Evaluating Policies to Reduce Vehicle Miles Traveled in the Commonwealth of Virginia

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Disclaimer

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Client Overview

This report was prepared for Amanda Hamm, Program Manager for the Connected and Automated Vehicle Program of the Virginia Department of Transportation.

Honor Code

On my Honor as a student, I have neither given nor received any unauthorized aid on this assignment nor am I aware of any breach of the Honor Code that I shall not immediately report.

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Acronyms

AAA: American Automobile Association
AHUA: American Highway Users Alliance
CAP: Commuter Assistance Program
CAV(s): Connected and Automated Vehicle(s)
CBO: Congressional Budget Office
CPI-U: Consumer Price Index for all Urban Consumers
CTB: Commonwealth Transportation Board
CTR: Commute Trip Reduction
DMV: Virginia Department of Motor Vehicles
DRPT: Virginia Department of Rail and Public Transportation
EPA: Environmental Protection Agency
FHWA: Federal Highway Administration
GHG: Greenhouse Gas
HTW: Highway Trust Fund
HUF: Highway Use Fee
LOS: Level of Service
NHTSA: National Highway Traffic Safety Administration
NSC: National Safety Council
SMART SCALE: System Management and Allocation of Resources for Transportation: Safety, Congestion, Accessibility, Land Use, Economic Development, and Environment
STB: Surface Transportation Board
TNC: Transportation Network Company
USDOT: United States Department of Transportation
VDOT: Virginia Department of Transportation
VMT: Vehicle Miles Traveled
VSP: Virginia State Police
WSDOT: Washington State Department of Transportation

Executive Summary

Transportation policy in the United States has historically favored automobile travel over other transportation modes. Historic and current public policies favoring automobile travel have resulted in a system which encourages excessive vehicle miles traveled. Over 85 trillion Vehicle Miles Traveled (VMT) were recorded in the Commonwealth of Virginia in 2019, 3 trillion more than were traveled in 2010.

Vehicular travel imposes a number of external costs on society in the form of greenhouse gas emissions, worse public health outcomes, and increased highway maintenance costs. To help reduce the budgetary burden created by excess VMT and to improve public health outcomes and traffic efficiency, Virginia should consider policies to reduce annual VMT in the Commonwealth.

This report identifies three alternatives, compared to the status quo, that might assist Virginia in achieving reduced VMT. These options are:

- A commute trip reduction law to reduce commute trips during rush hours
- A highway use fee, otherwise known as a tax on vehicle miles traveled
- A grant program to encourage use of connected and automated vehicles

These alternatives and the status quo policy were evaluated along the criteria of cost-effectiveness, political feasibility, ease of implementation, and equity. Alternatives were given ordinal ranks relative to each other along each criterion. Average ranks of the alternatives and the status quo policy were then used to determine the final recommendation.

This report recommends that Virginia continue its status quo policies governing VMT and transportation in the Commonwealth. Status quo includes indexing Virginia's fuel tax to the Consumer Price Index for urban consumers (CPI-U), an optional highway use fee (HUF) for some vehicles, and continued investment in the infrastructure improvements necessary for new technologies. The impact of the COVID-19 pandemic on transportation in Virginia and the United States remains highly unclear. Should long-term policy changes such as remote work reduce or increase VMT in Virginia, policymakers should be prepared to respond to those changes in a meaningful way. Special attention should continue to be given to a tax and revenue collection system based on VMT, rather than a simple tax on fuel consumption. Raising transportation revenues by proportionally taxing VMT adheres to economic principles of consumer sovereignty and efficient pricing. Though difficult to implement, a VMT tax should be an option policymakers continue to make a reality in the long-run.

Problem Statement

The number of vehicle miles traveled in Virginia is too high. From 2010 to 2019, VMT in the Commonwealth increased by an average of 0.44% each year; from 2015 to 2019, VMT increased by 1.08% on average each year. Vehicle travel decreased significantly in 2020, likely a result of restrictions relating to the COVID-19 pandemic. As a whole number, VMT increased from just over 82 trillion in 2010 to over 85 trillion in 2019. Nationally, VMT increased by 1.07% on average between 2010 and 2019. This difference, however, does not mean that significant costs are not imposed on Virginians as a result of excessive VMT. Excessive VMT imposes costs in the form of traffic congestion, greenhouse gas emissions, road maintenance costs, and public health. The Commonwealth of Virginia should consider policies to reduce total annual VMT.

Introduction

Decades of transportation and land-use management policies in the United States have served to reinforce the dependence of Americans on personal automobiles for most travel. The preference of policymakers to consistently favor this mode of travel should not be surprising; it is a mode with which people are intimately familiar, car ownership is a quintessential aspect of American culture, and for many years automobiles were a highly effective and efficient mode of transportation.

The efficiency of this mode declines, however, when it is the primary mode of travel used by most people. Traffic issues accumulate and aggregate as trip numbers increase, and these issues impose significant costs to society. The most visible and commonly discussed negative externality from automobile travel is traffic congestion, which imposes costs in the form of lost time, wasted fuel, and increased greenhouse gas (GHG) emissions. Likewise, societal dependence on this mode disadvantages those who cannot, should not, or prefer not to drive (Litman, 2022a). Excessive travel increases other costs as well; traffic accidents and fatalities increase as vehicle miles traveled increases, and roadways require repair and replacement at a higher rate. Likewise, reduced VMT produces tangible societal benefits—less reliance on automobiles encourages more activity and exercise, potentially improving public health.

There is a growing consensus that decades of policies favoring automobiles have resulted in "economically excessive travel, that is, vehicle travel for which total costs exceed total benefits" (Litman, 2022a). Neither economists nor transportation experts, however, can say what is the optimal number of vehicle miles traveled in a given jurisdiction might be—such a number would depend on a number of local factors, and might easily vary from day to day depending on road conditions, weather, the availability of other transportation modes, and other factors besides. States and localities have set various goals to either reduce vehicle miles traveled by a certain percentage, or to increase use rates for transportation modes other than drive-alone (i.e., single occupant) automobile travel. In Virginia, broad goals have been set by the Commonwealth Transportation Board (CTB) to improve economic prosperity, accessibility, safety, and public health (*VTrans Strategic Actions,* 2021). Virginia is currently working on several projects to achieve these goals, but no comprehensive plan has been established to date to reduce VMT in the Commonwealth.

Vehicle Miles Traveled

To illustrate the necessity of reducing VMT in Virginia, it is necessary to first illustrate how current VMT levels are economically excessive. Next, it is necessary to explore a few of the more-common policies which have, directly or indirectly, incentivized personal automobile travel over other transportation modes. Finally, this section concludes with a discussion on the usefulness of VMT reductions in achieving various societal goals. The relationship between VMT and other important policy goals, such as climate change mitigation and improved public health, should not be discounted. Reducing VMT ultimately goes far beyond the transportation benefits derived from those reductions, and policymakers would do well to consider the influence transportation policy has on the decisions made by individuals each day.

Fundamentally, economically excessive VMT is caused by policies (in both transportation and urban planning) which have underpriced automobile travel for automobile users. The true cost of traveling by automobile is not reflected in the prices paid by users; road, parking, insurance, and fuel prices do not reflect the marginal cost to society of highway usage. Phrased differently, the current system fails to return savings made to drivers when they reduce their driving (Litman, 1999). Consider the example of free parking. McCahill et al. (2016) found an increase in parking availability from 0.1 space per person to 0.5 was associated with a 30 percentage point increase in automobile share. Such policies have served to increase social costs associated with VMT, but no system exists which rewards drivers for contributing less to those costs.

Even so, free parking is only the tip of the iceberg. At a structural level, evidence for underpriced road travel is found in the periodic near insolvency of the Federal Highway Trust Fund (HTF). When this fund was created by Congress in 1956, it was intended to be a "user-supported fund," with fund revenues coming from federal fuel taxes, federal excise taxes levied on truck users, and interest accrued from investments (*The Highway Trust Fund,* 2017). This has not been the case for several years, however, and the fund now requires periodic Congressional appropriations to avoid insolvency, most recently in November 2021.

Although travelers do not take these policies into direct consideration when making travel decisions, they do consider these policies indirectly. A fundamental question in all decision-making is "who pays, and how much?" For automobile users, these policies have made the answer to that question "Not me, and not much." Distinguishing between types of cost is key—Litman (1999) finds that only 45% of the costs associated with vehicle travel are internal and variable, which is to say they are marginal. Because most of the costs are either external or internal and fixed, drivers do not pay different costs for driving more, and indeed pay fewer marginal costs for more miles traveled.

