NORTH CAROLINA DEPARTMENT OF TRANSPORTATION - NCDOT

VEHICLE MILES TRAVELED REDUCTION STUDY

DECEMBER 2024

Stantec

Table of Contents

1.0 INTRODUCTION 06

2.0 RESEARCH PHASE 08

2.1 VMT TRENDS IN NORTH CAROLINA....10
2.1.1 VMT Trends Through 2019....10
2.1.2 Factors that Influence VMT Growth....15
2.1.3 Pandemic VMT Trends....21

2.2 IDENTIFYING TDM STRATEGIES 25
2.2.1 Determining the Existing State of TDM Implementation....25
2.2.2 Expanding the List of Potential TDM Measures....28

2.3 TDM SUMMARY PAGES....31

3.0 TESTING PHASE 69

3.1 MODELING PACKAGE DEVELOPMENT....71

3.2 MODELING PROCESS....73
3.2.1 Asheville Modeling Adjustments....74
3.2.2 The Triangle Modeling Adjustments....76

3.3 MODEL RESULTS....80
3.3.1 Asheville Area Results....81
3.3.2 Triangle Area Results....82

3.4 MODEL RUN RESULTS COMPARED TO LITERATURE REVIEW RESULTS....84
3.4.1 Forward-Thinking Package....84
3.4.2 Transit-Based Package....85
3.4.3 Environmental Package....86
3.4.4 Low-Cost Package....87

4.0 SUMMARY AND NEXT STEPS 88

5.0 PLANNING FOR MODE CHOICE 90

5.1 CURRENT VMT TRENDS....93
5.2 NEEDED VMT REDUCTION RESEARCH....96
5.3 NORTH CAROLINA MODE CHOICE ENABLEMENT SCENARIOS....97
5.3.1 Hypothetical VMT Reduction Scenarios....100

5.4 VMT REDUCTION SCENARIO ESTIMATED POTENTIAL BENEFITS....103

APPENDIX 104

List of Tables

Table 1: Technical Advisory Committee Members....8

Table 2: Annual Total VMT (millions) for the United States and North Carolina (2003-2019)....10

Table 3: VMT Statistics for Federal-Aid Urbanized Areas in North Carolina....18

Table 4: Land Use Coverage within MPO's....25

Table 5: Number of Planning Organizations Implementing Certain Strategies....25

Table 6: TDM Strategies Implemented in Each Planning Area by Organization....26

Table 7: Strategies Ranked by Effectiveness in Reducing VMT and Ease of Implementation....27

Table 8: Ranking Matrix of Primary TDM Measures....72

Table 9: TDM Measures included in each Modeling Package....72

Table 10: VMT, Model Links and Link Distances by Area Type and Model....73

Table 11: Asheville Area 2040 VMT Changes as Compared to the Base Case....81

Table 12: Triangle Area 2040 VMT Changes as Compared to the Base Case....82

Table 13: VMT Targets around the United States and Canada....96

Table 14: Strategies Identified by Municipality to Reduce VMT....97

Table 15: Mode Choice Enablement Strategy Categories and Examples....99

Table 16: Per Capita Savings For Each Scenario....103

Table 17: Estimated Cumulative Avoided Costs Over This Period (2024 through 2050)....104

List of Figures

Figure 1: Annual Total VMT (millions) for the United States and North Carolina (2003-2019).....11

Figure 2: Annual Rolling Average of Total VMT (millions) for the United States and North Carolina (2003-2019).....11

Figure 3: North Carolina and United States VMT per Capita, 1981-2017.....12

Figure 4: Indexed 12-Month Rolling Average VMT for the United States and North Carolina in Rural and Urban Areas (2012=1.00) 13

Figure 5: Average Daily Household VMT in North Carolina by Area Type (2009).....14

Figure 6: Average Daily Number of Trips per Household in North Carolina by Area Type (2009).....14

Figure 7: Fastest Growing Large Metro Areas by Population in the United States, 2010-2019.....15

Figure 8: Urbanization in North Carolina: Counties by Percent Living in Municipalities.....16

Figure 9: 2019 Commuter Mode for North Carolina, the United States, and the "Median" State/District.....19

Figure 10: 2019 Commuter Mode for North Carolina, Texas, and Pennsylvania.....20

Figure 11: North Carolina Employment and Daily VMT by Month in 2020.....21

Figure 12: Difference in Weekday Traffic Volumes from March 2-6, 2020 to Future Weeks, Asheville and Triangle areas.....23

Figure 13: Difference in Weekday Traffic Volumes from March 2-6, 2020 to Future Weeks, Urban and Rural Count Locations.....23

Figure 14: VMT Reduction Results from the Asheville Model 81

Figure 15: VMT Reduction Results from the Triangle Model.....82

Figure 16: VMT Percent Difference from Base Case to Forward-Thinking Package.....84

Figure 17: Forward-Thinking Package Model Results Compared to Component Results from Literature Scan.....84

Figure 18: VMT Percent Difference from Base Case to Transit-Based Package.....85

Figure 19: Transit-Based Package Model Results Compared to Component Results from Literature Scan.....85

Figure 20: VMT Percent Difference from Base Case to Environmental Package.....86

Figure 21: Environmental Package Model Results Compared to Component Results from Literature Scan.....86

Figure 22: VMT Percent Difference from Base Case to Low-Cost Package.....88

Figure 23: Low-Cost Package Model Results Compared to Component Results from Literature Scan.....88

Figure 24: North Carolina Commute Mode.....93

Figure 25: Total VMT in the United States and North Carolina 2003-2023.....94

Figure 26: VMT Per Capita in United States and North Carolina 2003-2023.....95

Figure 27: Five Percent Reduction Scenario.....101

Figure 28: Ten Percent Reduction Scenario.....101

Figure 29: Fifteen Percent Reduction Scenario.....102

Figure 30: Twenty Percent Reduction Scenario.....102

Abbreviations

CAMPO	Capital Area Metropolitan Planning Organization
DVMT	Daily Vehicle Miles Traveiled
FBRMPO	French Broad River Metropolitan Planning Organization
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
GPS	Global Positioning System
HBO	Home-Based Other
HBW	Home-Based Work
HOV	High Occupancy Vehicle
MaaS	Mobility as a Service
MBUF	Mileage-based User Fee
MPO	Metropolitan Planning Organization
MSA	Metropolitan Statistical Area
NC	North Carolina
NCDOT	North Carolina Department of Transportation
NHB	Non-Home-Based Work
NHBW	Non-Home-Based Work
O-D	Origin-Destination
PO	Planning Organization
RPO	Rural Planning Organization
SOV	Single Occupant Vehicle
TAZ	Traffic Analysis Zone
TDM	Transportation Demand Management
TMA	Transportation Management Association
TNC	Transportation Network Compny (Uber, Lyft, etc)
TOD	Transit Oriented Development
TRB	Transportation Research Board
TREC	Transportation Research and Education Center (Portland, OR)
US	United States
VKT	Vehicle Kilometers Traveled
VMT	Vehicle Miles Traveled

1.0 INTRODUCTION

This report summarizes the findings of the VMT (Vehicle Miles Traveled) Study completed by Stantec for the North Carolina Department of Transportation (NCDOT). The goal of this study was to identify transportation demand management (TDM) measures or strategies to reduce vehicle miles traveled in urban, rural and regional areas of North Carolina. The study was guided by a technical advisory committee, comprised of members from both NCDOT and local planning organizations, that gave direction to the study and provided both important input and insights. The members are listed in the table below

The study was divided into two phases:

RESEARCH

The research phase involved a thorough review of VMT trends in North Carolina and the US, including expected VMT trend outcomes from the COVID-19 pandemic. In addition, a survey of TDM "experts", a literature review, and a survey of the 37 planning organizations in North Carolina to determine the current strategies in effect across the state were completed.

TESTING

The testing phase involved working with the Technical Advisory Committee to rank the TDM measures defined in the research phase and developing TDM "packages" that Stantec tested using the French Broad River Metropolitan Planning Organization (FBRMPO) and Triangle area travel demand models in the Asheville and Raleigh/Durham/Chapel Hill areas. The impacts that each package had on area-wide VMT, as well as on the VMT in the urban, rural and suburban areas of each planning area were identified.

This report describes the process and outcome of each phase and concludes with a summary of next steps to undertake to reduce VMT in North Carolina.

Name	Agency
Colin Mellor (Chair)	North Carolina Department of Transportation
Blair Chambers	North Carolina Department of Transportation
Matt Day	Triangle J Council of Government
Joe Hummer	North Carolina Department of Transportation
Phyllis Jones	North Carolina Department of Transportation
Anthony Prinz	Jacksonville Urban Area Metropolitan Planning Organization
John Ridout	Land of Sky Regional Council
Brandon Watson	Capital Area Metropolitan Planning Organization

Table 1: Technical Advisory Committee Members

2.0 RESEARCH PHASE

2.1 VMT TRENDS IN NORTH CAROLINA

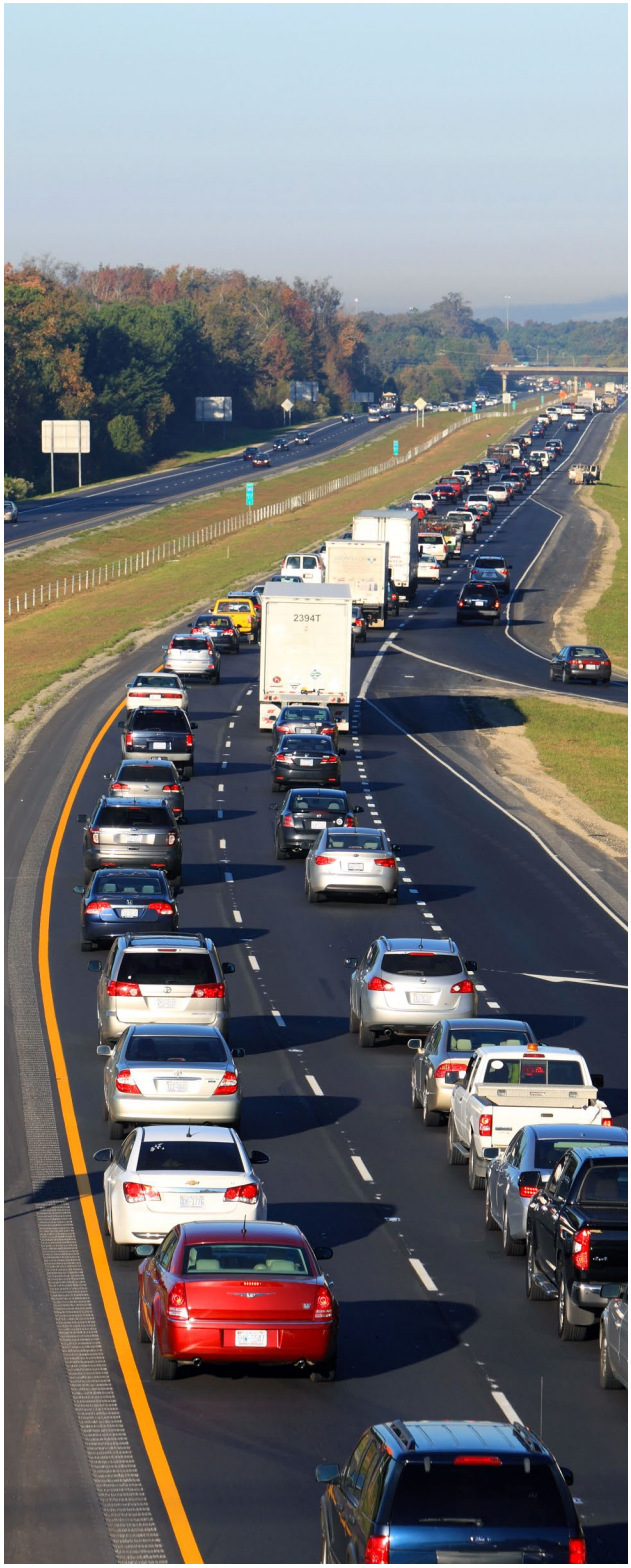
2.1.1 VMT Trends Through 2019

Between 2003 and 2019, annual vehicle miles traveled (VMT) in the United States grew from 2.89 trillion to 3.26 trillion, an increase of 376 billion VMT or 13 percent. During that same period, VMT in North Carolina (NC) grew from 93.7 billion to 123.1 billion, an overall increase of 29.5 billion or 31 percent. In fact, the NC VMT increase in this period represented about 7.8 percent of the total VMT growth in the United States. Annual VMT for both the United States and North Carolina are listed in Table 2 and shown graphically in Figure 1. The 12-month rolling average of VMT for both the United States and North Carolina, indexed to 2003, is shown in Figure 2. Both figures depict the general increasing trend in VMT, however, Figure 2 shows how the VMT in North Carolina is growing at a faster rate than in the US.

Year	United States	North Carolina (#'s to 100's)
2003	2,886,000	93,700
2004	2,937,000	94,800
2005	2,969,000	96,700
2006	2,999,000	101,800
2007	3,003,000	102,600
2008	2,928,000	100,200
2009	2,977,000	101,600
2010	2,996,000	102,400
2011	2,931,000	101,500
2012	2,954,000	104,000
2013	2,968,000	104,800
2014	3,031,000	106,100
2015	3,128,000	111,800
2016	3,175,000	115,800
2017	3,213,000	119,100
2018	3,225,000	118,200
2019	3,262,000	123,100

Table 2: Annual Total VMT (millions) for the United States and North Carolina (2003-2019)

Source: FHWA, Office of Highway Policy Information, Traffic Monitoring Trends Monthly Data



Source: Stantec project files. All photos in this report are from Stantec's North Carolina project files.

