events, and system-maintenance activities. The transportation-service industry continues to improve data collection, analysis, and forecasting tools to assess travel-time reliability. A relevant example of a major data-collection and analysis effort that includes a focus on travel times is the Texas Transportation Institute’s annual report on traffic congestion in major metropolitan areas in the United States (see Table 5). However, the information systems needed to make decisions based on reliability are still several years away. Further, while travel-time variability is important to decision makers, its relationship to growth policy is not very strong. This measure appears to be a useful indicator of system performance without being a basis for growth-policy decisions.

Refined Policy Area Transportation Review (PATR) is a slightly modified version of a growth management transportation test used in Montgomery County from 1992 to 2003. Under the PATR test, each policy area was allocated an amount of development (expressed in jobs and housing units) that could be supported by the existing and programmed transportation network. This maximum amount of development that could be approved was called the policy area’s staging ceiling, and was adopted annually by the County Council (M-NCPPC, 2009a).

The method used to determine staging ceilings was called Total Transportation Level of Service (TTLOS), in which congestion standards varied by policy area based on the amount of transit service provided. Traffic-congestion levels were measured using a metric called an Average Congestion Index.
The ACI reflected the average VMT-weighted volume-to-capacity ratio for the local roadways modeled in each policy area.

The TTLOS equation was defined as follows:

$$TTLOS = (Auto\ LOS \times Auto\ MS) + (Transit\ LOS \times Transit\ MS)$$

Where,

- **Auto LOS** = Average Congestion Index (ACI) Standard
- **Transit LOS** = Regional Transit Accessibility (to jobs and households)
- **Auto MS** = Mode Share (MS) for work trips by county residents using automobiles
- **Transit MS** = 1 – Auto MS

This equation was solved for the ACI standard (Auto LOS) for each policy area. By policy, the TTLOS was fixed at the countywide standard of 0.585 (roughly LOS C–).

Planning department staff considered the implementation of minor adjustments to PATR to better account for the quality of available transit service without reliance on a quantitative measure. Such modifications would have generally followed the Five-Group Framework identified in the *Staff Draft Policy Element of the 2003–2005 Annual Growth Policy Report* that identified five basic types of transit-service areas (see Table 6).
The intent was to have a policy area group system that would be more sensitive to transit availability and associate each group with a range of standards of average roadway congestion—the ACI standards. Thus, an investment in a sufficient amount of improved transit service could more likely result in an increase in the staging ceiling for an area because the policy area “moved up” within its group, rather than moving from one group to another in its entirety. A major limitation of this system, however, is that the minor changes desired to allow an area to “move up” incrementally within its group required a quantitative analysis tool to ensure that judgments are not arbitrary. As a result of this assessment, this approach was not considered further for regulatory purposes.

**Conclusion: Moving Forward But Not Quite There Yet**

The PAMR process is currently integral to Montgomery County’s growth policy and its master planning. These efforts were recently recognized by the Transportation Planning Council of the Institute of Transportation Engineers, which presented the Department with the 2009 Best Program Award for the “2009–2011 Growth Policy” study.
However, PAMR has limitations and detractors. Its principal shortcoming is a consequence of its relatively narrow function: to provide a reliable policy base for guiding administration of the APFO and establishing a reasonable balance between land uses and transportation in master plans. Because it averages the mobility experience of drivers and transit users in subcounty policy or planning areas, it does not specify the improvements that must be provided by public agencies or private developers to achieve an acceptable LOS for either mode. By relying on a transportation model that combines all road segments, all transit services, and all travel directions in peak periods it is not sensitive to the experiences of individual travelers to different destinations. And, because it focuses on the overall speed or time of entire trips, it averages out trip segments in which a commuter may experience LOS F with segments where the experience is at LOS A or B. Thus, without the additional analysis provided by the LATR test and other standard traffic-measurement techniques, specific capital or operational improvements in the system cannot be identified.

While “smart growth” groups have generally supported PAMR, some civic associations have opposed its use because it allows higher levels of roadway congestion in areas with better transit service, thus permitting more dense development or redevelopment to occur. These groups also favored a return to the pre-2003 policy-area tests that established housing and jobs ceilings for each policy area. In general, the opposition to PAMR comes from residents in detached single-family homes for whom automobility is highly valued. Other interests, such as pedestrian and bicycle advocacy groups, have supported the relaxed congestion standards and flexibility of mitigation approaches, recognizing that acceptance of slower speeds in highly congested areas facilitates the safety and convenience of those on foot and bicycle.

Developers have been ambivalent toward PAMR. They have liked the certainty it provides of the level of exaction they must provide in each planning area and that they are not required to conduct an individualized study of the area-wide impact of their projects as part of subdivision review. They have been critical of the mitigation requirements and succeeded in persuading the County Council in 2009 to reduce the percentage of trips that must be mitigated to satisfy PAMR.