Condon and Dow (2009) calculated the costs per passenger-mile of several competing urban transportation modes, and their analysis makes this point fundamentally clear. Comparing total costs per passenger-mile (a measurement which includes all external costs except pollution), the authors find a Toyota Prius (a hybrid gasoline-electric vehicle) to be the cheapest option at $1.09 per passenger-mile. By comparison, costs of $1.23, $1.62, $1.64, and $1.68 per passenger-mile were found for modern streetcars/trams, diesel buses, trolleybuses, and light rail, respectively (Condon & Dow, 2009). Although consumers may not be aware of these specific facts, this research shows clearly that automobile travel is often cheaper than other transportation modes, and even in cases where it is not cheaper, it is usually more convenient. It is important to note that these are generally urban options—rural households generally lack access to quality public transportation, leaving personal automobiles to be the only option available to them. Nevertheless, it should be emphasized that externalities associated with excess VMT are concentrated in urban areas. Excess VMT creates more congestion in Fairfax County than it does in Franklin County, which means the cost of VMT is greater to drivers in Fairfax than in Franklin.

In addition to these economic realities, the influence of automobiles on American culture in general must be considered. While this may not appear a salient point for policymakers, it is a fact that automobile ownership was, and continues to be, a status symbol for many Americans. "Car culture" has been an integral aspect of American society since at least the early 1950s—one need not look far to find countless films, books, or other cultural artifacts which glorify automobiles and automobile ownership. It should come as no surprise, therefore, to learn that policies and planning strategies of the past (which have, in turn, defined the policy landscape of the present) took car ownership as a for granted fact of life. Those who did not own cars were assumed to aspire to car ownership. The very concept of urban sprawl, which dominated urban and suburban planning for years, was predicated on car ownership –developers would not have built suburbs unless they expected homeowners to drive their personal (or employer-provided) vehicles for virtually all trips.

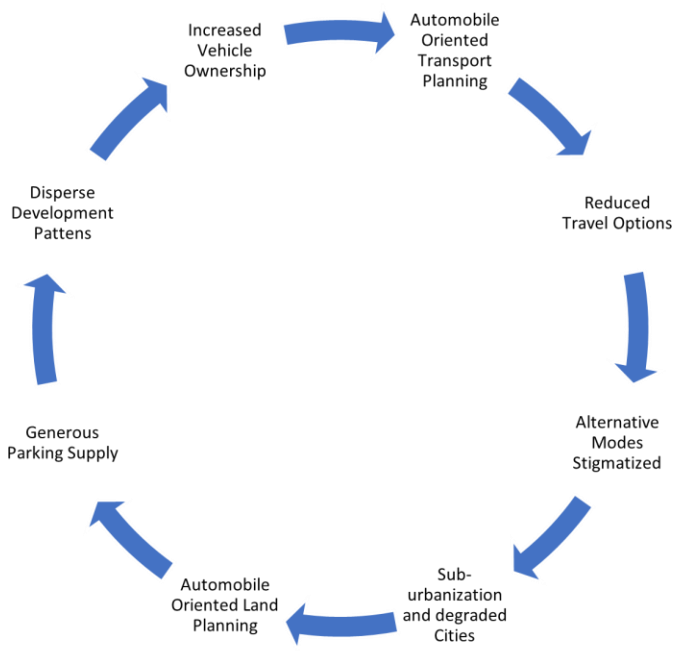

FIGURE 1: CYCLE OF AUTOMOBILE DEPENDENCY AND SPRAWL, COPIED FROM LITMAN, 2022. "ARE VEHICLE TRAVEL REDUCTION TARGETS JUSTIFIED?"

The relationship between car culture, automobile dependency, urban planning, and transportation policymaking is best seen in Figure 1, which shows the cycle of automobile dependency and sprawl as developed by Todd Litman, founder and executive director of the Victoria Transport Policy Institute. In his caption of the image, Litman writes, "This figure illustrates the self-reinforcing cycle of increased automobile dependency and sprawl. Establishing objectives to reduce vehicle travel and increase use of alternative modes can help correct existing market distortions that lead to inadequate transport options, economically excessive automobile travel, and sprawled land use patterns" (Litman, 2022a).

Although land planning policies may be an effective route to limiting economically excessive travel, such policy changes are outside the scope of this analysis. Rather, this analysis focuses on the vector identified by Litman in his analysis of the cycle: reducing vehicle travel and increasing the use of alternative modes. These methods are not mutually exclusive, and indeed some combination of shorter trips, fewer trips, and an increased use rate of alternative modes will likely be needed to reach a social optimum point. Yet in all cases, outcomes are most easily captured in a single measure: vehicle miles traveled.

Reducing VMT is not limited to improved transportation outcomes, such as reduced congestion or increased traffic safety—it can serve larger societal benefits as well. Although it is not necessarily the most effective method of achieving these larger outcomes, it can be highly cost-effective when all costs and benefits are considered

(Litman, 2022a)VMT reduction can help achieve multiple goals which may be of interest to any given community—in addition to traffic safety and reduced congestion, VMT can help achieve monetary savings to consumers, improved mobility, energy conservation, and emissions reductions, just to name a few (Litman, 2022a) Likewise, VMT is a useful metric because it allows for policy alignment between various levels of government and outside organizations; it is an objective and easily measured metric which can inform greatly on the transportation patterns and habits of society (Litman, 2022a).

VMT is further useful as an outcome measure because it is perhaps the only transportation measurement for which quality historical data exists. Other metrics, such as hours of congestion delay, level of service (LOS), or drive-alone rates, have less robust or even nonexistent historical data. For any new public policy, it is necessary to have some metric which permits comparison before and after policy implementation. Although other metrics may be able to deliver more targeted and specific information, they are fundamentally harder to measure, and a lack of historical data precents comparison between policies.

Vehicle miles traveled is a comprehensive metric in that it is correlated with several other outcomes which may be of equal or greater importance to policymakers. It was the known relationship between VMT and automobile emissions which in 2013 led the State of California to require transportation environmental impacts to be evaluated using VMT rather than LOS (Litman, 2022a). The shift from LOS to VMT should be emphasized as it "represents a dramatic shift for the land use and transportation planning fields, which have traditionally prioritized reductions in vehicle delay" (Lee & Handy, 2018). By using LOS as the metric for transportation improvement, it was implied that transportation *is* automobile travel, and vice versa. VMT reductions as the main outcome of new policies and programs serves to redefine what transportation is. At the very least it serves to bring planners and policymakers closer to the realities of surface transportation as experienced by all consumers each day. Transportation is not about getting to a location in the most efficient way *using a motor vehicle,* it is simply about getting to the location in the most efficient way.

Following California's lead, other states and localities have begun to redefine their transportation metrics. Indeed, Virginia was the first state on the East Coast to redefine its transportation metrics through the establishment of the SMART SCALE system in 2014, which is explored in greater detail in the following section.

Despite the obvious utility of VMT reduction as a quality metric, there are some who insist it is not an appropriate measure. Litman (2022a) notes that these critics range from highway advocacy and lobbying groups, such as the American Highway Users Alliance (AHUA) to environmental advocates wo would prefer to focus on increasing the number of "clean" vehicles on U.S. roadways. Concerning groups such as AHUA, their opposition to the metric should not be surprising—the organization represents a

number of companies involved in highway transportation, including automobile manufacturers, who stand to lose the most from reductions in motor vehicle travel. Likewise, although increasing the number of "clean" vehicles is a laudable goal, such a goal remains automobile-focused and potentially limits the utility of non-automobile options.

It is important to note that even the strongest advocates of VMT reduction as a metric, such as Litman, recognize there are legitimate criticisms of the metric. Yet much of this legitimate criticism is merely a function of specific policies and alternatives. Policies and strategies to reduce VMT should reflect basic market principles: "consumer sovereignty, efficient pricing, and neutral planning" (Litman, 2022a). Policies such as alternative driving days (as used in Mexico City and other locations worldwide) defy these principles and should be rightfully criticized for their failure to adhere to those basic market principles. Likewise, it is necessary for coordination among all levels of government before policies are implemented—transportation as a field of policy requires input from all levels of government. For example, state and federal policymakers should not promote policies which would make road travel more expensive if alternatives to road travel are not available, nor should significant funds be invested in alternative modes "without sufficient incentives to encourage their use" (Litman, 2022a). Finally, it must be emphasized again that there is no mechanism which policymakers might use to set specific daily or annual VMT goals to be achieved.

Ultimately, this report uses total annual vehicle miles traveled in the Commonwealth of Virginia as the outcome to be measured. It might be argued that this outcome is too broad, that the appropriate measure should be, specifically, vehicle miles traveled for passenger vehicles. This is a naïve argument. Although it is the case that the most visible examples of the problems posed by excessive VMT are gridlocked passenger vehicles during the morning and evening rush hour, VMT reduction should go beyond these visible mechanisms for reasons discussed above. The following section examines the governance structure of transportation policy in the United States and Virginia.