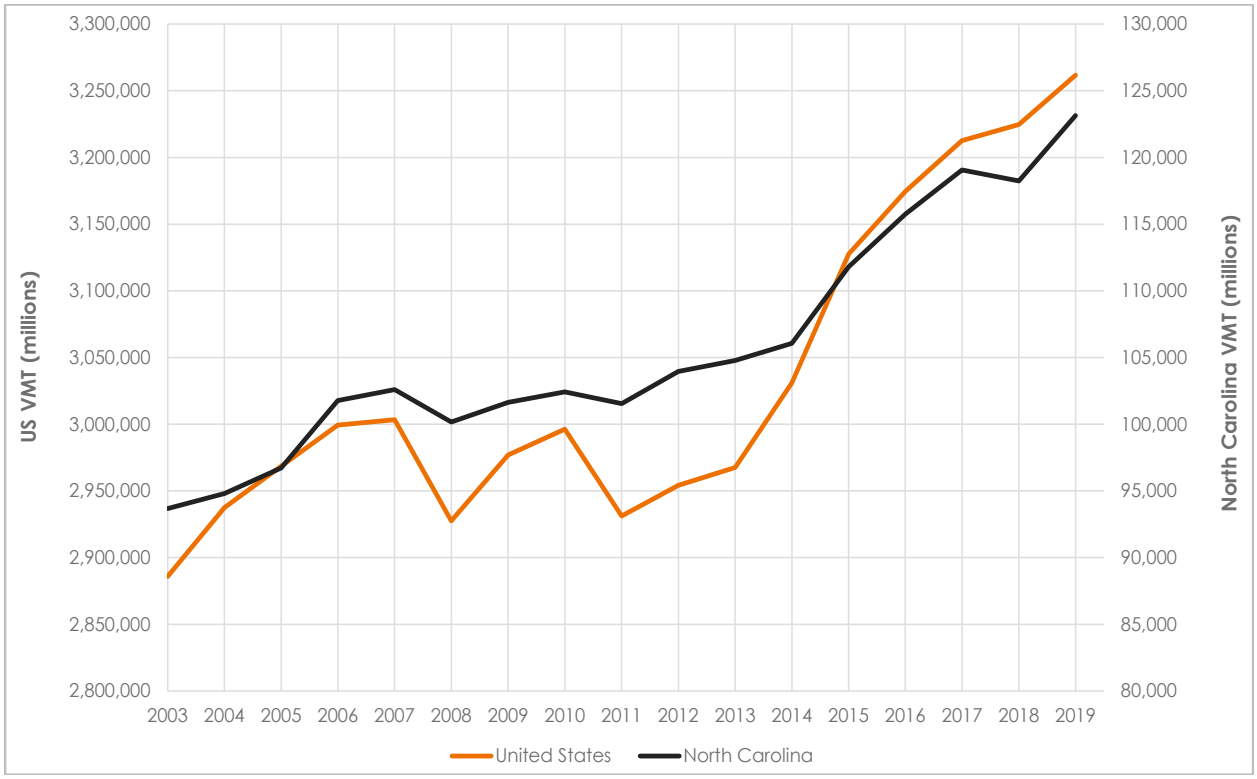


Figure 1: Annual Total VMT (millions) for the United States and North Carolina (2003-2019)

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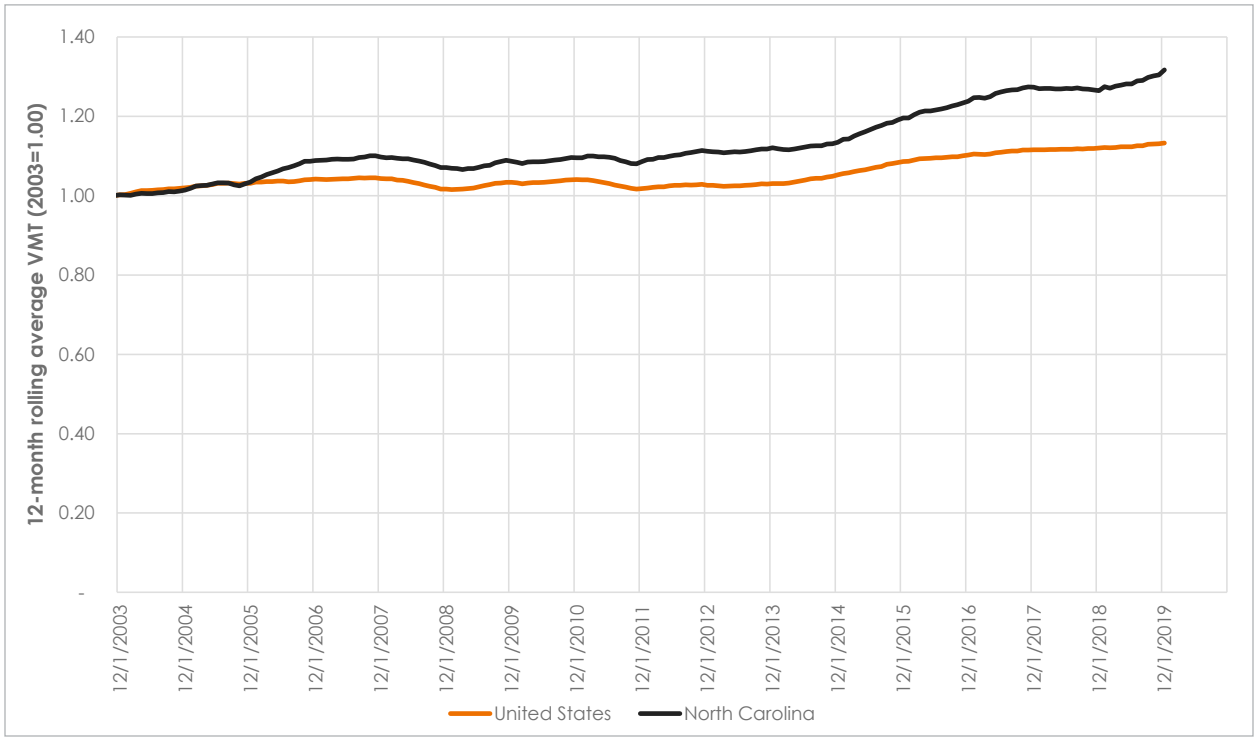


Figure 2: Annual Rolling Average of Total VMT (millions) for the United States and North Carolina (2003-2019)

Source: FHWA, Office of Highway Policy Information, Travel Monitoring Trends Monthly Data

The VMT per capita peaked in 2004 for the United States and in 2005 for North Carolina. The next years had decreases in VMT per capita, likely due to the economic downturn from the Great Recession. Prior to the downturn, VMT per capita grew steadily for over two decades in both the United States and North Carolina. VMT per capita began to grow again after 2013, surpassing 9,800 in the United States and 11,600 in North Carolina in 2017. Figure 3 shows the VMT per capita from 1981 to 2017 for the United States and North Carolina.

VMT per Capita (2017) surpassed

9,800

UNITED STATES

11,600

NORTH CAROLINA

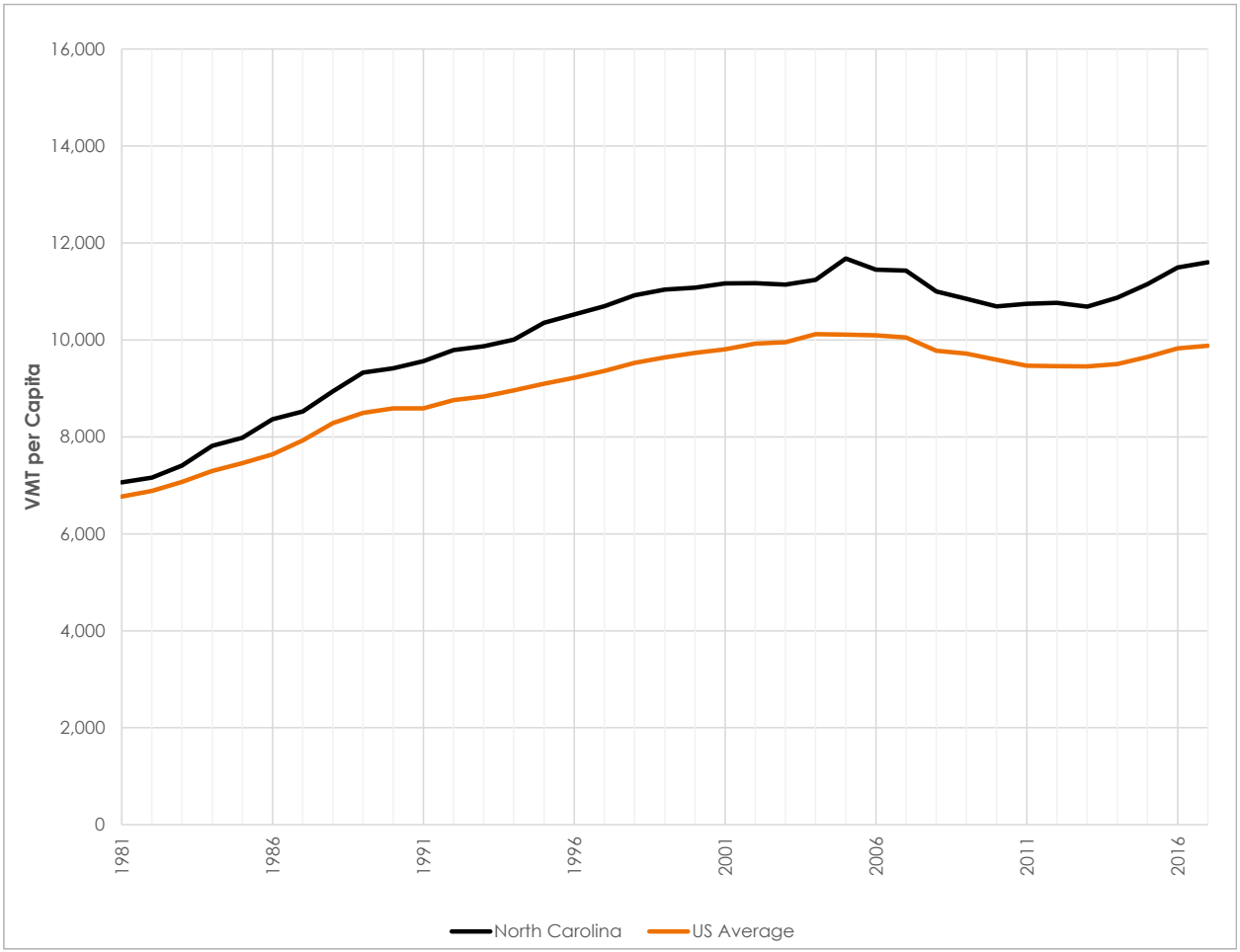


Figure 3: North Carolina and United States VMT per Capita, 1981-2017

Source: Eno Center for Transportation

VMT trends have been different in rural and urban areas. The FHWA provides estimates of both Rural and Urban VMT and defines rural areas similarly to the US Census as areas that have a population under 5,000. Urban areas are above that threshold and include small urban areas and individual urbanized areas as defined by the US Census. As shown in Figure 4, Urban VMT has been growing faster than Rural VMT both nationally and within North Carolina. Between 2012 and 2019, North Carolina Urban VMT grew at about 3.4 percent per year, while Urban VMT nationwide grew by about 1.9 percent per year. Rural VMT, both nationally and in North Carolina, grew by about 0.2 percent per year during this period. The rural and urban VMT growth is not just a function of travel behavior but also of population growth. Contributing factors to VMT growth are discussed in subsequent sections of this report.

VMT growth rate 2012-2019

UNITED STATES

0.2% PER YEAR RURAL

1.9% PER YEAR URBAN

NORTH CAROLINA

0.2% PER YEAR RURAL

3.4% PER YEAR URBAN

Source: FHWA, Office of Highway Policy Information, Table VM-2

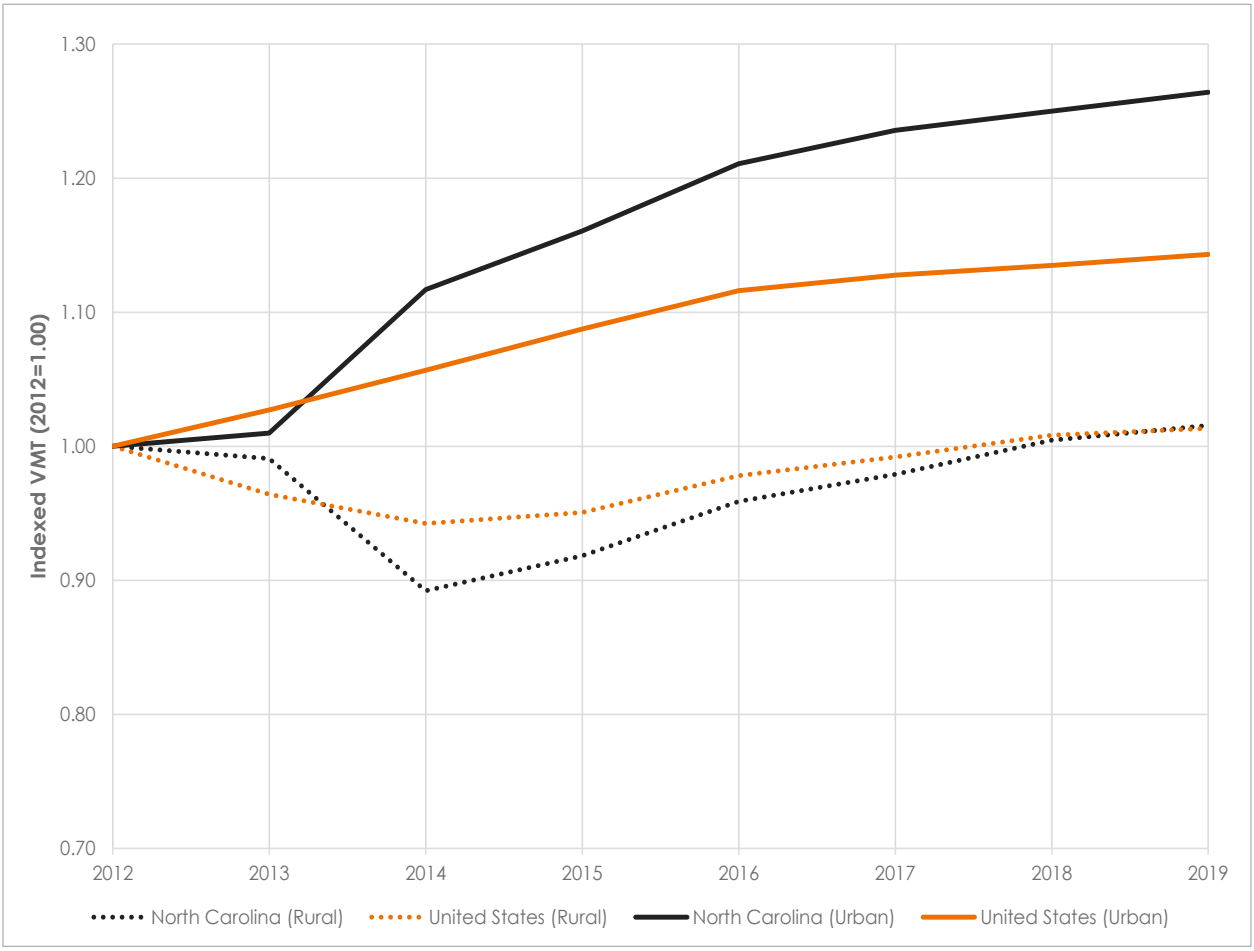


Figure 4: Indexed VMT for the United States and North Carolina in Rural and Urban Areas (2012=1.00)

Source: FHWA, Office of Highway Policy Information, Table VM-2

The faster growth rates in Urban VMT are an indication that both the United States' and North Carolina's populations are shifting to more urbanized areas. Interestingly, on a per household basis, urban households produce much lower average daily VMT and much fewer trips than both suburban and rural households. In 2009, the average urban household in North Carolina drove 32.7 miles per day while rural North Carolina households drove 74 percent more miles, or 56.8 miles per day. Similarly, urban North Carolina households averaged 4.4 automobile trips per day while rural North Carolina households averaged 23 percent more, or 5.4 trips per day. The average household VMT and number of automobile trips by area type in North Carolina are shown in Figure 5 and Figure 6, respectively.