The Montgomery County Department of Transportation and the County Executive (who, while a member of the Council in 2003, opposed the abandonment of the old policy area review process) objected to the introduction of PAMR (Leggett, 2009) and have since proposed an alternative to it—Transportation Policy Area Review (TPAR)—for use in subsequent growth policies (MCDOT, 2010). The TPAR proposal seeks to separate the measurement of arterial and transit adequacy, thus placing greater emphasis on reducing roadway congestion as a condition for development to proceed. The TPAR process improves upon PAMR by identifying specific transportation improvements that need to be included in subsequent capital budgets. However, it remains unclear whether it provides a better or more easily determined overall assessment of the current and forecasted state of mobility for a policy area. Its details and the extent to which it modifies or replaces PAMR may not be determined before the next round of growth policy, now scheduled for 2012.

In summary, the development community is concerned about the additional costs that the mitigation requirements add to a project and the uncertainty in a system wherein conditions may change on an annual basis. Many elected officials are concerned that a “pay and go” system does not provide sufficient commitment to their constituents that improvements will actually be implemented. And most stakeholders recognize the tension inherent in developing an analytic framework that is sufficiently robust to satisfy technical and legal challenges, yet simple enough to understand and explain; nearly all travel-forecasting tools suffer from the “black box” label.

The planning department is exploring alternative concepts through which transportation adequacy might be explored in future evaluations of sustainable communities and APFO definitions. These concepts reflect current stakeholder concerns that the present system remains insensitive to variables that promote smart growth.

Introducing Vehicle-Trip Length More Directly into the APFO Process

While the PAMR process implicitly incorporates trip lengths within the four-step travel demand-forecasting process, both PAMR and LATR use vehicle trip-generation rates for assessing impacts of and mitigation for new development. The Planning Board Guidelines incorporate transit proximity in vehicle trip-generation establishment. However, recent household surveys have confirmed that households in activity centers (where mixed land uses are concentrated) not only generate fewer vehicle trips, but that those trips are also shorter than trips generated outside activity centers, due in part to diversity and design characteristics not reflected at the regional model scale (Nelson\Nygaard Consulting Associates, 2005).
Incorporating Carbon Footprinting as an Equivalency Measure

The carbon footprint of a development site includes both the activities occurring on-site as well as the carbon required to connect the site to its constituent community. Therefore, a LEED (Leadership in Energy and Environmental Design) platinum building located in an isolated greenfield has a larger carbon footprint than the same building located in a connected activity center, due to the higher per-capita (or equivalent unit) VMT generated by the isolated location. There is general consensus among stakeholders that the VMT component should be included in the definition of development impact. Opinions differ, however, as to whether it is desirable to augment or replace an adequacy definition for mobility (or for another transportation measure such as accessibility or reliability) with an adequacy definition for sustainability. For instance, should a development in a Metro station policy area be able to mitigate its transportation impact by exactions that exchange VMT for other greenhouse-gas credits, such as installing a more effective green roof? These types of equivalencies are becoming more accepted in grading development quality through the LEED rating system, but cross-disciplinary actions are not yet generally accepted as an alternative means to define adequacy within any individual discipline.

Rethinking Local Fiscal Requirements

One of the primary concerns regarding APFO systems in general, and the PAMR process in particular, is that it only tells you what you cannot do. It does not facilitate the development of solutions. Another concern, as previously described, is that APFO tools may discourage planned growth in the most efficient, transit-served locations by making that development artificially expensive if the more efficient trip-making characteristics in those places are not adequately reflected in the APFO. Montgomery County is currently examining adjustments to the PAMR process that would replace the US$11,000 per vehicle-trip valuation with separate values specific to each policy area, reflecting the cost of infrastructure required to achieve adequacy in those areas.

Refining the Incorporation of Sustainable Performance Indicators

The state of the practice in developing sustainable transportation indicators is continually evolving. The primary purpose of an evaluation system such as PAMR is to manage the implementation of a predetermined end-state through the land-development process. However, PAMR is also a tool to re-evaluate the performance of the end-state during the master-planning process. As described in this article, the current process incorporates economic, environmental, and equity considerations. We recognize, however, that additional refinements are warranted, an interest that is shared with both the state of Maryland and the federal government in developing sustainability and livability principles and objectives.

The term “balance” is most frequently described in growth-policy discussions as a condition where the planned transportation systems are adequate to serve the planned land uses. As this article summarizes, the term is also appropriate to describe the balances that must be struck in successive APFO reviews between:

- Theoretical purity and ease of understanding
- Mathematical rigidity and judgment of policy makers
- Quantitative and qualitative values of transportation service, and
- Constituent desire to promote or dampen the rate of growth.

The policy pendulums tend to swing slightly along each of these axes from year to year. The increasing scarcity of land, budgets, and natural resources at both global and local scales has increased the need to incorporate sustainability into each successive APFO amendment. In summary, one of the most sustainable growth-policy elements may be the regular stakeholder review needed for continual course correction toward an ever-moving target.

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