Governance

Federal Authority

Transportation policy in the United States has always been a combined effort of federal and state governments. At a federal level, the current policy structure flows from the Federal-Aid Highway Act of 1956 and the Highway Revenue Act of 1956 which led to the establishment of the modern U.S. Interstate Highway System (*The Highway Trust Fund*, 2017). In 1966, the federal system was further updated by the Department of Transportation Act of 1966 which established the United States Department of Transportation (USDOT). Under USDOT, the Federal Highway Administration (FHWA) and the National Highway Traffic Safety Administration (NHTSA) were created to oversee federal highway funds and regulate motor vehicles on public roads, respectively. Additional administrations have been added or created under USDOT since the 1960s to address aviation, trucking, railroads, and maritime transportation. Independent of USDOT is the Surface Transportation Board (STB), which primarily focuses on regulations pertaining to interstate commerce.

The principal responsibility of the FHWA is administration of the Federal Highway Trust Fund, which has separate accounts for highways and mass transit. Approximately 84% of the total revenue of these funds comes from federal fuel taxes on gasoline and diesel fuel—18.4 cents per gallon and 24.4 cents per gallon, respectively. The remaining revenue comes from federal sales taxes on tractors, heavy trucks, tires for those vehicles, and an annual use tax on those vehicles *(What is the Highway Trust Fund,* 2020). Congress may also appropriate money for the fund directly, as was the case in November 2021 when the Infrastructure Investment and Jobs Act was enacted and more than $90 billion was appropriated for the highway account and $28 billion was appropriated for the mass transit account (*Status of the Highway Trust Fund*, 2022). Funds from the HTF are disbursed by FHWA to state and local governments as grants; the federal government ultimately accounts for about one quarter of all public spending on roads and highways in the United States (*What is the Highway Trust Fund*, 2020).

In addition to fund oversight and management, the FHWA also promulgates rules and regulations concerning roadway construction and operation. Federal grants disbursed by FHWA are generally contingent upon grant recipients meeting these federal standards, as is the case with almost all federal funding. This structure thus has the effect of setting a baseline standard for transportation infrastructure quality across the United States; it is the reason roads across the country look similar whether they are in California or Virginia. Thus, the primary interest of FHWA has been, and continues to be, the *infrastructure* of transportation.

Equally important to infrastructure considerations are the vehicles which utilize that infrastructure, and regulation on this front is a key responsibility of NHTSA. At a general level, NHTSA determines what is necessary for a vehicle to be lawful on any public road through its creation and oversight of the Federal Motor Vehicle Safety Standards (FMVSS) which have specifications for nearly all aspects of motor vehicle design, use, and performance. These standards are divided into four categories—crash avoidance, crashworthiness, post-crash survivability, and other (i.e., safety concerns outside the scope of these first three categories, such as interior trunk release). As a rulemaking agency and regulator of vehicle safety, NHTSA serves to set a national standard for all motor vehicles (*Mission,* 2019).

For highway transportation in the United States, these two administrations reign supreme. Through their responsibilities, it is seen they exist to set a national standard for transportation which serves to facilitate interstate commerce and make interstate travel easily achievable. The nuts and bolts of transportation—operation, construction, maintenance, and enforcement—is largely a function of state (or local) governments. The federal government helps pay for the costlier aspects of transportation, especially infrastructure construction, but it is largely silent on *how* transportation policy should be conducted. Intuitively, this distinction makes perfect sense—the majority of trips taken daily in the United States are local in nature, and there are too many jurisdictions in the country for the federal government to deal with transportation problems effectively or efficiently.

State Authority

In the Commonwealth of Virginia, transportation issues may fall under the jurisdiction of four separate, independent agencies. The first, arguably the most important for daily travel, is the Virginia Department of Transportation (VDOT), which is tasked with roadway construction, operation, and maintenance. In addition to building and maintaining Virginia's roads, bridges, and tunnels, VDOT further creates rules and regulation concerning all aspects of the physical infrastructure of public roadways in the Commonwealth (*The Commonwealth's Transportation Agency,* 2022).

Most policy alternatives which seek to reduce the total number of vehicle miles traveled will fall outside the scope of VDOT. One example of a policy alternative which would fall under the purview of VDOT are road pricing schemes such as tolls. In any case, all proposed policy alternatives would do well to consider input from the agency as the institutional expertise of VDOT will help inform these policies. Likewise, policies seeking to reduce total VMT rely on VDOT for data collection. VMT figures for Virginia are measured by VDOT through sensors "in or along streets and highways and other sources" (*Traffic Data,* 2022). Data from these sensors are used to provide estimates of daily VMT on all road segments in Virginia for specific groups of facilities and vehicle

types. These data are then published annually by VDOT and are the data upon which the VMT reduction programs considered later in this report are evaluated.

The second agency of import is the Virginia Department of Rail and Public Transportation (DRPT). DRPT has various responsibilities but is nevertheless largely focused on the improvement of transportation in the Commonwealth. At a practical level, DRPT directs and manages funds used to support transportation projects in the Commonwealth which do not involve the construction or maintenance of roadways—carpools and vanpools in the Commonwealth are supported by DRPT, in addition to local public transportation.

For this report, the role played by DRPT as the lead agency for commuter and Transportation Demand Management (TDM) programs must be emphasized. DRPT oversees funds and administers programs which "provide transportation choices, make Virginia's transportation more efficient, and help improve air quality" (*Commuter Programs Overview,* 2022). Statewide, many programs are funded through DRPT's Commuter Assistance Program (CAP) grants. These grants are awarded to proposals which "provide information on commute options to the public, encourage the use of transit, vanpooling, carpooling, and telework, mitigate congestion on Virginia's highways and roads, and improve air quality" (*Commuter Assistance Program Grants*, n.d.).

A third agency which must also be considered is the Virginia Department of Motor Vehicles (DMV). Popular opinion of the DMV may not be high, but it is important to stress that the responsibilities of the DMV extend beyond operator licensing and vehicle registration. The DMV is the collector of the Commonwealth's fuel taxes and further oversees trucking operations in Virginia. Indeed, the DMV is a crucial revenue collector for Virginia, bringing in $2.86 billion in revenue during FY2019 on a budget of just under $260 million (*About DMV,* n.d.). Thus, policy alternatives which seek to reduce total annual VMT through certain taxes are likely to fall under the purview of the DMV.

Across and above each of these agencies is the Commonwealth Transportation Board (CTB). The Board numbers seventeen members: the Secretary of Transportation, the Commissioner of VDOT, the Director of DRPT, and fourteen additional citizen members who are appointed by the Governor to four-year terms and serve at the Governor's pleasure (*Meet the CTB Members,* 2021). In the context of this report, the CTB's role as the administrator of Virginia's transportation trust fund is crucial. Transportation funding in Virginia was significantly revised in 2020 through the General Assembly's enactment of the Governor's Omnibus Transportation Bill, Chapter 1230 (hereafter, "Chapter 1230"). Under Chapter 1230, all transportation revenues in Virginia are deposited in the Commonwealth Transportation Fund and then distributed to various programs and funds. These sub-funds cover all aspects of transportation in

the Commonwealth, across each agency mentioned above. Chapter 1230 further specifies the relative proportions to be distributed to each sub-fund and the prioritization of that funding. Likewise, the CTB is important because it is the final decision-maker in many transportation projects. Therefore, some alternatives proposed in this report may require CTB approval in order to be implemented.

To create the best outcomes, the CTB has used the SMART SCALE scoring system since 2014 to evaluate proposals. This process is similar to the analysis done later in this report; competing proposals are evaluated based on a number of criteria, but the key analysis is a cost-benefit analysis of the proposed project. Projects are then ranked based on their score and the CTB decides which projects will be approved and which will not. Importantly, the CTB is not bound by the ranking of the SMART SCALE system, but CTB proposed changes to project funding schemes must be justified and approved by a majority vote of the Board (*SMART SCALE Technical Guide,* 2022).

The SMART SCALE process has made some ground toward breaking the cycle of automobile dependence. SMART SCALE projects are evaluated using key factors including safety improvements, congestion reduction/mitigation, accessibility, land use, economic development, and environmental impacts (*SMART SCALE: How It Works,* n.d.). Following this evaluation, a cost-benefit analysis of proposed projects is conducted using the cost estimated in the submitted proposal. Thus, proposals which score highest are those which have the highest ratio of benefits to costs; "the evaluation focuses on the degree to which a project addresses a problem or need relative to the requested funding for the project" (*SMART SCALE Technical Guide,* 2022). The factors used demonstrate the Commonwealth's ongoing work toward moving transportation beyond added lanes and new roads. Moreover, the objectivity afforded by SMART SCALE is a marked improvement over the previous funding process which produced considerable uncertainty because of its opaque, highly politicized nature. Importantly, SMART SCALE projects operate on a biennial schedule whereby applications are accepted in March of even-numbered years with final selections made in June of the following, odd-numbered year.