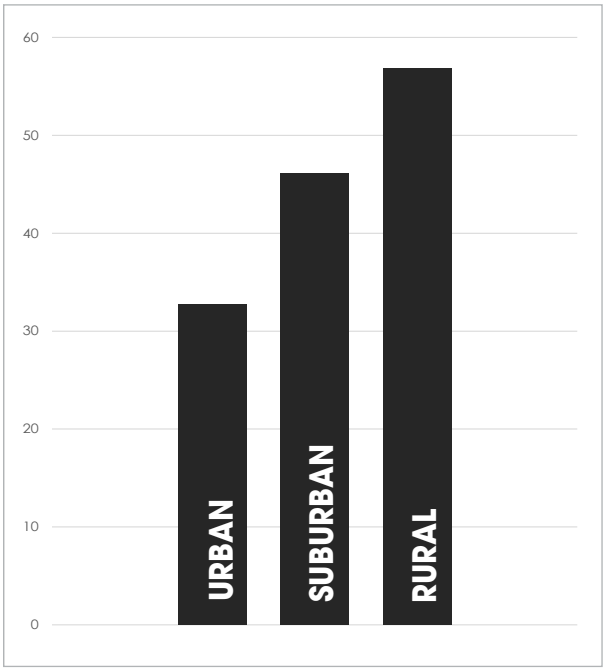


Figure 5: Average Daily Household VMT in North Carolina by Area Type (2009)

Source: Bureau of Transportation Statistics

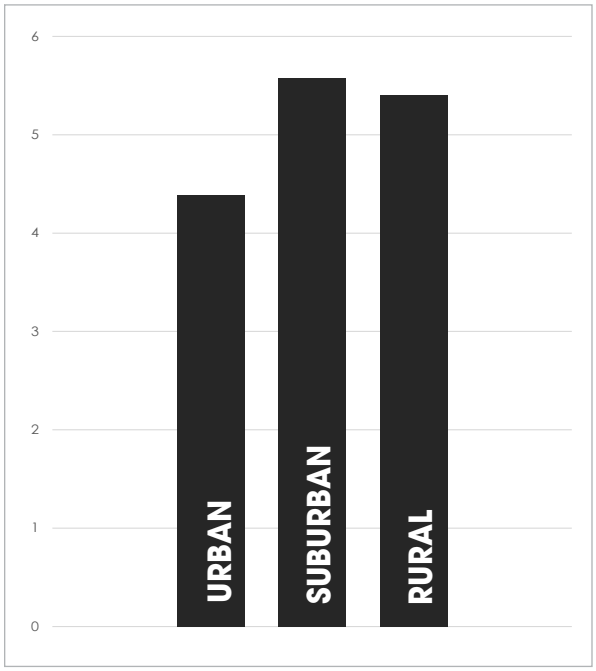


Figure 6: Average Daily Number of Trips per Household in North Carolina by Area Type (2009)

Source: Bureau of Transportation Statistics

2.1.2 Factors that Influence VMT Growth

Several factors have influenced the strong VMT growth in North Carolina including total population growth, the prevalence of rural areas and the availability of the roadway network, and the availability and use of alternative transportation modes.

2.1.2.1 Population Growth

North Carolina is one of the fastest growing states in the United States. According to the US Census, North Carolina had the 4th highest overall state population growth between 2000 and 2019. The state's population grew by a total of 2,406,470 persons, trailing only the population growth in Texas, California, and Florida. During that time, North Carolina's population grew at a rate of 1.28 percent per year and its rank in population increased from the 11th most populous to the 9th most populous state.

The US Census identifies a metropolitan statistical area (MSA) as an economically integrated set of counties with a core central city populated by at least 50,000 persons. In 2018, nearly 7 out of 8 Americans lived within one of the 383 MSA's. 53 of these MSA's have populations of more than one million persons and are classified as "large". As shown in Figure 7, two of the fastest growing large MSA's between 2010 and 2019 are located within North Carolina; Raleigh was the 2nd fastest growing MSA with 23.0 percent growth and Charlotte was the 10th fastest growing MSA with 17.5 percent growth.

Total VMT increases as total population increases. Between 2010 and 2019, North Carolina's population grew from 9,574,323 to 10,488,084, an increase of 913,761 persons. During this period, the average annual population growth was 1.02 percent per year compared to the total VMT growth of 1.72 percent per year.

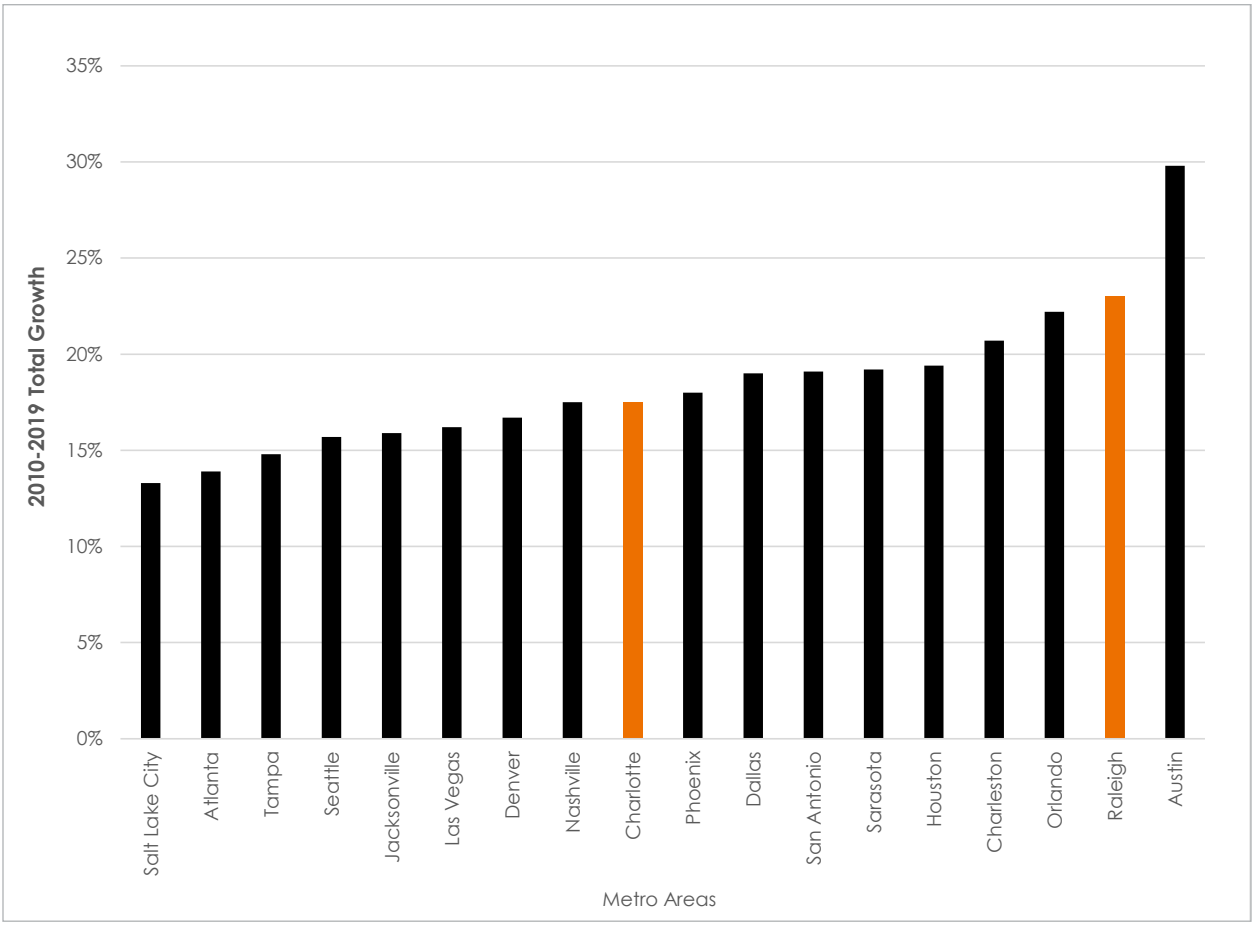


Figure 7: Fastest Growing Large Metro Areas by Population in the United States, 2010-2019

Source: US Census Bureau

2.1.2.2 Land Use

Dispersed land use patterns contribute to VMT. Longer distances between home and work, shopping and school result in more VMT as compared to the equivalent trip in a more densely developed area. North Carolina is one of the most rural states in the US. According to the 2010 US Census, North Carolina was ranked second among all states in terms of the largest rural population. About 3.23 million persons, or almost 34 percent of North Carolina's 9.5 million residents lived in rural areas in 2010.

Recent statistics from the North Carolina Office of State Budget and Management indicate that North Carolina is becoming more urban. As of July 1, 2019, 57 percent (5.9 million people) of North Carolina's population lived in urban areas, yet 32 percent of North Carolina counties had less than 20 percent of their population living in municipalities. The distribution of the rural population within the state is shown in Figure 8. The most rural areas of the state are concentrated in the western mountain areas and the northern areas of the Outer Banks.

Current land use has developed as a result of decades of well-intentioned policies that have had unintended consequences. Policies such as exclusionary zoning practices, excessive and unnecessary parking requirements; height requirements, minimum lot sizes; and other restrictions in how some residents build their communities has collectively limited the ability to create denser, walkable neighborhoods with access to needed amenities for other residents. When it comes to highway widening projects, some communities are finding that they cannot build their way out of the pitfalls of suburban sprawl. When applying the economic principles of Diminishing Marginal Utility (DMU) to highway widening projects, each successive lane added is more challenging and costly to build but results in proportionally less capacity benefits.

If implemented properly and uniformly, increased flexibility in local zoning and land use ordinances can increase economic opportunities while reducing state-wide VMT and create the incremental density needed for successful multi-modal and active transportation investments that that enable mode shift by creating a built environment conducive to reducing VMT.

NCDOT has a role to play by working closely with local partners on community long-range plans that effectively coordinate transportation and land-use strategies.

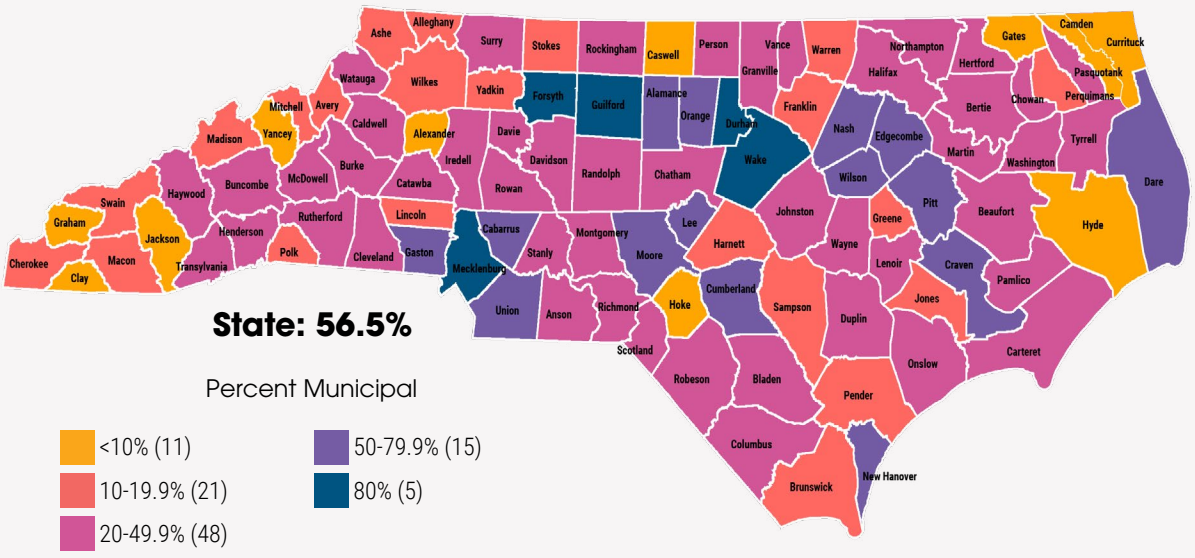


Figure 8: Urbanization in North Carolina: Counties by Percent Living in Municipalities, 2019

Source: NC Office of State Budget and Management

2.1.2.3 Available Roadway Network

The availability of roadways promotes vehicle use and is also a contributor to VMT. Table 3 shows the 2017 roadway miles, land area, population and daily VMT (DMVT) statistics for 19 Federal-Aid Urbanized areas in North Carolina as compared to the average and median of these statistics for 492 areas around the US.
As shown:

- Only five of the North Carolina areas have total roadway miles greater than the national average for Federal Aid Urbanized areas, but 12 of the 19 North Carolina areas have more miles of roadway per person than the national average.
- 16 of the 19 North Carolina areas have total daily VMT per capita greater than the national average. Only Greenville and Jacksonville have daily VMT per capita less than the national median.
- 13 of the 19 North Carolina areas have daily VMT per roadway miles that are higher than both the national average and median.

Lower density environments lead to greater distances between destinations, greater car dependency, and increased VMTs.