Finally, the role of the Virginia State Police (VSP) in surface transportation should be noted. As the chief enforcement agency of the Commonwealth, VSP is responsible for day-to-day enforcement of the Code of Virginia and any associated rules and regulations. For surface transportation, this role is most easily considered through vehicle inspections. Vehicles in the Commonwealth are required to be inspected annually to ensure compliance with state and federal law, and all vehicles are listed in a database overseen by VSP. The fact that vehicles require annual inspection should not be minimized; such inspections provide a unique opportunity for the collection of revenue or the enforcement of new regulations.

Two factors become readily apparent from this discussion of transportation governance. First is that the state level is the appropriate level for any programs intended to reduce VMT. Although local governments may be more appropriate in some cases, the fact that transportation is chiefly funded by the state supports the state remaining the principal level of analysis. Second, the existing and historical governance structure reinforces the fact that policies have historically encouraged or otherwise taken for granted personal automobile ownership. For example, it is telling that the mass transit account of the Federal Highway Trust Fund was not established until 1983, a full 27 years after the creation of the original trust fund (Davis, 2019). This is further reinforced at the state level, though Virginia has made significant progress in the past decade toward defining a transportation future which considers all modes. Nevertheless, it is clear that policies which seek to reduce the number of vehicle miles traveled in Virginia *must* consider transportation options outside of the historical menu. This process is well underway in the private sector, and government must make up ground quickly if for no other reason than to ensure steady streams of revenue. The following section details the role technology may yet play in reducing total VMT.

The Role of Technology

As with many other fields, transportation in the United States is currently undergoing a technological revolution. With vehicles, this advancement has previously been gradual and slowly effected; vehicles of newer model years are typically more technologically advanced than the previous year's model. Likewise, infrastructure technologies (e.g., red-light cameras, message boards, etc.) are deployed gradually to allow sufficient time to work out various issues and perfect the technology. Nevertheless, rapid changes have taken place over the previous decade which have redefined transportation and transit.

Arguably the first (and most impactful) of these transformations was the introduction of ride hailing services such as Uber and Lyft. Uber and Lyft profoundly shifted transportation habits, especially in urban areas. Nevertheless, the benefits these companies afforded to travelers, namely convenience and ease, must be weighed against the costs imposed on society broadly. Diao et al. (2021) studied the impact of transportation network companies (TNCs) on urban transportation using fixed-effect panel models based on metropolitan statistical data. The authors found that the entrance of TNCs to the transportation market led to a 0.9% increase in congestion intensity, a 4.5% increase in congestion duration, an 8.9% decline in transit ridership, and no statistically significant change in levels of vehicle ownership. These impacts are not insignificant, and the loss of revenue from declining levels of transit ridership could have a major impact on state and local budgets, especially if transit ridership rates do not recover in the aftermath of the COVID-19 pandemic.

The introduction of Uber and Lyft opened the floodgates to additional services intended to improve transportation options. Services offering shared e-bikes and electric scooters for short trips have proliferated, and many companies sell the same products for private ownership. With shared transportation options, it is essentially a requirement that the service have a smartphone application and the ability to pay through it. As new technologies continue to be developed and applied, new transportation services will continue to proliferate.

Historically, government has failed to keep pace with modern technological advancements, and the transportation field bears out this fact. Private companies have successfully profited from the use of new technologies, but such profits are inefficiently passed on to government budgets, if they are passed on at all. Virginia has attempted to combat this reality by enacting a Highway Use Fee (HUF) in 2020 for electric vehicles and fuel-efficient vehicles (defined as vehicles with a combined fuel economy of 25 miles per gallon or greater). This fee is indexed to fuel tax rates and is further based on average miles traveled in a year. In practice, however, this means that the state receives

no revenue from electric vehicle miles traveled in excess of average miles traveled (*Mileage-Based User Fee Program Interim Report,* 2021; *Surface Transportation,* 2021).

It is incumbent upon all levels of government to utilize new technologies to recoup the losses in revenue from more fuel-efficient vehicles and, indeed, from future programs and policies seeking to reduce total annual VMT. Policymakers should not shy away from new technologies simply because they are new. Rather, policymakers should endeavor to utilize technology effectively to maximize positive outcomes and minimize costs to government. These costs are not insignificant, and whether they are borne by individuals, governments, or society broadly they must be considered to better illustrate the problem of excessive VMT.

Costs

Excess VMT imposes a number of costs on society which might be reasonably expected—wasted fuel, emissions from that wasted fuel, and traffic congestion resulting in lost time. Equally important to consider are the public health costs associated with excess VMT, such as traffic fatalities. Finally, the cost of excess VMT as it relates to highway maintenance is important, as greater road use (i.e., higher VMT) results in greater maintenance costs and more rapid depreciation of highways and streets. Accurate measurement of these costs to Virginians is challenging, but this section endeavors to quantify the largest of these costs to best illustrate the true cost of highway travel.

Vehicle Operating Costs

The first costs to consider, arguably the most important on a daily basis, are the vehicle operating costs imposed on individual consumers and drivers. These are the costs which drivers most commonly consider when deciding how much to drive; if the cost per mile driven increases, it stands to reason that people will drive less on average. Yet, because of the depreciation and the significant capital costs associated with purchasing a vehicle, it generally costs consumers *less* per mile if they drive more miles. The American Automobile Association (AAA) provides annual estimates for driving costs, and their analysis bears out this fact. According to AAA, in 2019 the weighted average cost for a vehicle driven 10,000 miles per year is about $0.79 per mile. At 15,000 miles driven, this number declines to $0.62 per mile, and at 20,000 miles the cost further decreases to $0.53 per mile (*Your Driving Costs,* 2019). This is not to say that it is wholly cheaper to drive more, as more driving at the very least depreciates vehicles faster and requires more fuel. Using an estimated average of 15,000 miles driven per driver per year, this means that total costs for vehicle operation in Virginia, as paid by consumers, totaled just under $53 billion in 2019.

Highway Costs

Highway costs as a result of excess VMT are best explored in two forms. First are the costs associated with repairing and maintaining existing roads. For the base year, these costs are assumed to be equal to the budget allocated for VDOT's Highway Maintenance and Operating Fund in FY2019, which totaled just under $2.2 billion. These costs are expected to grow in future years, and declining revenues have resulted in transfers needing to be made from the construction fund to the operating fund to cover costs (*VDOT Annual Budget: Fiscal Year 2019,* 2018). The budget of VDOT's highway fund is projected to grow equal to projected inflation in this analysis.

Equally important to consider is the value associated with all Virginia roads. Pricing the value of a road network is no easy task, and it is important to note that such value can change quickly over time as other factors (e.g., employment rates, regional economic growth, etc.) change. Despite these challenges, the Bureau of Economic Analysis (BEA) calculated the value of all roads in the United States in 2019 to be just over $3.8 trillion (*Fixed Assets Accounts Tables,* 2022). In 2019, VDOT was responsible for 164,132 public road lane miles, approximately 1.9% of all public road lane miles in the United States (*State Statistical Abstracts 2019: Virginia,* 2019). It is assumed that the value of roads at a state level is equivalent to the percentage of national road lane miles in that state, so the value of Virginia's road network in 2019 is estimated at $72.84 billion. This figure, however, is not the cost associated with VMT, rather it is necessary to consider the depreciation of that value over time. Calculating the depreciation of these assets over time, assuming no additional construction or improvement will occur, is no easy task and there is considerable debate as to what an annual depreciation value for highways and streets should be. I estimate the yearly depreciation value to be 2.1%, meaning depreciation costs in the base year are estimated to be just over $1.5 billion, declining by 2.1% each year.

Emissions

Reducing total vehicle GHG emissions is perhaps the most cited reason for using VMT as a metric instead of LOS (Litman 2022a). The relationship between VMT and carbon dioxide levels is well documented; according to the Environmental Protection Agency (EPA), the average passenger vehicle emits about 404 grams of carbon dioxide per mile (*Greenhouse Gas Emissions,* 2018). Using total annual VMT in Virginia for 2019 (about 85 trillion), this means about 38 million tons of carbon dioxide were emitted by vehicles traveling on Virginia highways in 2019. Using a social cost of carbon dioxide of $51 per ton (Rennert et al., 2021), this means emissions from vehicles traveling in Virginia in 2019 had a total cost of about $1.94 billion in 2019. It should be noted here that this figure assumes *all* VMT in Virginia comes from gasoline-powered passenger vehicles. Factually, this is not the case, but the magnitude of difference is likely not large enough to impact the overall analysis. What is important to remember is that less VMT means less emissions, and these emissions are far costlier in aggregate than any individual likely imagines them to be when deciding whether to drive. Expressed in terms of VMT, GHG emissions imposed societal costs of about $0.02 per mile in 2019.