FEDERAL - AID URBANIZED AREA	TOTAL ROADWAY MILES	TOTAL DVMT (1000)	CENSUS POPULATION	NET LAND AREA (SQ MILES)	PERSON PER SQ MILES	MILES OF ROADWAY PER 1000 PERSONS	TOTAL DVMT PER CAPITA	DMVT/ ROADWAY MILES (1000)
Charlotte, NC--SC	6,268	48,297	1,249,442	741	1,685	5.0	38.7	7.7
Raleigh, NC	5,283	33,139	884,891	518	1,708	6.0	37.4	6.3
Winston-Salem, NC	3,024	15,474	391,024	323	1,212	7.7	39.6	5.1
Durham, NC	1,850	13,388	347,602	182	1,913	5.3	38.5	7.2
Greensboro, NC	2,084	12,936	311,810	185	1,684	6.7	41.5	6.2
Fayetteville, NC	1,787	8,457	310,282	198	1,567	5.8	27.3	4.7
Asheville, NC	2,624	12,767	280,648	265	1,060	9.3	45.5	4.9
Wilmington, NC	1,139	6,005	219,957	134	1,644	5.2	27.3	5.3
Myrtle Beach--Socastee, SC--NC	1,901	6,919	215,304	190	1,131	8.8	32.1	3.6
Concord, NC	1,715	7,957	214,881	180	1,192	8.0	37.0	4.6
Hickory, NC	2,028	7,996	212,195	262	811	9.6	37.7	3.9
Gastonia, NC--SC	1,234	6,168	169,495	139	1,223	7.3	36.4	5.0
High Point, NC	1,171	5,355	166,485	113	1,473	7.0	32.2	4.6
Burlington, NC	827	4,473	119,911	90	1,326	6.9	37.3	5.4
Greenville, NC	603	2,500	117,798	65	1,807	5.1	21.2	4.1
Jacksonville, NC	389	2,130	105,419	71	1,478	3.7	20.2	5.5
Rocky Mount, NC	514	1,985	68,243	46	1,485	7.5	29.1	3.9
Goldsboro, NC	565	1,767	61,054	53	1,154	9.2	28.9	3.1
New Bern, NC	365	1,292	50,503	43	1,163	7.2	25.6	3.5
Average of all Federal-Aid urbanized areas	**2,053**	**11,402**	**452,930**	**179**	**2,092**	**6.4**	**26.4**	**4.5**
Median of all Federal-Aid urbanized areas	**859**	**3,382**	**129,891**	**72**	**1,873**	**6.0**	**25.3**	**4.2**

Table 3: VMT Statistics for Federal-Aid Urbanized Areas in North Carolina, 2017

Source: Table HM-72 Highway Statistics, Federal Highway Administration Office of Highway
Note: Grey shaded cells indicate values greater than the average

2.1.2.4 Dependence on the Personal Vehicle

NCDOT reports that there are 98 public transit systems in North Carolina. The primary transit service provided is by fixed-route buses. In 2017, 56.4 million trips, or 89 percent of all the transit trips in North Carolina were made using fixed-route buses. Most of the fixed-route buses typically serve corridors connecting residential areas with concentrated areas that include employment, shopping, education, or medical services, as well as municipal and government offices. As such, the rural and spread-out nature of urban areas in North Carolina makes it difficult for traditional fixed route public transit to be successful in terms of trips made when compared to the number of total trips.

Figure 9 compares the 2019 commuter mode of travel, as reported by the US Bureau of Transportation Statistics, for North Carolina, the US, and the median state/district in the US. As shown, the majority of commuters in North Carolina, 80.2 percent, drove alone to work. This is more than the US as a whole and the median state/district. Transit followed a similar trend; 1.1 percent of commuters used transit in North Carolina compared to 5.0 percent nationally and 1.4 percent in the median state/district. A positive trend in North Carolina in terms of VMT is that the percent of commuters that worked from home in North Carolina was more than in the nation and the median state/district; in North Carolina, 6.7 percent of commuters worked from home while 5.7 percent worked from home nationally and 5.4 percent worked from home in the median state/district.

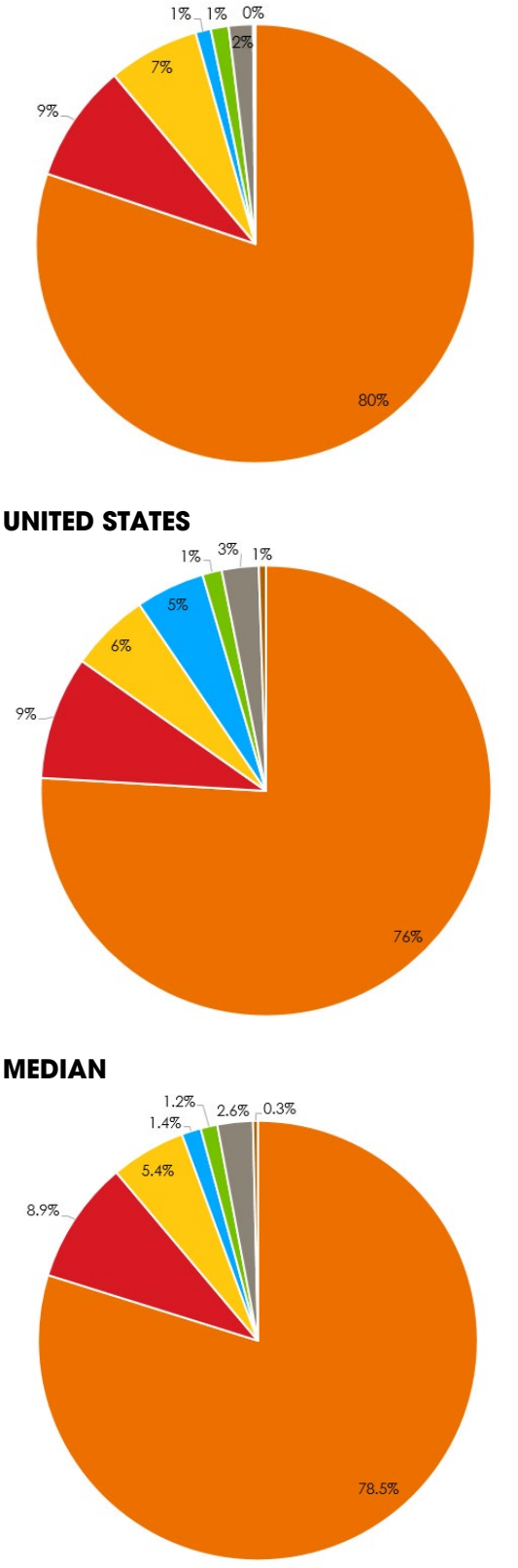


Figure 9: 2019 Commuter Mode for North Carolina, the United States, and the "Median" State/District

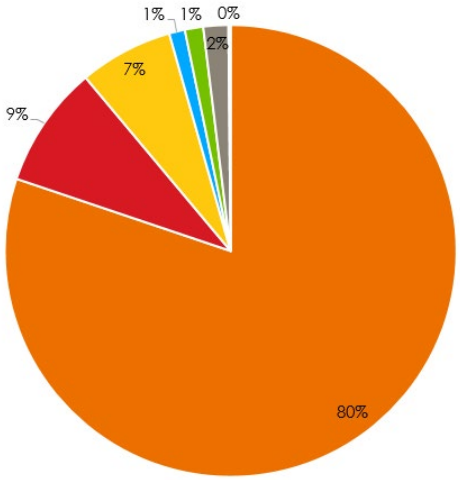
Source: US Bureau of Transportation Statistics, Commute Mode

Figure 10 compares the 2019 mode of travel for commuters in North Carolina to those in Pennsylvania and Texas. These two states are considered to be "peer" states of North Carolina as they both have multiple large urban areas as well as a significant amount of rural space. In North Carolina and Texas, slightly more than 80 percent of workers drive to work alone compared to about 75 percent of Pennsylvania's workers. The lower drive alone share in Pennsylvania is likely due to its large "older" cities (Philadelphia and Pittsburgh) having more established public transportation systems. As a case in point, 5.7 percent of Pennsylvania workers took public transportation to work compared to 1.1 to 1.3 percent of North Carolina and Texas workers. With 6.7 percent of workers working from home, North Carolina has a higher telecommuting adoption rate than Texas' 5.7 percent and Pennsylvania's 5.4 percent.

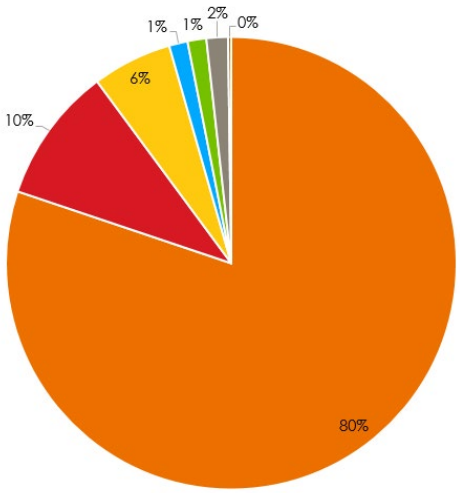
LEGEND

- DROVE ALONE
- CARPOOL
- WORKED AT HOME
- PUBLIC TRANSPORTATION
- TAXI, MOTORCYCLE, OR OTHERS
- WALKED
- BICYCLE

NORTH CAROLINA



TEXAS



PENNSYLVANIA

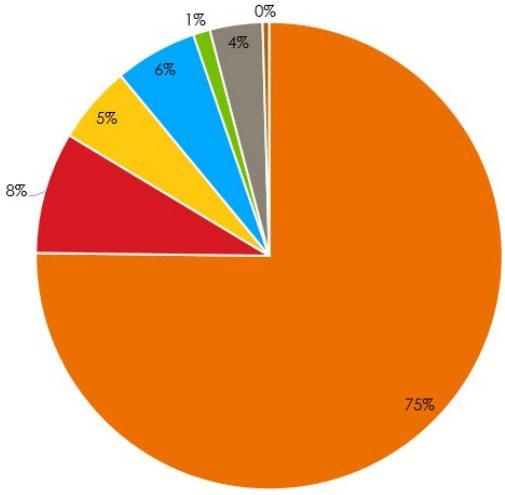


Figure 10: 2019 Commuter Mode for North Carolina, Texas, and Pennsylvania

Source: US Bureau of Transportation Statistics, Commute Mode

2.1.3 Pandemic VMT Trends

In March 2020, the COVID-19 pandemic began to impact the daily routine of Americans nationwide, including in North Carolina. During this month, Governor Cooper signed numerous executive orders to limit the spread of COVID-19, including:

- Executive Order 117: Closing K-12 public schools statewide (March 14)
- Executive Order 118 Closing restaurants and bars for dine-in service (March 17)
- Executive Order 120: Extending the public school closure to May 15 and banning gatherings of more than 50 people (March 23)
- Executive Order 121: Issuing a Stay at Home Order from March 30 to April 29 (except for essential service) and banning gatherings of more than 10 people (March 27)

As North Carolinians were encouraged to stay home and as jobs in certain economic sectors (such as restaurants, performing arts venues, and sporting facilities) were lost, VMT was significantly reduced. Compared to January 2020, April 2020 employment and daily VMT were 18 and 36 percent lower, respectively.

Since then, daily VMT and employment have gradually increased as restrictions have loosened. At the end of 2020, there was still significantly lower employment and telecommuting was still prevalent.

Also, since people are still encouraged to socially distance, transit use declined dramatically during the same period with more people using their personal vehicle for trips that they may have used transit for in the pre-COVID past. In December 2020, national public transit ridership was still down about 65 percent[1]. The pandemic has also increased at-home deliveries. McKinsey & Company reported that in 2020, last-mile deliveries increased ten-fold over 2019[2].

These trends have contributed to the rebound of daily VMT. In North Carolina, daily VMT in October 2020 was slightly higher than it was in January 2020 (although still about 4.2 percent lower than October 2019 VMT). Figure 11 compares the employment and average daily VMT for all months in 2020 for North Carolina.

1. APTA: https://www.apta.com/wp-content/uploads/APTA-COVID-19-Funding-Impact-2021-01-27.pdf
2. https://www.mckinsey.com/industries/travel-logistics-and-infrastructure/our-insights/us-freight-after-covid-19-whats-next#

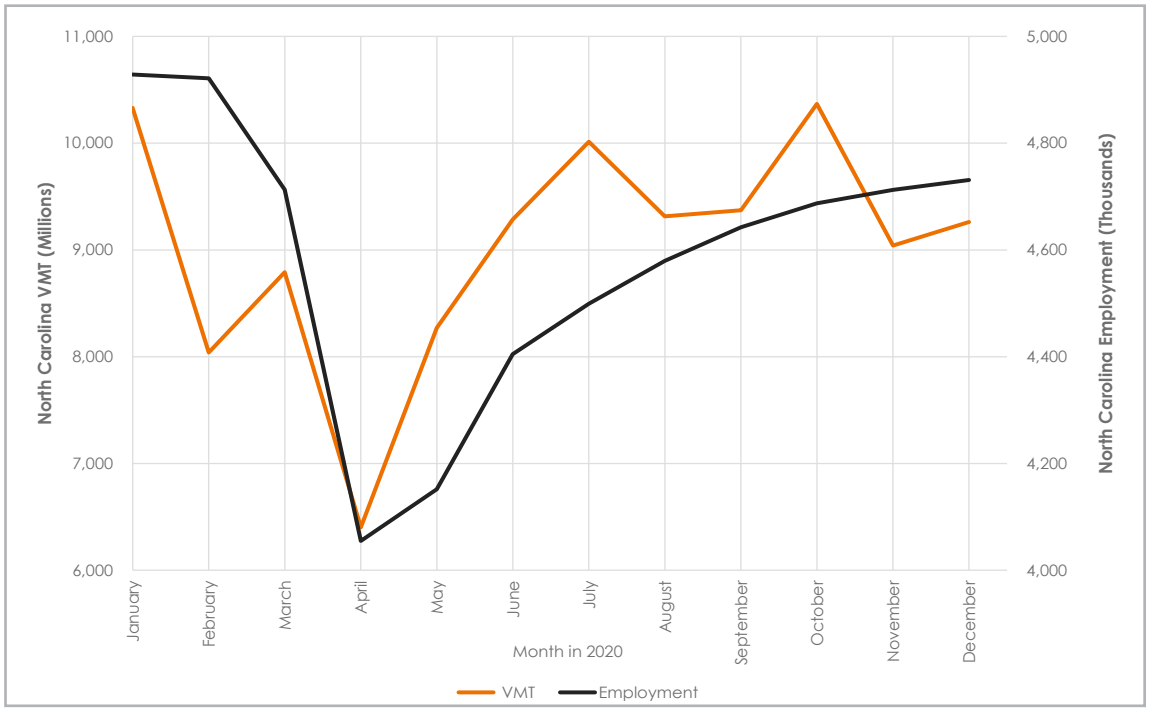


Figure 11: North Carolina Employment and Daily VMT by Month in 2020

Source: Federal Highway Administration (VMT) and Bureau of Labor Statistics (Employment)

The traffic recovery from the COVID-19 pandemic has varied by area. For example, the sum of daily traffic volumes at five continuous count locations in the Asheville area reached pre-pandemic levels for the first time since mid-March during the 17th week of the pandemic (June 29-July 3).

In the Triangle region for the same week, however, the sum of traffic volumes at nineteen continuous count locations were 22 percent lower than pre-pandemic levels. Part of the reason for this difference is that the Asheville area is more rural than the Triangle area; due to inherently longer trip distances, rural communities are more reliant on their automobiles than suburban and urban areas.

Additionally, leisure activities in rural areas may have gained popularity during the pandemic due to the ease of social distancing in outdoor recreational and less dense areas. In fact, after July, rural count location daily volumes were typically at least 10 percent closer to pre-COVID levels than urban count location volumes. Figure 12 shows the difference in weekday traffic volumes from the pre-pandemic week of March 2-6, 2020 to following weeks for the Asheville and Triangle areas. Figure 13 shows the difference in weekday traffic volumes from the pre-pandemic week of March 2-6, 2020 to following weeks for combinations of urban/rural and interstate/non-interstate locations.

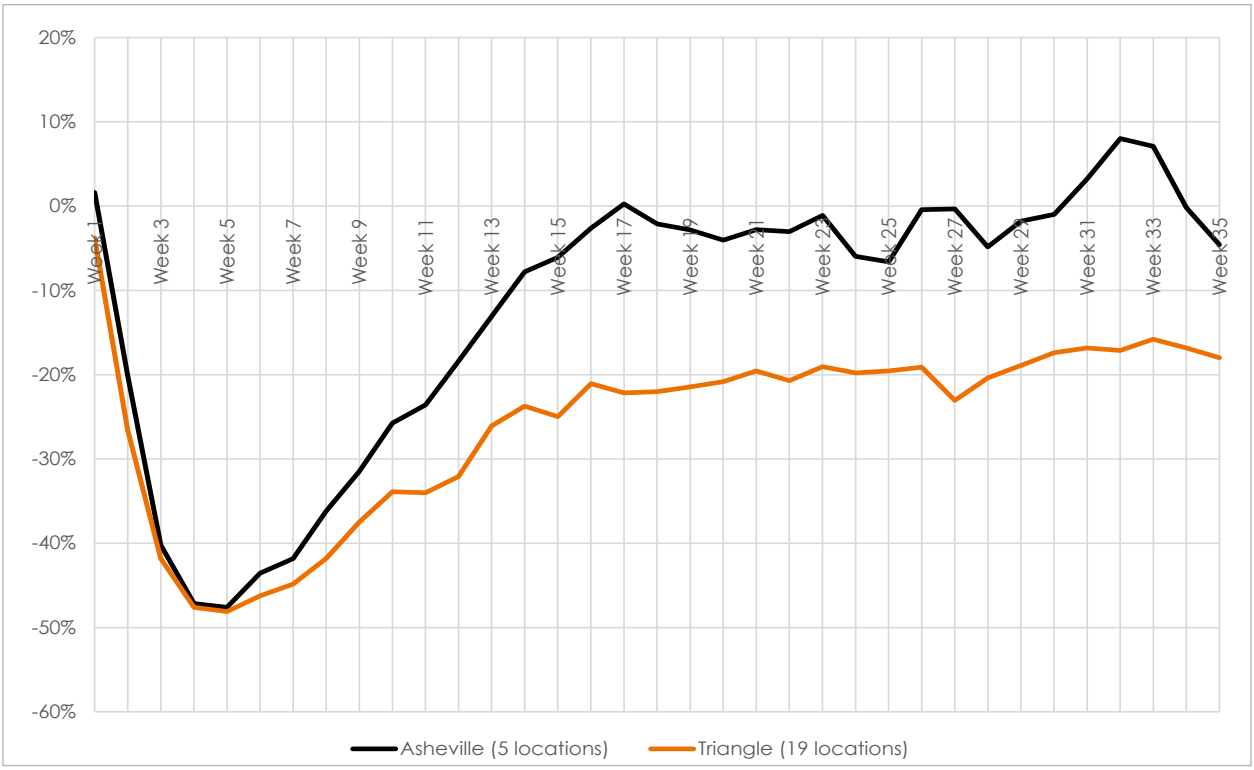


Figure 12: Difference in Weekday Traffic Volumes from March 2-6, 2020 to Future Weeks, Asheville and Triangle areas
Source: NCDOT

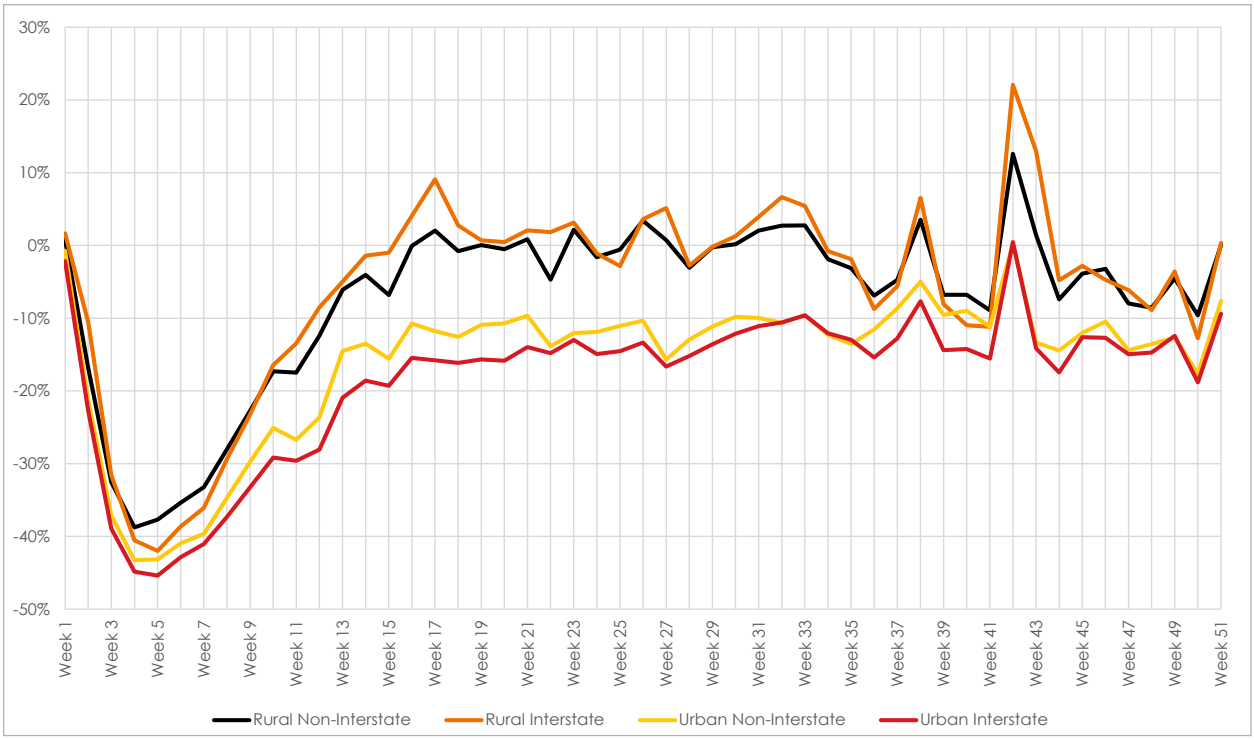


Figure 13: Difference in Weekday Traffic Volumes from March 2-6, 2020 to Future Weeks, Urban and Rural Count Locations
Source: NCDOT

2.1.3.1 Post-Pandemic Impact on VMT

The COVID -19 pandemic will likely have a long-lasting impact on commute patterns as many employees have worked from home for at least a year. During this time, employees have optimized their work from home set-up by purchasing furniture, electronics, and even moving into new homes. Employers have supported their employees by making sure they had the equipment they needed, ensuring the networks could handle the surge in people working from home, and in some cases, subsidizing employees' infrastructure costs to make their work from home set up better. The result of the investment and duration of the pandemic is that many employers and employees now know that it is possible to effectively work from home. In a November/ December 2020 poll by PwC[3], 61 percent of executives thought that a typical employee needed to be in the office no more than three days per week to maintain a distinctive culture for the company if COVID-19 was no longer a concern.

In the employee component of the survey, 74 percent of employees indicated that they would want to work remotely for at least two days a week after COVID-19 is no longer a concern.

The long-term impact to VMT is yet to be determined, both nationally and in North Carolina. While telecommuting clearly reduces commuting trips, research has shown that it may also cause an increase in other "shorter" trips as workers may run errands or take similar trips during the workday. Additionally, workers may move further away from the office if they know that they can make the commute only a few days a week, thereby potentially offsetting the VMT reduction due to telecommuting. Finally, the pandemic may have encouraged some workers to telecommute full-time and move to a different state than their office. It is unclear what type of long-term change to VMT North Carolina would see from this possible shift in work behavior.

3. US Remote Work Survey: PwC

2.2 IDENTIFYING TDM STRATEGIES

The goal of the study was to identify transportation demand management (TDM) strategies that could be implemented in all areas of North Carolina, including rural areas, to reduce VMT. Rural areas are typically much harder to target with TDM strategies, as many strategies target denser land uses. As such, it was important to cast a wide net that included not only tried-and-true measures, but also newer, and perhaps more innovative solutions.

2.2.1 Determining the Existing State of TDM Implementation

A baseline assessment of the TDM measures that have already been implemented across the state was completed. NCDOT has many TDM resources on its website, including webinars and reports, to assist planning organizations with TDM Planning[4]. An initial "list" of TDM measures was identified from the Statewide Transportation Demand Management Strategic Plan Update (January 30, 2018)[5]. This report identified the TDM measures implemented (at that time) in five areas of North Carolina including: Asheville, Charlotte, the Piedmont Triad, the Triangle (the Raleigh-Durham-Chapel Hill area) and Wilmington.

The TDM strategies list was the basis for a SurveyMonkey survey that was sent to all 37 planning organizations (POs) within North Carolina. The intent of this survey was to understand the TDM measures currently implemented across the state and to have an indication of the perceived effectiveness of these measures. In addition, the survey asked whether the measure was implemented by the planning organization or another public or private entity. The SurveyMonkey survey sent to the POs is shown in Appendix A-1.

Twenty-three of the 37 POs within the state responded; 12 of the responses were from Rural Planning Organizations (RPOs) and 11 were from Metropolitan Planning Organizations (MPOs). Many of the MPOs cover more than one area type. Of the 11 MPOs that responded, 7 indicated they covered rural areas, 7 indicated they covered suburban areas, and 10 indicated they cover urban areas. Table 4 shows the composition of areas in the MPOs.

4. Travel Demand Management (TDM) (ncdot.gov)
5. Statewide TDM Strategic Plan.pdf (ncdot.gov)

Rural+Suburban+Urban	6
Urban	3
Rural+Urban	1
Suburban	1

Table 4: Land Use Coverage within MPO's

Source: Stantec Survey

The survey asked which of the 24 TDM measures listed were implemented in each respondent's planning area. As shown in Table 5, the most commonly implemented TDM measure across planning areas was transit services, followed by bicycle infrastructure, complete streets, downtown revitalization, and telecommuting. The only strategies not implemented in any planning area were a VMT tax and a gas tax increase.

NO.	MEASURE
23	Transit Services
22	Bicycle infrastructure
21	Complete Streets
21	Downtown Revitalization
20	Telecommuting
19	Mixed Land Use Zoning
16	Vanpool Services
15	Broadband Infrastructure Improvements
14	Compact Residential Development
13	Park & Ride Lots
12	Compressed work week
12	Transit and Vanpool Fare Subsidies
10	Compact Employment and Activity Centers
9	Parking Pricing
9	Transit-Oriented Development
7	Ridematching Services
4	Alternative Mode Rebates/Incentives
4	Guaranteed Ride Home
3	Trip Reduction Ordinances
3	Car-Free Zones
1	HOV Facilities
1	Road/Congestion Pricing
0	Gas Tax Increase
0	VMT Tax

Table 5: Number of Planning Organizations Implementing Certain Strategies

Source: Stantec Survey

Table 6 below presents the strategies that have been implemented in each planning area and by which organizations. This matrix shows that across all strategies, across all planning areas surveyed, there is currently a 47 percent implementation rate of the VMT reduction strategies listed. This shows a significant coverage of VMT reduction strategies, especially considering that not all the strategies listed could be applicable for all areas.

TDM STRATEGY IMPLEMENTATION BY ORGANIZATION

legend
- ● - OTHER ORG ONLY
- ● - PO ONLY
- ● - BOTH

	RPOs																MPOs						
	Albemarle Rural Planning Organization	Cape Fear RPO	Down East Rural Planning Organization	Eastern Carolina Rural Planning Organization	High Country Council of Governments	Isothermal RPO	Kerr-Tar Regional Council of Governments	Mid-East RPO	PBRPO	Piedmont Triad RPO	Triangle Area RPO	Upper Coastal Plain RPO	CAMPO	City of Jacksonville	CRTPO	Durham-Chapel Hill-Carrboro MPO	French Broad River MPO - Combined	Gaston Cleveland Lincoln MPO	GH MPO	Greensboro MPO	GSATS MPO	New Bern Area MPO	WMPO
HOV Facilities															●								
Park & Ride Lots		●		●	●	●			●		●		●	●	●	●	●			●			●
Vanpool Services	●	●		●		●	●	●	●		●		●	●	●	●	●			●		●	●
Transit Services	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Ridematching Services													●		●	●	●			●			●
Guaranteed Ride Home													●			●				●		●	
Bicycle infrastructure	●	●	●	●	●	●	●	●		●	●	●	●	●	●	●	●	●	●	●	●	●	●
Transit and Vanpool Fare Subsidies		●	●	●	●		●	●			●		●		●	●	●			●			
Alternative Mode Rebates/Incentives													●		●	●	●						
Transit-Oriented Development					●			●				●	●		●	●	●					●	●
Compact Employment and Activity Centers			●	●		●					●		●		●	●	●	●					●
Compact Residential Development	●	●	●		●	●					●	●	●	●	●	●	●	●					●
Mixed Land Use Zoning	●	●	●	●	●	●	●	●			●	●	●	●	●	●	●	●				●	●
Complete Streets	●	●	●	●	●	●	●	●		●	●	●	●	●	●	●	●	●		●	●	●	●
Downtown Revitalization	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●			●	●
VMT Tax																							
Road/Congestion Pricing															●								
Gas Tax Increase																							
Parking Pricing		●		●	●			●								●	●			●		●	●
Broadband Infrastructure Improvements	●		●	●		●	●	●				●	●	●	●	●	●		●	●		●	
Telecommuting	●		●	●	●	●	●	●	●		●	●	●	●	●	●	●	●	●	●		●	●
Compressed work week	●			●		●	●				●	●	●	●	●	●	●						●
Car-Free Zones												●				●	●						
Trip Reduction Ordinances												●	●			●							

Table 6: TDM Strategies Implemented in Each Planning Area by Organization

Source: Stantec Survey

The survey also asked POs which TDM strategies they thought were the top five most effective for reducing VMT in their area and which were the top five easiest to implement. Table 7 shows these responses combined across POs and ranked based on both effectiveness and ease of implementation. Of the top five overall ranked strategies; transit services, telecommuting, vanpool services, complete streets, and bicycle infrastructure; four of these are also in the top five most implemented strategies from Table 5 above.