Congestion and Lost Time

The costs imposed on Virginians from congestion as a result of excess VMT is highly salient for policymakers and individuals seeking to reduce congestion. A February 2020 report from TRIP, a national transportation research nonprofit, found that congestion cost Virginia drivers $4.6 billion in 2019 as measured based on wasted

fuel and lost time. It is important to note that these costs are not borne equally by all Virginians, and that this figure was calculated from the standpoint for Virginia drivers rather than all Virginians. Unsurprisingly, the report found that the highest costs were borne by drivers in Northern Virginia and the Washington, D.C. metro area where cost per driver was estimated to be $2,015, compared to a cost of $510 per driver in the Roanoke metropolitan area. These figures were calculated based on the Texas Transportation Institute's Urban Mobility Report (published annually), which is the same data source for a number of statistics published by the federal government (*Virginia Transportation by the Numbers,* 2020).

Congestion costs in future years were based on this $4.6 billion figure, assumed to grow with inflation over the next decade. This means that, for 2033, costs associated with congestion are projected to be more than $6.7 billion.

Public Health

Public health costs resulting from excess VMT include the cost of automobile collisions resulting in injury or death—greater VMT results in a greater number of automobile collisions—and the cost to society from reduced physical activity as the result of reliance on automobiles for travel (Currey et al., 2014).

In 2019, there were 128,172 traffic crashes in Virginia resulting in 827 fatalities and 65,708 injuries. In relation to VMT, this means there were 0.93 fatalities for every 100 million vehicle miles traveled. Several studies support the argument that traffic fatalities and injuries increase as VMT increases (Mohan, 2008; Bose et al., 2011). The National Safety Council (NSC) calculates the cost of traffic crashes using wage and productivity losses, medical expenses, administrative expenses, motor-vehicle damage, and employers' uninsured costs (*Guide to Calculating Costs,* n.d.). NSC estimates the economic cost of a traffic fatality to be $1,704,000, thus the total cost of traffic fatalities in Virginia was over $1.4 billion in 2019. This report does not consider the cost of accidents beyond fatalities due to the significant variation in the cost of traffic injuries and accidents which do not result in injuries. Again, the point here is to show that decreasing VMT serves to decrease the number of accidents in general, which in turn reduces costs, both in terms of injuries and fatalities, but also the cost of congestion associated with traffic crashes.

More difficult to quantify are the effects of excess VMT on everyday public health outcomes such as obesity and hypertension. Ewing et al. (2003) found that residents of counties in the United States with higher per capita VMT were less likely to walk for leisure and more likely to be obese, have higher Body Mass Index, and experience hypertension. The causes of these findings are inherently tied to policies of automobile dependency which result in cities and neighborhoods which are less accessible to non-automobile transportation modes. Although a monetary cost of these

effects is not calculated here, policymakers should still consider how different policies either encourage or discourage healthy activity such as daily exercise.

Evidence from Other Jurisdictions

Although a number of states have set targeted goals for VMT reduction or a related driver metric (e.g., transportation-related emissions reductions), fewer states have established programs clearly designed to achieve these goals. Likewise, some states have created programs which do not necessarily have the goal of reducing total VMT but may still do so. These policies include pricing mechanisms intended to make the cost of road travel more accurately reflect the costs to society of building and maintaining highways, incentives for alternative travel modes, and transportation demand management programs intended to change commuter behavior. This section details those policies and programs which are most relevant to this report.

Washington State: The Commute Trip Reduction Law

In 1991, Washington State enacted a Commute Trip Reduction (CTR) law as part of the Washington Clean Air Act to "reduce carbon emissions and traffic congestion on the state's busiest commuter routes" (*Commute Trip Reduction Program,* n.d.). Although reducing VMT was not the stated goal of the law, VMT is one of the main outcome measures used. The law is applicable to "worksites with 100 or more full-time employees who begin their shift between 6 and 9 a.m. on weekdays in the nine most populous counties in the state" (*Commute Trip Reduction Program,* n.d.). Originally implemented and administered at a state level, the CTR Efficiency Act of 2006 effectively devolved the administration of the program to localities (*About the Commute Trip Reduction (CTR) Law,* 2018).

Under the CTR law, qualifying worksites (hereafter, "employers") are required to create and manage their own programs based on strategies identified as having the greatest effect on their employees and local goals and ordinances pertaining to reducing trips and VMT. To measure progress toward meeting the established goals, employers are required to conduct surveys of their employees biennially to measure VMT and the mode choices of their employees (*Commute Trip Reduction Program,* n.d.). Likewise, employers are required to have an individual who acts as the Employee Transportation Coordinator (ETC) and is the primary contact between the employer and government (*Commute Trip Reduction,* n.d.). Finally, employers must submit their program report to their relevant locality biennially for review and approval. It is important to note that there are no specific penalties for employers who fail to meet established goals; employers are merely required to "exercise a good faith effort" in collaborating with government in the administration and implementation of the law(*Commute Trip Reduction: Basic Introduction,* n.d.). Although administration has devolved to local jurisdictions, the Washington State Department of Transportation (WSDOT) continues to provide technical assistance to both localities and employers to ensure established goals are met.

The results of enacting the CTR law in Washington State show great promise for other jurisdictions seeking to reduce VMT. From 2007 to 2016, the average VMT per surveyed employee declined by 7.4 percent in King County, the most populous county in the state. In totality, the program serves to reduce VMT, on average, by about 79 million miles each year. King County estimates this reduction correlated with a 3.7 million gallon reduction in fuel consumption, equivalent to about $10 million in commuter savings and an annual GHG reduction of 33,500 metric tons (*About the CTR Law,* 2021).

Oregon State: "OReGO"

Another promising strategy which may be applied to VMT reduction goals is Oregon State's "OReGO" program. Notably, this program as it currently functions is not intended to reduce statewide VMT, but rather it is a pricing mechanism intended to operate as an alternative to the state fuel tax. Essentially, it is intended to substitute a tax on VMT for a fuel tax. For every vehicle mile traveled, participants are charged 1.9 cents per mile traveled. Revenues from this tax are deposited directly into the state's highway fund. Participants are reimbursed for any fuel taxes paid while participating in the program in order to avoid double charging, and state law prohibits reimbursement greater than the road charges to ensure the program cannot be abused.

At a practical level, vehicles participating in OReGO are equipped with a device installed into their on-board diagnostics (OBD) port, standard on all cars manufactured since 1996 (Bock, 2021). Participants in the program are able to choose from one of three "account managers," each with its own pros and cons, and the installed device records and reports VMT to the chosen manager. All participants receive periodic statements detailing road charges and fuel tax credits (if applicable) (*How it Works,* n.d.). To incentivize participation in this program, additional vehicle registration fees for electric and highly efficient (40 MPG or better) vehicles are waived such that owners pay only the base fee of $43 per year (Jones & Bock, 2017). Without these fee waivers, such vehicle owners could reasonably expect to pay hundreds of dollars in additional registration fees.

This program is not intended to reduce total VMT in Oregon, although it may very well have that effect; more data is needed to determine the program's impact on VMT, but it may be impossible to do so until such time as the program is enacted for all Oregon drivers (a policy which the Oregon State legislature is considering). VMT pricing which accurately reflects the cost of road travel can be reasonably hypothesized to reduce VMT *if* it is the case that excess VMT is, at least in part, the result of underpriced travel. Despite the lack of evidence for the program's effect on total VMT in Oregon, this policy alternative represents a significant step toward government embrasure of technologies which can benefit both state budgets and ordinary citizens.

Criteria

The alternatives presented in this report will be evaluated along the following criteria. Methodologies for each criterion are discussed in greater detail in the **Methodology** section.

Cost-effectiveness

A highly important criterion, cost-effectiveness measures the net present value of all costs associated with a given alternative, divided by the projected number of vehicle miles traveled in the final year of the observation period. Although this criterion is quantitative, several assumptions must be made for each proposed alternative. Ultimately, this alternative is intended to measure the relative cost for the proposed alternatives to reduce VMT; lower values are perceived as more effective than higher values.

Political Feasibility

This criterion focuses on the political feasibility of the given alternative. This is a highly important qualitative measure, as structural changes to transportation policy in Virginia require approval of the General Assembly. It is key to emphasize that feasibility is considered at a state level, rather than a national level. Support for a given policy will be important in the General Assembly broadly, but key decision makers must likewise support the given alternative. These decision makers include relevant committee chairs, party leaders, the governor, and relevant stakeholders. Metrics to indicate support might include previous votes on similar issues, press releases, and speeches.

Ease of Implementation

Legislative and gubernatorial of a policy is not the entire policy story. For all alternatives, it is important to consider the relative complexity of implementation in practice. As with political feasibility, this is a qualitative criterion which requires some measure of quantitative facts to adequately assess. At a base level, policies which are more technically complex and require input from multiple agencies will be more difficult to implement than policies which call for minimal changes within a single agency. Likewise, policies requiring additional rule and regulation promulgation will be easier to implement than those which do not. This criterion further takes into account the anticipated time required for program maturity.

Equally important to these structural considerations are agency staff opinions on a given alternative. At a minimum, existing staff must have the right skills necessary to

begin implementing the alternative. Staff should also be in general support of the policy; staff may drag their feet or even resign before implementing a particularly unpopular alternative. Finally, it is again important to consider the importance technology plays in implementing a given alternative. If staff are required to master a new technology, or if the alternative requires significant technological hurdles to overcome, it will be more difficult to implement.

Equity

All considerations of equity, regardless of policy area, necessarily involve balancing the interests of one group against the interests of another. Ultimately, attempting to satisfy all competing interests is not possible; any attempt to do so would see a policy collapse in on itself before it could be truly implemented. In such cases, it is most important to identify two groups whose interests will be strongest in the chosen area. With the case of policies designed to reduce total VMT, these groups are those who drive the most by necessity and those who drive less.

Travel in motor vehicles is inherently more important to the daily lives of some individuals than it is to others. Some individuals are faced with extenuating circumstances that prohibit them from making any significant changes to their regular travel habits—those living in rural areas would likely fall under this umbrella. Others, however, may make a number of trips which are ultimately unnecessary, or at the very least economically excessive—driving to the grocery store, driving home, and then driving back to the grocery store for another item would be one such example. Policies which seek to reduce the total annual VMT in Virginia will necessarily impact those who drive the most for necessity, especially if those policies involve increasing travel prices as paid by drivers.

Methodology

Prior to determining the impact of various policies on future VMT, it is necessary to first set a baseline projection for VMT the observed period. In this case, the projected period is ten years into the future (i.e., 2033). Projections were made by first calculating annual VMT in Virginia in the base year, 2019. 2019 was chosen as a base year for these calculations due to the enormous discrepancy between 2019 and 2020 VMT numbers as a result of the COVID-19 pandemic. It is assumed in this analysis that VMT figures for 2021 and later years will be similar to, if not greater than, VMT observed in 2019. According to FHWA, total national VMT is expected to increase at an average annual rate of 0.7% between 2019 and 2049 (*Forecasts of Vehicle Miles Traveled,* 2021). VMT reductions for the various policies considered are based on these projections and are detailed in the relevant subsections for each alternative.

Costs associated with these alternatives are categorized on the costs detailed above. With the exception of highway depreciation, cost projections were made based on the total cost of each category per VMT in the base year. These costs were then projected to grow with the average inflation projected by the Congressional Budget Office (CBO) over the 2021–2031 period, which is 2.1% (*An Update to the Budget and Economic Outlook,* 2021). Once these costs per VMT in the projected years were calculated, they were then multiplied by the projected VMT for each year in the observation period. The net present value (NPV) of these costs were then calculated using a discount rate of 3% (Cellini and Kee, 2010) and divided by the total VMT projected to be observed in the final year, 2033. The results from these calculations were then used to rank the different alternatives on the same scale used for other criteria.

Ranked scores for the criteria of *political feasibility, ease of implementation, and equity* were assigned based on the qualitative components detailed in each criterion subsection. Average ranks along each criterion were then calculated, with special consideration given to the *political feasibility* and *ease of implementation* criteria. These criteria were considered more important than cost-effectiveness and equity given the already high costs associated with excess VMT. The outcomes matrix at the end of the **Alternatives** section details these results. VMT calculations and NPV calculations and cost tables are reported in the **Appendix.**

Alternatives

Status Quo: Fuel Tax Indexed to CPI--U

The first alternative considered must necessarily be the status quo policy for reducing VMT, such that there is one. Although Virginia does not have a policy or goal to reduce statewide VMT, the impact of an annually increasing fuel tax on driving habits should be considered. In 2020, the General Assembly passed a law to increase Virginia's tax on gasoline and diesel fuel to 26.2 cents per gallon by July 1, 2021, and thereafter increase the tax annually by indexing it to the consumer price index for urban consumers (CPI-U). Although a new policy, the tax increase is not associated with any new costs for the Commonwealth (SB 890, 2020).

Given that this policy is the status quo, the cost-effectiveness analysis for this alternative is calculated as the NPV of all costs divided by the VMT projected to be observed in 2033 using the 0.7% average annual growth rate. This policy ties with *Alternative 1* on this criterion—$8.02 in NPV total costs is worth one vehicle mile traveled in 2033. It should be noted, however, that there is considerable uncertainty surrounding this estimate. The impact of fuel tax increases on consumer behavior is a topic much explored by economists, and it is possible that annual increases in the fuel tax may reduce VMT in the long-run. It is also possible, however, that fuel tax increases will have no effect on VMT in the long-run as consumers may respond to the increases by purchasing more fuel efficient or even electric vehicles. Policymakers in Virginia should investigate the impact these fuel tax increases have on VMT in future years.

The status quo policy scores highest in terms of both *political feasibility* and *ease of implementation*. This policy is already in place in Virginia. Although Governor Youngkin and other lawmakers have endorsed a "gas tax holiday" in Virginia in response to fuel price increases associated with the Russo-Ukrainian War, no statements or other information was found to suggest that such a holiday would not be longer than a few months. Governor Youngkin submitted a bill to the General Assembly in April 2022 which would suspend the Commonwealth's fuel tax in May, June, and July, phase the tax back in the following two months, and limit future annual increases of the tax to 2% (Delaney and Pointer, 2022). Passage of the measure would require bipartisan support and is by no means guaranteed, especially considering the negative impacts such a holiday would have on Virginia revenue. For the same reasons, implementation likewise scores highest—Virginia has levied a fuel tax since 1923 and increasing the value of the tax poses no additional implementation challenges (Stephens, 2021).

In terms of equity, this policy ranks third among the options considered. Although fuel taxes are a tax on consumption and may be approximated as a tax on vehicle travel in general, such taxes do not distinguish between income or more fuel-

efficient vehicles. Taxes on consumption are therefore regressive, as lower income households spend a greater proportion of their income on the tax than wealthier households, and wealthier households are more likely to own better and more fuel-efficient vehicles than low-income households (Litman, 1999; Ferrel and Reinke, 2015).

Alternative 1: Commute Trip Reduction Law

This alternative calls for passage of a Commute Trip Reduction (CTR) law by the Virginia General Assembly modeled on the existing CTR law in effect in Washington State. Qualifying localities under this law would be all cities, counties, and city-county combinations in Virginia with a population greater than 100,000. These localities include those in Northern Virginia (Fairfax County and City, Prince William County, Loudon County, Arlington County, Alexandria City, Stafford County, and Spotsylvania County), the Richmond metro area (Richmond City, Chesterfield County, Henrico County), the Charlottesville metro area (Charlottesville City and Albemarle County), the Hampton Roads area (Chesapeake City, Newport News City, Norfolk City, and Hampton City), and the Roanoke metro area (Roanoke City, Roanoke County, and Salem City) (U.S. Census, 2020).

As with the Washington State CTR law, employers subject to the law would be those with worksites in the designated counties and cities with more than 100 full-time employees who begin their shifts between 6 a.m. and 9 a.m. on weekdays. A comprehensive estimate of the number of employers and employees affected by this law was not made for this report due to lack of quality data—rather, I assumed an even 800,000 employees would be affected (about 20% of all employees in Virginia). This assumption is based on data from Seattle which reported that over 139,000 employees in that city are impacted by CTR daily (*Commute Trip Reduction: Basic Introduction,* n.d.).

Under this alternative, qualifying employers would be required to develop a plan to reduce daily VMT of employees biennially and these plans would be submitted to DRPT for approval. Likewise, employers would be required to conduct biennial surveys of their employees to determine their typical commute patterns and the VMT produced by their commutes. This program would not set any standard for VMT reduction, as setting an arbitrary standard could potentially have a negative impact on economic growth and productivity.

Conceptually, this alternative suggests that people drive alone to and from work because they are simply not aware of viable alternatives—if people were able to understand savings produced from commuting in other modes, then people will engage in those other modes so they can save money. Despite this consideration, however, employers would still be expected to reduce per person VMT in each period. Should per person VMT increase in the biennial period, program administrators would work closely with employers to devise a better plan that is capable of reducing employee

VMT. Finally, under this law employers would be required to make available to their employees their plan and take special care to ensure employees are aware of the transportation options available.

In terms of *cost-effectiveness,* this alternative ties with the status quo. The total NPV of costs associated with the program is over $755 billion, and total VMT in 2033 is expected to be about 84 million miles less in 2033 under this alternative than the status quo.

Political feasibility of this alternative ranks third compared to other alternatives and the status quo. No evidence for support of this policy by key decision makers was found, and it is unlikely that support will increase given the various commuter programs already in place across the Commonwealth. Employers especially may balk at such a proposal. Although no costs to employers were assumed to be incurred from this alternative, employers would likely make the argument that complying with this law, even in good faith, would be prohibitively difficult and that the onus of reducing commute trips should not fall to employers.