TDM STRATEGIES	Most Effective	2nd most effective	3rd most effective	4th most effective	5th most effective	Total	Easiest	2nd easiest	3rd easiest	4th easiest	5th easiest	Total
Transit Services	4	8	0	3	3	18	5	4	2	2	0	13
Telecommuting	2	3	1	4	0	10	5	4	0	3	0	12
Vanpool Services	0	3	1	3	0	7	3	2	2	4	0	11
Park & Ride Lots	1	1	4	0	0	6	1	4	3	1	0	9
Bicycle infrastructure	0	2	3	2	0	7	2	2	3	1	2	10
Complete Streets	2	1	3	1	4	11	1	0	3	3	2	9
Mixed Land Use Zoning	0	1	3	1	2	7	1	0	0	1	1	3
Downtown Revitalization	1	1	0	2	1	5	0	0	2	1	2	5
Compressed work week	1	1	0	0	1	3	1	1	0	0	2	4
Guaranteed Ride Home	0	0	1	0	1	2	0	2	2	0	1	5
Ridematching Services	0	0	0	1	1	2	2	1	0	0	2	5
Broadband Infrastructure Improvements	1	0	2	0	2	5	0	0	1	0	2	3
Transit and Vanpool Fare Subsidies	0	1	1	1	0	3	0	1	0	0	0	1
Compact Employment and Activity Centers	0	0	1	0	1	2	0	1	0	0	1	2
HOV Facilities	0	0	0	0	0	0	1	0	0	0	0	1
Parking Pricing	0	0	1	0	0	1	0	0	0	0	1	1
Alternative Mode Rebates/Incentives	0	0	0	0	0	0	0	0	1	0	1	2
Transit-Oriented Development	0	0	0	1	1	2	0	0	0	0	0	0
Compact Residential Development	0	0	0	0	0	0	0	0	0	1	0	1
Gas Tax Increase	0	0	0	0	1	1	0	0	0	0	0	0
VMT Tax	0	0	0	0	0	0	0	0	0	0	0	0
Road/Congestion Pricing	0	0	0	0	0	0	0	0	0	0	0	0
Car-Free Zones	0	0	0	0	0	0	0	0	0	0	0	0
Trip Reduction Ordinances	0	0	0	0	0	0	0	0	0	0	0	0

Table 7: Strategies Ranked by Effectiveness in Reducing VMT and Ease of Implementation
Source: Stantec Survey

Additionally, the survey asked if the POs had completed any studies that evaluated the effectiveness of VMT-reducing policies enacted in their jurisdiction. Of the 23 POs that responded to the survey, 5 indicated they had completed at least one of these types of studies for their area.

This survey revealed there is not only knowledge and awareness of various VMT reduction strategies across North Carolina's POs, but also widespread implementation of many of these measures across the state. Overall, North Carolina's POs are focused on implementing overall planning and development ideologies, like complete streets, while other organizations such astransit agencies, municipalities, transportation managment associations and private entities, are focused on providing specific services, like transit.

2.2.2 Expanding the List of Potential TDM Measures

The project team also reached out to transportation experts within Stantec that work around the world including in multiple US states, the United Kingdom, India and Australia/New Zealand. A survey (see Appendix A-2) was sent to these experts and follow-up interviews were conducted. The responses and interviews identified source documents and projects with TDM strategies. These additional sources were reviewed and resulted in an expanded list of possible TDM measures.

At the same time, Stantec completed a literature review that focused on research presented or published by the Transportation Research Board and other documented research conducted at academic institutions. The research cast a wide net; additional TDM measures around the world were identified as well as estimates of the qualitative effectiveness of each measure. The review included sources that measured the effectiveness of existing implemented TDM measures and modeled effects of TDM measure implementation on vehicle miles traveled (VMT). Appendix A-3 lists the sources referenced in this literature review.

Additionally, the review included planning documents from municipalities, both domestic and international, to investigate specific planned use cases for TDM strategies, potential synergy between measures, and communication materials intended for public consumption.

This research was used to develop summary pages for each identified TDM measure. The summary pages:

- defined each measure,
- evaluated the area type that the measure could be implemented in,
- provided examples of successful implementation in North Carolina (if applicable) and around the world,
- identified implementation considerations,
- identified the range of expected VMT reduction that could be expected with each measure, and
- identified the organization that would likely implement the measure.

A total of 38 TDM Summary Pages were developed. The intent of these pages is to be a comprehensive introductory resource that North Carolina's POs can use to find helpful information regarding each TDM measure when considering methods to reduce VMT in their areas.

The TDM measures were categorized to better identify their prime methodology with respect to reducing VMT. These categories included: worksite/workplace, regional, telecommunication, land use, public policy/regulatory, pricing, application-based and support strategies.

TDM MEASURES BY AREA TYPE

STRONG IMPACT ●
MODERATE IMPACT ●

	 URBAN	 SUBURBAN	 RURAL
ACCESS PRIORITY	●	●	
AFFORDABLE HOUSING	●		
ALTERNATIVE MODE SHARING	●		
CAR SHARING	●		
COMPLETE STREETS	●		
COMPRESSED WORK WEEK	●	●	●
CONNECTIVITY	●	●	●
CUSTOM TRANSIT	●	●	●
DEVELOPMENT IMPACT MITIGATION	●	●	
EMPLOYEE PARKING CASH-OUT	●	●	
GAS TAX-INCREASE	●	●	●
HOV FACILITIES	●	●	●
INFORMATION SERVICES-BROADBAND EXPANSION			●
INTERNET-BASED STRATEGIES	●	●	●
MIXED LAND USE	●	●	
NON-MOTORIZED MODE SUPPORT	●	●	
PARK AND RIDE LOT		●	●
PARKING PRICING	●	●	
PUBLIC TRANSIT	●	●	
ROAD PRICING	●	●	
TELECOMMUTING-TELEWORK	●	●	●
TRANSIT-ORIENTED DEVELOPMENT	●	●	
TRANSPORTATION MANAGEMENT ASSOCIATION	●	●	
TRIP REDUCTION ORDINANCE	●	●	
VANPOOLS	●	●	●
VMT TAX	●	●	●

TDM MEASURES BY AREA TYPE

	STRONG IMPACT	MODERATE IMPACT
 **URBAN**	Access priority Affordable housing Alternative mode sharing Car sharing Complete streets Compressed work week Development impact mitigation Employee Parking cash-out Gas tax increase HOV facilities Internet-based strategies Mixed land use Non-motorized mode support Parking pricing Public transit Road pricing Telecommuting-telework Transit-oriented development Transportation management association Trip reduction ordinance Vanpools VMT tax	Connectivity Custom Transit
 **SUBURBAN**	Compressed work week Connectivity Custom transit Development impact mitigation Gas tax increase HOV facilities Internet-based strategies Non-motorized mode support Park and ride lots Public transit Telecommuting-telework Transit-oriented development Transportation management association Trip reduction ordinance Vanpools VMT tax	Access priority Employee Parking cash-out Mixed land use Parking pricing Road pricing
 **RURAL**	Compressed work week Custom transit Gas tax increase Information services-Broadband Expansion Internet-based strategies Telecommuting-telework VMT tax	Connectivity HOV facilities Park and ride lots Vanpools

2.3 TDM SUMMARY PAGES

Worksite/Workplace

- Employee Parking Cash-Out Program
- Transportation Management Associations
- Alternative Work Schedules

Regional

- Park and Ride Lots
- Alternative Mode Sharing
- Carsharing
- Flexible Public Transit
- Public Transit
- High Occupancy Vehicle (HOV) Facilities
- Non-Motorized Mode Support
- Vanpool

Telecommunication

- Internet Based Strategies
- Information Service: Broadband Expansion
- Telecommuting/Telework

Land Use

- Providing Affordable Housing
- Complete Streets
- Transit Oriented Development
- Connectivity
- Development Impact Mitigation
- Jobs/Housing Balance
- Mixed Land Use

Public Policy/Regulatory

- Access Priority/Restriction
- Trip Reduction Ordinance

Pricing

- Gas Tax Increase
- Parking Pricing
- Road Pricing and Cordon Pricing
- VMT Fee or Tax

Application-Based

- Mobility as A Service
- Ride-Matching Applications

Support

- Compact Development/Clustering
- Facility Amenities
- Guaranteed Ride Home
- Incentive Programs
- Parking Management
- Public Education and Promotion
- Ride-Matching Services
- Transit Fare Subsidies
- Vanpool Fare Subsidies

EMPLOYEE PARKING CASH-OUT PROGRAM

REGION TYPE

URBAN SUBURBAN

DESCRIPTION

Many employers provide their employees a "free" parking space. Parking cash-out allows employees to opt out of using this space in exchange for payment which may be used to purchase transit fares, or in some programs, kept as cash. The program is typically administered on a monthly basis but some daily cash-out programs do exist.

The cost of providing parking to employees is high. According to WGI, the 2019 average construction cost for a parking spot in a parking structure in Charlotte was $18,122. A surface lot parking space would be less, but would likely cost between $2,000 and $3,000 per space.

In addition to the construction costs, annual operation and maintenance can add about $300-$500 per year ($2013) per space, and the initial land costs can also be high, particularly in a dense urban area.

PROS

- Encourages non-vehicle modes, including transit, walking, and biking.
- Reduces the employee costs related to parking facilities and makes transit less costly to employees.

CONS

- Not all commuter trips can be served by alternative modes of transportation.

POTENTIAL VMT REDUCTION IMPACT

For Parking Cash-Out programs, the commuting VMT per employee may decrease by as much as 12%. (Best Workplaces for Commuters)

Research in a Portland State University Transportation Research and Education Center (TREC) monthly webinar concluded that a monthly cash-out program that requires employers to offer employees the option to cash out their parking on a monthly basis was estimated to result in a change in commuter VMT of -7.9% (Indianapolis) to -29.8% (New York City) and a city-wide change in commuter VMT of -2.9% (New York City) to -19.7% (Boston/Cambridge).

IMPLEMENTATION CONSIDERATIONS

Parking cash-out programs work best in areas that have good transit coverage.

NORTH CAROLINA EXAMPLES

- Pendo, a technology company with an office in Raleigh, provides free parking or a stipend for employees who choose to bike, walk, or use public transportation to get to work.

OTHER EXAMPLES

- Seattle Children's Hospital
- Delta Dental of Washington
- Downtown Grand Rapids, Inc.

https://www.smartergrowth.net/wp-content/uploads/2018/04/Examples-of-employers-implementing-parking-cash-CSG.pdf

SOURCES

"Parking Cash Out: Implementing Commuter Benefits as One of the Nation's Best Workplaces for Commuters", Best Workplaces for Commuters, March 2005.
http://www.reconnectingamerica.org/assets/Uploads/bestpractice090.pdf

"Parking Management: Comprehensive Implementation Guide." Litman, Todd. Victoria Transport Policy Institute, 19 November 2023.
www.vtpi.org/park_man_comp.pdf

"Webinar: Transportation Benefits of Parking Cash-Out, Pre-Tax Commuter Benefits, and Parking Surtaxes" Greenberg, Allen; Choe, James; Sethi, Sonika; and Stoll, Colleen, (2017). TREC Webinar Series. 23.
http://pdxscholar.library.pdx.edu/trec_webinar/23

"Show me the money: Offering commuting and parking cash-out benefits", Transit Screen Blog, November 8, 2019.
https://transitscreen.com/blog/commuting-cash-out-programs-parking-public-transit-employee-incentives-decrease-traffic-how-to-create-effective-transit-programs-in-the-office/

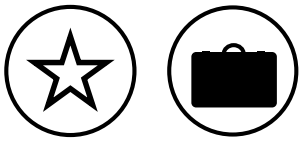
TYPE OF TRIPS TARGETED

Commuter trips

POTENTIAL APPLICATION LOCATIONS

Urban City Centers
Town Center

IMPLEMENTED BY



STATE GOV'T PRIVATE

TRANSPORTATION MANAGEMENT ASSOCIATIONS

REGION TYPE

URBAN SUBURBAN RURAL

DESCRIPTION

Transportation Management Associations (TMAs) are independent groups that coordinate transportation services, usually in partnership with government entities. TMAs can consist of private citizens, employers, business owners, developers, or other stakeholders. Coordinated services can include ride-matching, employer shuttles, shared parking, paratransit, travel alerts, safe routes to school/work, bikesharing, or carsharing. TMAs can also be a valuable channel for communicating and marketing new TDM measures.

TMAs cover defined geographic areas and can have a mix of voluntary and compulsory membership. Required membership can be part of zoning and variance agreements. Voluntary membership rationale includes the economic growth seen in areas with TMAs and the ability to have a formal stakeholder voice. TMAs are not for profit and funding can be a mix of private funding like membership fees and public funding.

PROS

- Provides a formalized group to interface with stakeholders in localized TDM measures.
- Provides a way for government entities to promote and track employer and business based TDM measures.
- Has shown success in low-population, rural areas.

CONS

- Success is dependent on the willingness of participants.
- Is a government partnership group, not government controlled.