Alternative 1 ranks second on the *ease of implementation* criterion. This is not to say that effective implementation of this policy is especially easy, only that it is less complicated than the other alternatives considered here. Implementing this policy would require a number of new staff (assumed to be 25) working for DRPT. DRPT is assumed to be the lead agency for this alternative given the agency's history of commuter-focused programs. Staff at DRPT are presumed to be invested in reducing commute trips and the externalities associated with such trips. Meaningful implementation of this law requires employers to be invested in outcomes. Employer buy-in could potentially be increased by emphasizing cost savings to employers (i.e., having to pay for fewer parking spaces for the same number of employees).

On the *equity* criterion, this policy ranks second among the alternatives considered. This alternative is considered more equitable than the status quo because it targets a specific type of VMT which is often associated with the greatest externalities, which increase costs. Although this policy may be deemed inequitable for those who already use a mode other than automobile travel for commuting, it is important to note that there are no wealth transfers associated with this alternative. That is to say, this alternative does not propose paying employees to change modes, but rather expects commuters to understand the cost savings they might expect by switching commute modes.

Alternative 2: VMT Tax

This alternative is best envisioned as a per mileage tax on vehicle miles traveled for all vehicles registered in Virginia. This policy does not seek to impose any

restrictions on drivers and would be modeled on Oregon's "OReGO" program, detailed above. As noted above, this policy is intended to make costs paid by drivers more accurately reflect the costs incurred by all society from that travel.

Under this alternative, Virginia would copy the program currently underway in Oregon. All light-duty passenger vehicles registered in Virginia with OBD ports would be automatically enrolled in the program. The Commonwealth would contract with the three account managers used in Oregon to record VMT data, and vehicle owners would be given their choice among the three options. Third-party account managers are used to ensure privacy of users—this alternative presents serious privacy challenges, as the same mechanism that allows for mileage tracking allows location tracking as well. As with the OReGO program, the Commonwealth would receive only aggregated and anonymized data (Bock, 2021).

The cost of implementing a VMT tax program in Virginia is estimated to be 5% of VDOT's maintenance and operating budget for 2019—just under $110 million. Operating costs beyond the first year of the program are estimated to be 10% of first year program costs, about $11 million annually. The effects of a VMT tax on VMT were calculated using an elasticity measure of -0.3 (Litman, 2022d). The tax value of 2.4 cents in the first year of the program was added to the estimated vehicle operating costs per VMT. Using the projected VMT of 2023, I solved for the new VMT and estimate a -1.15% change in VMT due to a 2.4 cent tax per mile on each VMT. This change is assumed to occur in each of the following years; total VMT saved over the observation period is estimated to total over 15 billion. Owing to significant cost, this alternative ranks fourth on the criterion of *cost-effectiveness.*

Although expensive to implement, a tax on VMT in Virginia is not politically infeasible. In 2020, Virginia created an optional mileage-based fee program for electric and other vehicle types subject to the Highway Use Fee (HUF) created in the same bill (*Mileage-Based User Fee Program Interim Report,* 2021). This alternative would go significantly beyond this program, however, as participation in the program would be made mandatory. Legislators would likely balk at making such a program mandatory, especially if doing so did not eliminate the Commonwealth's fuel tax. The *political feasibility* of this alternative is ranked third among the alternatives considered.

Implementation of this alternative would be incredibly complicated. Virginia would not be able to levy a tax on VMT on non-Virginia vehicles, so the Commonwealth's fuel taxes would need to remain in place. Drivers would necessarily be charged this tax, but they could only be reimbursed if they kept detailed receipts of fuel purchases. Likewise, this policy would require coordination among numerous agencies and stakeholders, severely complicating any immediate implementation of the tax. For these reasons, this policy is ranked third for *ease of implementation.*

Crucially, however, a tax on VMT is among the most equitable options to fund transportation. A tax on VMT should be adjusted according to vehicle axle weight and might further be prorated based on annual miles traveled (Boesen, 2020; Litman, 1999). This means that drivers would be charged a lower rate for, potentially, the first 5,000 miles in a year, and then pay a higher rate for all miles traveled after that. In addition to allowing tax adjustments based on miles traveled, a mileage tax associated with individual vehicles could further be based on the value of the vehicle, risk of accident, and associated emissions. In effect, such a tax would be highly progressive as higher income individuals tend to own more valuable vehicles and drive more often (Litman, 1999). **Alternative 2** ranks first on the *equity* criterion among the alternatives considered here.

Alternative 3: CAV Grant Program

The final alternative considered is a new grant program administered by the Virginia Department of Rail and Public Transportation (DRPT) for new programs using connected and automated vehicles (CAVs). These vehicles, popularly known as 'robotaxis,' are widely expected to be the next revolution in surface transportation. At this time, it is unclear what impact CAVs will have on transportation, but numerous studies (e.g., Fagnant and Kockelman, 2015; Loeb and Kockelman, 2019) have shown that, if sufficiently utilized, CAVs could reduce total VMT, alleviate traffic congestion, and improve overall mobility. Crucially, however, these outcomes will only be possible if CAVs have sufficient market penetration. Current perceptions of CAVs suggest that the public is, at best, apathetic and, at worst, hostile to their use (Haboucha et al., 2017; Bansal and Kockelman, 2017). To improve the outcomes widespread CAV use makes possible, it is necessary for the general public to become acquainted and comfortable with the technology. Programs funded by this grant would go a long way toward achieving a more efficient and effective transportation future.

A new grant would be established within the Commuter Assistance Program (CAP) of DRPT to fund local projects utilizing CAVs. Two such grant programs are already administered by DRPT—one intended to help fund the cost of existing programs, and another to establish new programs intended to mitigate congestion and reduce single-occupant trips (*Commuter Assistance Program Grants*, 2022). Currently, CAP Project Assistance grants require candidate projects to demonstrate certainty in their ability to achieve a measurable reduction in single-occupant trips. The new grant would replace the single-occupant outcome measure with VMT reductions. Likewise, all CAV grants would contain the necessary caveat that they be used to fund projects utilizing CAVs.

This grant would take several important steps toward achieving VMT reductions over a long-term period. Although significant results from the authorization of such a grant may not be seen for several years, getting CAVs on the road and in use is a crucial

to demonstrate their effectiveness and usefulness to a skeptical public. Likewise, this grant recognizes the fact that transportation is inherently local—data from 2017 shows that a full 75% of all one-way household trips were ten miles or less (*FOTW #1042,* 2018). Rather than creating statewide laws and adjudicating all transportation from a state level which might lead to policies which are effective in some localities and ineffective in others, this alternative ensures that solutions to transportation issues as a result of excess VMT are tailored to individual localities or metro areas.

In terms of *cost-effectiveness*, this option ranks third of the policies analyzed here. Program costs were calculated in terms of additional staff needed for the program and the grant value to be awarded. I assumed five new staff would be needed to administer this program—their jobs would largely involve collaborating with project proposers and evaluating submitted projects. As with the other alternatives considered here, the total NPV of costs associated with this alternative exceeds $755 billion. I project that this alternative would not reduce VMT until the fifth year of implementation, 2027, when VMT is expected to change by -0.10% relative to the baseline and increase by -0.02% in each year thereafter.

This policy ranks fourth in terms of *political feasibility.* Without demonstrating proof that the vehicles can be effective and useful, lawmakers are unlikely to support significant investment in the technology. Although Virginia has revised laws and regulations to permit CAV testing in the Commonwealth, the General Assembly has not yet taken comprehensive action beyond these basic steps. This may change, however, as Virginia continues to make infrastructure improvements necessary to facilitate CAV operations. Lawmakers may be more likely to support investing significant funds in this space once the vehicles become tangible to them.

CAV improvements present numerous technical and ethical challenges which must be overcome to make CAVs a reality. Regulators must determine in some fashion how an automated vehicle will choose between two bad outcomes. Although these challenges may appear to represent rare edge cases, these ethical challenges must be sufficiently answered to permit CAV operations. To date, NHTSA nor any other federal regulatory body has sufficiently addressed the question of CAV regulation. This incomplete regulatory picture further makes implementation of the alternative viable in the short term. To be effective, this alternative requires that meaningful projects be created and executed using funding made available. Success, therefore, requires a number of components—functional, safe, regulator-approved vehicles. Further, it requires that CAVs be utilized effectively—single-occupant trips should be minimized, CAVs should not generate additional congestion from failure to integrate with existing vehicles, and the vehicles should not roam streets and generate empty VMT if not in use. For these reasons, this alternative ranks fourth on the criterion of *ease of implementation.*

As with previous criteria, the equity of this policy depends largely on the type of project used and proposed. Projects which utilize this alternative to provide much needed "last-mile" service to those utilizing public transportation or non-automobile modes would be more equitable than a project which provides services using a TNC model in urban areas to consumers already using Uber, Lyft, or another TNC. Due to the significant uncertainty regarding the outcome of any individual project, this alternative ranks last in terms of *equity*.

The low rankings given to this alternative should be considered in the context provided above. If federal policymakers and regulators come to a meaningful policy governing CAV usage (especially ethical and "who pays" challenges), this alternative could become highly feasible. Significant research suggests that CAVs could significantly reduce congestion and improve transportation efficiency if used properly and in sufficient numbers (Maciejewski & Bischoff, 2018; Rämä et al., 2018; Loeb & Kockelman, 2019). Given the local nature of transportation and the practical limitations of CAV technology, projects implemented at a local or regional metropolitan level are the most likely outcome and states should plan accordingly. Although CAVs are not currently feasible on any level which could produce meaningful, state level outcomes, it is not unreasonable to suppose the necessary technology and infrastructure will be available by the end of the decade, if not sooner.

Outcome Matrix

Policy/Criteria	Cost-Effectiveness	Political Feasibility	Ease of Implementation	Equity	Average
Status Quo	$8.02 (T1)	1	1	3	1.5
CTR Law	$8.02 (T1)	3	2	2	2
VMT Tax	$8.11 (4)	2	3	1	2.5
CAV Grants	$8.04 (3)	4	4	4	3.75

Recommendation & Conclusion

Based on the outcomes matrix above, I recommend no policy change beyond those changes already scheduled to occur under the Status Quo policy, annual changes to Virginia's fuel tax indexed to the CPI-U. As noted at the beginning of this report, 2019 is used as a base year for this report because it is the last "normal" year for which quality data exists. The effects of the COVID-19 pandemic continue to ripple across the United States, and at time of writing it is unclear to what degree VMT in Virginia "rebounded" from the historically low level recorded in 2020. COVID-19 may have permanently changed transportation habits in both Virginia and the United States. More data and research are needed to learn the impact remote work options have on VMT in Virginia and across the nation.

Remote work options have proliferated since pandemic-related restrictions were first imposed in March 2020. In 2019, just 4% of all employees in the United States were employed remotely—by May 2020, 43% of all employees worked exclusively from home (Goldberg, 2022). These numbers have variously decreased and increased throughout the pandemic, often in response to new, more easily transmissible variants of the COVID-19 virus (Saad and Wigert, 2021). Yet, it appears increasingly likely that some sort of hybrid arrangement is likely to be made permanent—91% of employees already working some hours remotely hope remote options continue, while just 9% want work from home policies to end (Saad and Wigert, 2021; Wigert, 2022). A hybrid option—where employees come into the office on some days and stay home on others—appears to be the most likely outcome for the future (Wigert, 2022). The impact such policies will have on total VMT both nationally and in Virginia is unclear, but it is not unreasonable to imagine that it will take longer than this report anticipated for VMT in Virginia to return to 2019 levels.

Limited data, however, suggests that even if a majority of employees work from home at least part time, VMT will not permanently decline to levels comparable to 2020. Although total VMT declined sharply in 2020, these reductions primarily occurred in the first half of the year. VMT levels in September and October 2021 were nearly 98% of pre-pandemic averages (Lloyd, 2022). Indeed, it may well be the case that remote work and hybrid policies *increase* VMT—extra automobile trips may be taken which, in total, are greater than VMT would be without remote work policies (Curry, 2020). More research is needed to determine the impact long-term remote work options will have on observed VMT. If remote work is here to stay, as it appears to be, it will be necessary for policymakers to consider its impacts on VMT, as well as other metrics. Remote work policies may encourage population movements out of city centers but required trips into urban cores may generate more total VMT.

Much focus has been given to the fuel tax component of the status quo policy, but it is important to consider status quo policies go beyond the current fuel tax. Virginia has made considerable progress in recent years towards improving transportation policy in the Commonwealth, and it is important to stress that transportation improvements require many years to become reality. Virginia's HUF for electric, alternative fuel, and other fuel-efficient vehicles is a great start, but a truly equitable and efficient revenue source for the Commonwealth's highway operation and maintenance fund requires participation of all vehicles in Virginia. Indeed, this policy may best be achieved through a federal tax system for VMT, whereby fund transfers between states are possible to most efficiently make the costs paid for transportation by drivers in a given location reflect the true economic cost of their travel. A VMT tax creates considerable privacy concerns, which are only partially alleviated through third-party contracts.

Finally, I recommend that policymakers in Virginia continue to take the steps necessary to make CAVs possible in large numbers on public roads. This includes infrastructure investments necessary to support these vehicles, and regulatory action that permits their use in large numbers on public roads. As with other technologies, the effectiveness and usefulness of CAVs will likely require some level of proof to be acceptable to sufficient numbers of people. Prior to potentially establishing a distinct grant to support CAV operations, it might prove useful to fund a CAV project through the existing CAP grant.

As this report makes clear, transportation issues extend beyond automobiles. It is necessary for policymakers and stakeholders alike to understand the ongoing changes in the transportation landscape. Recent changes involving work habits may significantly reduce VMT associated with commuting, but total VMT may still increase as more total trips are taken. As CAV technologies and capabilities continue to advance, such vehicles may soon prove to be a feasible and highly effective transportation option. Although it is not reasonable to set a specific goal for VMT reduction statewide, Virginia should ensure that VMT reduction is used as a metric in urban planning and transportation policy and program proposals. Just as transportation goes beyond automobiles, reducing VMT produces tangible benefits beyond improved traffic flow.

Appendix: Tables and Calculations

TABLE 1: VMT CALCULATIONS FOR DIFFERENT POLICY ALTERNATIVES, IN TRILLIONS

Year	Status Quo VMT	CTR Law VMT	VMT Tax VMT	CAV Grant VMT
2019	85.43			
2020	86.03			
2021	86.63			
2022	87.24			
2023	87.85	87.76	86.84	87.85
2024	88.46	88.37	87.45	88.46
2025	89.08	88.99	88.06	89.08
2026	89.71	89.62	88.68	89.71
2027	90.34	90.25	89.30	90.25
2028	90.97	90.88	89.92	90.86
2029	91.60	91.52	90.55	91.48
2030	92.25	92.16	91.18	92.10
2031	92.89	92.81	91.82	92.72
2032	93.54	93.46	92.47	93.35
2033	94.20	94.11	93.11	93.99

TABLE 2: COST CALCULATIONS BY CATEGORY OVER OBSERVATION PERIOD, IN BILLIONS

Year	Vehicle Stock	Highway Depreciation	Highway Maintenance	Emissions	Congestion	Public Health
2019	$52.87	$1.53	$2.20	$1.71	$4.60	$1.37
2020	$54.20	$1.50	$2.24	$1.74	$4.69	$1.39
2021	$56.11	$1.47	$2.31	$1.80	$4.84	$1.44
2022	$57.63	$1.44	$2.38	$1.85	$4.98	$1.48
2023	$59.25	$1.41	$2.44	$1.90	$5.12	$1.52
2024	$60.92	$1.38	$2.51	$1.96	$5.26	$1.56
2025	$62.63	$1.35	$2.58	$2.01	$5.41	$1.61
2026	$64.40	$1.32	$2.66	$2.07	$5.56	$1.65
2027	$66.21	$1.29	$2.73	$2.13	$5.72	$1.70
2028	$68.07	$1.26	$2.81	$2.18	$5.88	$1.75
2029	$69.99	$1.24	$2.89	$2.25	$6.05	$1.80
2030	$71.96	$1.21	$2.97	$2.31	$6.22	$1.85
2031	$73.98	$1.19	$3.05	$2.37	$6.39	$1.90
2032	$76.07	$1.16	$3.14	$2.44	$6.57	$1.95
2033	$78.21	$1.14	$3.23	$2.51	$6.76	$2.01

TABLE 3: TOTAL COST CALCULATIONS FOR ALTERNATIVES, IN BILLIONS

Year	Total Costs (Status Quo)	Total Costs, CTR Alternative	Total Costs, VMT Tax Alternative	Total Costs, CAV Grant Alternative
2019	$64.27			
2020	$65.76			
2021	$67.97			
2022	$69.75			
2023	$71.64	$71.65	$71.75	$71.65
2024	$73.59	$73.59	$73.60	$73.60
2025	$75.60	$75.60	$75.61	$75.61
2026	$77.66	$77.66	$77.67	$77.67
2027	$79.78	$79.78	$79.79	$79.79
2028	$81.96	$81.96	$81.97	$81.97
2029	$84.21	$84.21	$84.22	$84.22
2030	$86.51	$86.52	$86.53	$86.53
2031	$88.89	$88.89	$88.90	$88.90
2032	$91.33	$91.34	$91.34	$91.34
2033	$93.85	$93.85	$93.86	$93.86
NPV (2023–33)	$755.21	$755.22	$755.41	$755.31

TABLE 4: COST-EFFECTIVENESS RATIO CALCULATIONS

Alternative:	Status Quo	CTR Law	VMT Tax	CAV Grant
Net Present Value (billions):	$755.21	$755.22	$755.41	$755.31
VMT, end of 2033 (trillions):	94.20	94.11	93.11	93.99
Cost-Effectiveness Ratio:	$8.02	$8.02	$8.11	$8.04

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