POTENTIAL VMT REDUCTION IMPACT

VMT reduction is dependent on the programs the TMA implements. From 2009 to 2011, three Portland area TMAs reduced VMT from between 0.003% to 0.03% of the regional VMT (Mosaic).

IMPLEMENTATION CONSIDERATIONS

Getting consensus and buy-in from potential members is key.

NORTH CAROLINA EXAMPLES

- Charlotte
  https://www.charlottecentercity.org/
- GoRTP
  https://www.rtp.org/local-transit/

OTHER EXAMPLES

- Nationwide – over 150 TMAs in the US in 2015
- Virginia
  https://mobilitylab.org/what-is-mobility-lab/
- New Jersey
  https://gmtma.org/
- Maine
  http://dune.une.edu/theses/65

SOURCES

Oregon Department of Transportation, "Mosaic Programs Guide", 2012.
https://www.oregon.gov/ODOT/Planning/Documents/Mosaic-Programs-Guide.pdf

TYPE OF TRIPS TARGETED

All

POTENTIAL APPLICATION LOCATIONS

Any

IMPLEMENTED BY

COUNTY/ LOCAL GOV'T MPO/RPO PRIVATE

ALTERNATIVE WORK SCHEDULES

(COMPRESSED WORK WEEKS)

REGION TYPE

URBAN SUBURBAN RURAL

DESCRIPTION

Traditional work schedules consist of working an 8-hour day, 5 days a week typically Monday through Friday from about 8 AM to 5 PM. An alternative work schedule varies these work hours to spread the typical 40-hour work week over different hours of the day and sometimes for fewer days per week. If the 40 hours are spread over a shorter week, reductions in commuter VMT can be achieved. For example, if a commuter works 10 hours per day for 4 days per week, instead of 8 hours per day for 5 days per week, they reduce their weekly commuter VMT for this trip type by 20 percent. If they spread two weeks of work (80 hours) over 9 days instead of 10 days, a 10 percent reduction in commuter VMT can be achieved.

PROS

- Appealing to the worker because they have an extra day off. Can result in better employee health and employee productivity and retention.
- No additional cost to the employer to implement this policy.

CONS

- May not be feasible for all job types.

POTENTIAL VMT REDUCTION IMPACT

A study of a 4/40 work week (4 10-hour days instead of 5 8-hour days) in Los Angeles County showed that employees actually made more trips on their compressed workweek day off than they would have, had they been working. These extra trips were typically shorter in length and often were "chained trips" from one destination to another. Each participant in the study drove about 46 miles less per week than when they worked a 5-day week (Ho and Stewart).

IMPLEMENTATION CONSIDERATIONS

This measure may not be applicable to all job types.

NORTH CAROLINA EXAMPLES

- Raleigh
  https://www.wral.com/some-triangle-employers-offering-shorter-work-weeks/18542010/

OTHER EXAMPLES

- Microsoft Japan
  https://www.npr.org/2019/11/04/776163853/microsoft-japan-says-4-day-workweek-boosted-workers-productivity-by-40
- Shake Shack, Wildbit, Cockroach Labs
  https://edition.cnn.com/2019/07/01/success/four-day-work-week/index.html

SOURCES

A. Ho, J. Stewart, "Case Study on Impact of 4/40 Compressed Workweek Program on Trip Reduction",Transportation Research Record, 1992 .
http://onlinepubs.trb.org/Onlinepubs/trr/1992/1346/1346-005.pdf

Texas A&M Transportation Institute Mobility Investment Properties, "Compressed Work Weeks"
https://mobility.tamu.edu/mip/strategies-pdfs/travel-options/technical-summary/compressed-work-weeks-4-pg.pdf

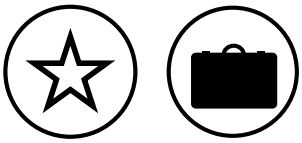
TYPE OF TRIPS TARGETED

Commuter Trips

POTENTIAL APPLICATION LOCATIONS

Many potential applications to many job types

IMPLEMENTED BY



STATE GOV'T PRIVATE

Regional

PARK AND RIDE LOTS

REGION TYPE

SUBURBAN RURAL

DESCRIPTION

Park and ride facilities are parking lots where commuters can park their personal vehicles and transfer to a "higher occupancy" transportation mode such as light rail, bus, or carpool vehicles.

Park and ride facilities are typically adjacent to a transit station and/or a highway to allow for an easy connection between modes. Park and ride lots may be maintained by the Department of Transportation or other public agency and monitored by local law enforcement to prevent vehicle theft and overnight parking. Lots may also be converted from existing underutilized or unutilized lots like shopping centers.

PROS

- Provides an opportunity for commuters who may otherwise drive alone to work to use either public transit or carpooling for part of their commute.
- Provides carpoolers with a safe, central location to meet at the beginning of the carpool.
- May be combined with other uses, such as storage for DOT maintenance equipment, or unused mall lots.
- Compliments other Transportation Demand Management (TDM) measures, such as public transit and High Occupancy Vehicle (HOV) lanes.

CONS

- Park and ride lots have a finite capacity; once that capacity is met for the day, it cannot be used by additional commuters.
- Workers may decide to live further away from their jobs if a park and ride lot provides an opportunity to drive only a portion of the distance for each commute. In some cases the overall trip length may be longer and while some part of their trip may be in a shared vehicle, their overall VMT may not be reduced.

POTENTIAL VMT REDUCTION IMPACT

Reductions in VMT are dependent on the number of spaces provided, the distance from the lot to a final destination, and the shared mode. VMT reductions for specific scenarios can generally be calculated by taking the number of spaces (assuming 70-85% occupancy from Federal Highway Administration (FHWA) or based on local data) and the remaining distance to a central business district. An FHWA study found that the installation of park and ride facilities may reduce regional VMT by 0.1-0.5%. (California Air Pollution Control Officer Association)

IMPLEMENTATION CONSIDERATIONS

There may be land acquisition required, although if the land is close to a highway's right-of way or transit station it may already be owned by the North Carolina DOT. Park and ride lots incur operation and maintenance cost and may require law enforcement surveillance.

NORTH CAROLINA EXAMPLES

- Piedmont Area
  https://www.partnc.org/162/Park-Ride-Locations
- Land of Sky
  http://www.landofsky.org/pdf/LGS/RPO/Map33_ParkNRideLots_Dec2015.pdf
- GoTriangle Transit
  https://gotriangle.org/park-and-ride
- Charlotte
  https://charlottenc.gov/cats/bus/Pages/park-and-rides.aspx
- UNC Chapel Hill
  https://move.unc.edu/transit/park-ride/

OTHER EXAMPLES

- Hudson County NJ
  https://hudsontma.org/park-and-ride-lot-locations

SOURCES

"Multi-Pollutant Emissions Benefits of Transportation Strategies", Chapter 3 Transportation Demand Management Strategies, FHWA, Updated June 28, 2017.
https://www.fhwa.dot.gov/Environment/air_quality/conformity/research/mpe_benefits/mpe03.cfm#:~:text=Since%20park%2Dand%2Dride%20facilities,reduce%20vehicle%20trip%2Dmaking%20entirely.

"Quantifying Greenhouse Gas Mitigation Measures", California Air Pollution Control Officers Association, 2010.
https://www.aqmd.gov/docs/default-source/ceqa/handbook/capcoa-quantifying-greenhouse-gas-mitigation-measures.pdf

TYPE OF TRIPS TARGETED

Commuter trips

POTENTIAL APPLICATION LOCATIONS

Urban City Centers
Town Center

IMPLEMENTED BY

STATE GOV'T COUNTY/ LOCAL GOV'T TRANSIT AGENCY

Regional

ALTERNATIVE MODE SHARING

REGION TYPE

URBAN SUBURBAN

DESCRIPTION

Alternative mode sharing is a service in which non-automobile vehicles (typically bicycles or scooters, non motorized or electric) are available to individuals to either rent for a fee or reserve for free. Some sharing programs require that vehicles be taken from and returned to docking stations, while other programs allow customers to drop off vehicles at the end of their journey.

In the latter instance, vehicles are equipped with a GPS device that allows potential customers to see where available vehicles are on a smart phone application and allows the sharing company to locate their assets when maintenance is required. Some sharing services require customers to pre register an account, while others just require a credit card to unlock the bicycle or scooter. Vehicles may have to be re- distributed throughout the day to ensure that the available vehicle supply meets the demand.

PROS

- Alternative mode sharing can be an inexpensive way for some customers to "test out" bicycles and scooters before buying their own.
- If the sharing platform does not use docking stations or if the docking stations are close together, it adequately addresses the "first mile/last mile" problem.

CONS

- Alternative mode sharing relies on adequate infrastructure to work well. If customers feel unsafe or in danger when riding a bicycle or scooter, the program will not be successful.
- The platform requires a higher density to be successful; few people are going to utilize this service if the closest shared vehicle to their location is over a half mile away.
- Programs without docking stations have the potential to block sidewalks if demand in a certain area is too high or users do not adhere to parking regulations.
- Vehicle misuse, such as not following traffic controls, can lead to liability issues and fatalities.

POTENTIAL VMT REDUCTION IMPACT

A household survey of Sacramento following the implementation of an e-bike and e-scooter program showed that 3-13% of households used the service. 35% of trips substituted car travel, while 30% substituted walking and 5% were used to connect to transit.

The 2018 Portland Oregon E-Scooter Findings Report concluded that e-scooters trips shifted primarily from walking, Single Occupant Vehicle (SOV) and ridesharing trips and that e-scooter trips replaced 301,856 vehicle trips that would have traveled in SOV's and other shared vehicle trips, or about 1% of the total area VMT.

IMPLEMENTATION CONSIDERATIONS

Many of these types of programs, especially scooter sharing programs, have had strained public-private partnerships and issues with public perception, which was seen in Hoboken, NJ's six-month pilot program of e-scooters in 2019.

Safety issues are also a large concern with alternative mode sharing. There were two fatalities involving shared Revel mopeds in New York City in July 2020 which garnered considerable public attention and caused temporary suspension of the program. E-scooters have also shown a pattern in fatalities, with several occurring across the county in Washington D.C, Atlanta, San Diego, Los Angeles, and Cleveland.

NORTH CAROLINA EXAMPLES

- Charlotte
  Lime scooters- **https://www.li.me/locations**
  Charlotte BCycle- **https://charlotte.bcycle.com/**
- Raleigh
  Gotcha Scooter - **https://ridegotcha.com/locations/raleigh/**
- UNC-Wilmington
  Bird Bike Share- **https://uncw.edu/seahawk-life/services/parking-transportation/transportation/bike-share**

OTHER EXAMPLES

- New York City
  https://www.citibikenyc.com/
- Austin, Texas
  https://wheels.co

SOURCES

"Investigating the Influence of Dockless Electric Bike-share on Travel Behavior, Attitudes, Health, and Equity", Fitch, D., Mohiuddin, H., & Handy, S., UC Office of the President: University of California Institute of Transportation Studies, 1 March 2020
https://escholarship.org/uc/item/2x53m37z

"Revel Suspends Moped Service in New York City After 2 Deaths", Michael Gold, The New York Times, 28 July 2020.
https://www.nytimes.com/2020/07/28/nyregion/revel-scooters-death-nyc.html

"2018 E-Scooter Findings Report", Portland Bureau of Transportation.
https://www.portland.gov/sites/default/files/2020-04/pbot_e-scooter_01152019.pdf

TYPE OF TRIPS TARGETED

All types of trips; typically "short" trips

POTENTIAL APPLICATION LOCATIONS

Dense residential areas, universities

IMPLEMENTED BY

STATE GOV'T COUNTY/ LOCAL GOV'T PRIVATE MPO/RPO

Regional

CARSHARING

REGION TYPE

URBAN SUBURBAN

DESCRIPTION

Carsharing is a car rental service that can replace vehicle ownership. Cars are available in mainly residential areas, and users can "rent" the car by the hour, adhering to pick-up and drop off protocols. There is usually a fixed charge associated with the rental and a per-hour charge. This rental model allows customers to make longer distance car trips without owning a car. Other trips made by the customer would typically be made via transit or walking (or other alternative travel mode). Most carsharing is facilitated through smartphone apps.

In the US, there are primarily two types of carshares available: For-profit private vehicle rental companies oriented toward local residential use (Zipcar) and Peer-to-peer services, in which owners list their vehicles for rent for short periods (Turo).

PROS

- Reduces the need to own a vehicle, more economical to customers. Many successful applications on university campuses.
- Makes dense, urban residential areas with limited parking and multiple mode options more appealing to live in.

CONS

- Needs residential density to be successful.
- Since it is generally a for-profit model, it is highly dependent on getting participants. In the last few years, many start-ups have closed (Car2Go, Enterprise Carshare).

POTENTIAL VMT REDUCTION IMPACT

A study in 2016 on the now folded Car2Go service found that households who used Car2Go in 2015 across five cities showed between 6% and 16% reduction in VMT.

IMPLEMENTATION CONSIDERATIONS

Current models for carsharing are operated by private companies and supported and regulated by relevant government bodies. Implementation requires attracting a carsharing service with favorable legislation that also regulates the operation of the service to protect consumers and the greater community.

NORTH CAROLINA EXAMPLES

- NC State ZipCar
  https://www.zipcar.com/universities/north-carolina-state-university

OTHER EXAMPLES

- ZipCar
  https://www.zipcar.com/
- Turo
  https://turo.com/

SOURCES

- "Impacts of car2go on Vehicle Ownership, Modal Shift, Vehicle Miles Traveled, and Greenhouse Gas Emissions: An Analysis of Five North American Cities", Elliot Martin, Susan Shaheen, TSRC, July 2016.
  http://innovativemobility.org/wp-content/uploads/2016/07/Impactsofcar2go_FiveCities_2016.pdf

TYPE OF TRIPS TARGETED

Infrequent car trips

POTENTIAL APPLICATION LOCATIONS

Dense residential areas, universities

IMPLEMENTED BY

PRIVATE

Regional

FLEXIBLE PUBLIC TRANSIT

(CUSTOM TRANSIT STRATEGY)

REGION TYPE

SUBURBAN RURAL

DESCRIPTION

Flexible public transit services are a hybrid of traditional, fixed route bus service and demand response (or paratransit) service. The objective is usually to provide the benefits of public transit to those who cannot safely complete the first mile/last mile of their trip, live in sparsely populated rural areas, are senior citizens, or have a disability. Typically, passengers contact the agency offering the service to reserve their trip. There are multiple examples of a flexible public transit service, including:

- Route deviation: The service has a defined path and schedule, but the vehicle may deviate from the path to pick up or drop off riders. Maximum deviation varies by service and can range from a quarter of a mile to a mile.
- Point deviation: The service has a defined area of service and stops, but no defined path.
- Demand-Responsive Connector: The service is effectively demand response, except that it has scheduled stops at public transit stations. In this way, it provides a means to access transit stations without having to drive or walk to the station.
- Request Stops: The service has a fixed, scheduled route in which some stops are served only at the request of passengers. These stops are typically removed from the main route and skipping the stops may save significant time if they are not requested.
- Flexible-Route Segments: Part of a service has a scheduled fixed route and part of it operates as demand response. This service may be efficient if the fixed route portion of it is in high density areas while the demand response portion is in low density areas.

PROS

- Provides a transit solution to the first-mile/last-mile problem.
- Well-suited for subdivisions with poor connectivity.
- Performs the same task as paratransit with a lower marginal increase in VMT. In the case of paratransit, the vehicle is driven only if a passenger requests it. In the case of flexible public transit, the bus is already driving along the route, so the marginal increase in VMT is only the deviation from the bus's route or the shortest path between the origin and terminal points.

CONS

- Operates at lower speeds (longer travel times) between scheduled stops than typical transit. This could deter people from using the service.
- As more people utilize flexible public transit, the travel times become slower, making the service less attractive.

POTENTIAL VMT REDUCTION IMPACT

Flexible public transit does not appear in the literature as a primary strategy for reducing VMT, although we assume that the strategy can be used to increase ridership on a public transit system.

In a survey of on-demand transit riders in a West Sacramento Pilot Program, 50% of the respondents said their trip would have been made by ridesharing by Uber/Lyft, 34% said their trip would have been made in an Single Occupant Vehicle (SOV), 34% said their trip would have been made by catching a ride with a friend or family member and 19% said their trip would have been made by bus (note that the respondents were able to choose more than one option).

IMPLEMENTATION CONSIDERATIONS

May be implemented with, or instead of, traditional public transit service. Requires a reservation system to schedule non permanent stops. May benefit from strong cell phone network and data network coverage such that customers and vehicles can easily communicate with the dispatcher.

NORTH CAROLINA EXAMPLES

- Ashe County
  http://www.actatravels.com/?page_id=745
- Cherokee Community Routes
  http://cherokeetransit.com/community.html
- GoWake Access
  https://www.wakegov.com/departments-government/human-services/programs-assistance/gowake-access-transportation

OTHER EXAMPLES

- Corpus Christi, TX
  https://www.ccrta.org/wp-content/uploads/2020/01/93Jan2020.pdf

SOURCES

"A Methodology for Choosing between Route Deviation and Point Deviation Policies for Flexible Transit Services" Yue, Zheng et al. Journal of Advanced Transportation. 12 Aug. 2018, doi:10.1155/1409.
https://pdfs.semanticscholar.org/a293/3bd56b11e17741b980e711290581a39186cf.pdf

"A Guide for Planning and Operating Flexible Public Transportation Services" National Academies of Sciences, Engineering, and Medicine. 2010. Washington, DC: The National Academies Press.
http://www.trb.org/Publications/Blurbs/163788.aspx

"West Sacramento's On-Demand Rideshare Pilot: A Summary of 6-month User Survey Findings", February 2019.
https://www.cityofwestsacramento.org/home/showdocument?id=8637

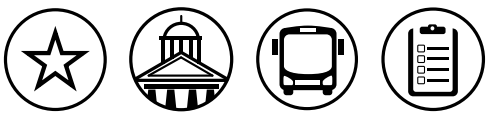
TYPE OF TRIPS TARGETED

All trips, particularly taken by the disabled or elderly, visitor trips

POTENTIAL APPLICATION LOCATIONS

suburbs and rural areas

IMPLEMENTED BY



STATE GOV'T COUNTY/ LOCAL GOV'T TRANSIT AGENCY MPO/RPO

Regional

PUBLIC TRANSIT

REGION TYPE

URBAN SUBURBAN

DESCRIPTION

Public transit is a set of transportation modes available to the public that maintain a published schedule on an established route on which passengers pay a fee and travel together. Examples of public transit include buses, light rail, commuter rail, subway, ferries, and trollies. Public transit is most effective where it can be used by the most people. For this reason, transit is most prevalent in urban areas, in suburban areas that can bring commuters into city offices, and on college campuses.

PROS

- Public transit can be the most efficient way to transport people (in terms of VMT).
- Provides a transportation option to those who cannot drive or do not own their own vehicle.
- Allows passengers to multi-task since they do not have to drive.

CONS

- Underutilized public transit does not reduce VMT and may increase VMT.
- Due to its fixed route nature, public transit rarely takes passengers from their initial origin to their final destination. At least one other transportation mode needs to be included.
- Cost-efficiency decreases as group size increases, as public transit fares are per person. There is little incentive for a group of four to use transit if they can drive.

POTENTIAL VMT REDUCTION IMPACT

The VMT reduction impact varies depending on the transit system implemented. According to a publication by Smart Growth America, a 1% increase in transit frequency saves 0.5% in VMT, light rail can yield a corridor-level VMT reduction of 1-2%, and bus rapid transit can also yield a corridor-level VMT reduction of 1-2%.

IMPLEMENTATION CONSIDERATIONS

Most transit systems such as light rail, commuter rail, subway, elevated train, or any other track or cable-based system require significant funding for both physical infrastructure (tracks, stations, etc.) and right of way. Some opportunities may be present where decommissioned rail infrastructure or existing right of way can be utilized. Transit systems require significant political support from several levels of government and the formation of a transit agency. If a transit agency exists, any expansion of services must have their full support.

NORTH CAROLINA EXAMPLES

- Charlotte
  https://charlottenc.gov/cats/Pages/default.aspx
- Raleigh
  https://goraleigh.org/
- Greensboro
  https://www.partnc.org/
- GoTriangle
  www.gotriangle.org

OTHER EXAMPLES

- Minneapolis and Seattle
  https://usa.streetsblog.org/2019/02/08/minneapolis-and-seattle-have-achieved-the-holy-grail-for-sustainable-transportation/

SOURCES

"Driving Down Emissions, Transportation, Land Use and Climate Change", Smart Growth America.
https://t4america.org/wp-content/uploads/2020/10/Driving-Down-Emissions.pdf

TYPE OF TRIPS TARGETED

All

POTENTIAL APPLICATION LOCATIONS

Urban, suburban, and locations where public transit currently exists.

IMPLEMENTED BY

STATE GOV'T

COUNTY/ LOCAL GOV'T

TRANSIT AGENCY

MPO/RPO

Regional

HIGH OCCUPANCY VEHICLE (HOV) FACILITIES

REGION TYPE

URBAN SUBURBAN

DESCRIPTION

High Occupancy Vehicle (HOV) facilities are exclusive facilities for vehicles that qualify as an HOV, typically requiring at least two or three occupants including the driver. These facilities provide an inherent benefit to passengers in HOVs compared to passengers in non-HOVs. A common HOV facility is an HOV lane on a limited access highway. The goal of these lanes is to allow HOVs to travel faster in their separate lane from non-HOVs during periods of traffic congestion. HOV lanes may or may not: operate as a standard general purpose lane outside of peak commuting periods, provide continuous access with general purpose lanes, or have separate structural elements from the general purpose lanes. HOV lanes may also be on highway on-ramps with ramp meters; by being separated at the meter, HOVs can "queue jump" in front of non-HOVs. Another HOV facility is HOV parking which reserves desirable spots (typically closest to the destination building) in a lot or garage for HOVs.

PROS

- Rewards carpooling, which reduces VMT.
- For HOV lanes, may be used in conjunction with bus transit routes to enhance the service by providing a more reliable travel time.

CONS

- Not clear that HOV facilities encourage people to carpool.
- If an HOV facility was constructed new instead of converted from an old facility, it may induce additional demand on adjacent facilities.
- HOV Facilities do not reduce VMT if the additional passenger(s) in an HOV would otherwise have taken mass transit or not taken the trip at all.
- HOV facilities only provide a benefit to HOV passengers if there is sufficient demand for the adjacent non-HOV facilities. If there is no congestion on a highway, there is no reason to use an HOV lane.
- HOV facilities have a limited capacity. Once that capacity is reached, they provide no benefit to those that use it.

POTENTIAL VMT REDUCTION IMPACT

The ability of HOV lanes in reducing VMT is not supported by high quality research. Theoretical results show that HOV lanes may be able to reduce VMT and commuting costs in some situations. Regression results show that on average HOV lanes have an ambiguous impact on reducing VMT with either a 1-2% increase or decrease in VMT depending on the modeling assumptions (Shewmake, 2018). Part of the reason for this is that HOV lanes are often added to existing highways, not converted from existing general purpose lanes. The added capacity of the HOV lane may cause induced demand, in which the new capacity from the HOV lane encourages more drivers to utilize the corridor, thereby increasing VMT.

IMPLEMENTATION CONSIDERATIONS

Designating HOV parking spots is a very low-cost option. Other facilities are expensive due to the infrastructure costs. Public opinion may be against HOV lanes as they can only be used by a certain portion of the vehicles on the road. Enforcement, particularly of occupancy in HOV lanes, can also be challenging.

NORTH CAROLINA EXAMPLES

- No HOV lanes at present, although part of the I-77 Express Lanes were converted from HOV lanes **https://www.i77express.com/**

OTHER EXAMPLES

- Los Angeles County, California **http://media.metro.net/projects_studies/hov/images/hov_map.pdf**
- Washington State **https://wsdot.wa.gov/travel/operations-services/ramp-meters**

SOURCES

"The Impact of High Occupancy Vehicle Lanes on Vehicle Miles Traveled", Sharon Shewmake, March 28, 2018. **https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1986503**

State-Level Strategies for Reducing Vehicle Miles of Travel. University of California. Michelle Byars, Yishu Wei, Susan Handy. 2017. **https://d3n8a8pro7vhmx.cloudfront.net/climateplan/pages/44/attachments/original/1509403808/2017-PTA-Handy_UCDavis_VMT_Report_1.pdf**

The NC Motor Fuels Tax, www.ncdot.gov/about-us/how-we-operate/finance-budget/nc-first/Documents/nc-first-brief-edition-1.pdf. **https://www.ncdot.gov/about-us/how-we-operate/finance-budget/nc-first/Documents/nc-first-brief-edition-1.pdf**

TYPE OF TRIPS TARGETED

All, but primarily commuter trips.

POTENTIAL APPLICATION LOCATIONS

Suburban and urban highways, office parks

IMPLEMENTED BY

STATE GOV'T COUNTY/ LOCAL GOV'T PRIVATE

Regional

NON-MOTORIZED MODE SUPPORT

REGION TYPE

URBAN SUBURBAN

DESCRIPTION

Non-motorized modes of transportation include walking and biking. These modes can be recreational or for conveyance. Non-motorized mode support focuses on strategies to support and encourage walking or biking. This can include installing and maintaining sidewalks and bike lanes, increasing connectivity, public education and promotion campaigns of non-motorized modes, bicycle parking, bicycle racks on buses, pedways, and Safe Routes to School or work programs. This strategy could be used to support other strategies like Complete Streets.

PROS

- Non-motorized mode support increases transportation options, which benefits both drivers who switch to other modes and non-drivers.
- Walking and cycling are often more affordable than other modes of transportation.
- Non-motorized mode support can be combined with other strategies to reduce VMT.

CONS

- Streets and bike lanes need to be maintained for continued use.
- Non-motorized modes have a relatively high injury and fatality rate per mile due to driver's lack of awareness when sharing the road.
- Not suitable for rural areas, only suitable for areas with good connectivity.

POTENTIAL VMT REDUCTION IMPACT

The Center for Clean Air Policy Guidebook allots a 2.5% reduction in VMT for the combined impact of all bicycle related measures. California Air Pollution Control Officer Association (CAPCOA) Fewer bicycle-related measures results in a lower impact.

A study from University College London found that 5-10% of automobile trips could be shifted to non motorized modes in urban areas. When other strategies like parking pricing reduced vehicle travel, between 10% and 35% of the trips shifted to walking or biking. (Mackett)

The town of Cottonwood, Minnesota-funded Safe Routes to School program built a path around Cottonwood Lake in 2009 through the Minnesota DOT. Before the construction of the path, only about 5% of Lakeview students walked or biked to school. Today, 11% of students use the path at least once per week and an additional 13% use the path at least once per month to walk or bike to school and for other recreational purposes.

IMPLEMENTATION CONSIDERATIONS

Successful walking and biking facilities need to be implemented in routes where there is a demand; the facilities must have a "destination". Connectivity is important.

Educating drivers and making them aware of other road users is critical to support the safety of pedestrian and other non-motorized mode users.

NORTH CAROLINA EXAMPLES

- Cape Fear Regional Bike Plan **https://www.pendercountync.gov/pcd/wp-content/uploads/sites/15/2017/07/Cape_Fear_Bicycle_Plan_DRAFT_screenquality.pdf**
- NCDOT Safe Routes to School **https://www.ncdot.gov/divisions/bike-ped/Documents/NCDOT_SRTS_Description.pdf**
- Bikes on Buses, Raleigh, NC **https://raleighnc.gov/transit-streets-and-sidewalks/bikes-buses**
- Walk Raleigh **https://raleighnc.gov/walk-raleigh**

OTHER EXAMPLES

- Bicycle Parking and Amenities – Arlington, MA; Cambridge, MA; Norwell, MA; Portland, OR **https://www.mapc.org/wp-content/uploads/2017/10/TDM-FINAL-REPORT-7_15_0.pdf**
- Safe Routes to School – various nationwide locations **https://www.saferoutespartnership.org/local/local-success-stories#statesrts**

SOURCES

"How to Reduce the Number of Short Trips by Car", Roger Mackett, European Transport Conference, Centre for Transport Studies, University College London, 2000. **https://aetransport.org/public/downloads/xBVhC/2543-514ec4aa1b046.pdf**

"Quantifying Greenhouse Gas Mitigation Measures", California Air Pollution Control Officers Association, 2010. **https://www.aqmd.gov/docs/default-source/ceqa/handbook/capcoa-quantifying-greenhouse-gas-mitigation-measures.pdf**

TYPE OF TRIPS TARGETED

All trips

POTENTIAL APPLICATION LOCATIONS

Dense urban areas, towns, commercial centers, residential neighborhoods, recreation areas

IMPLEMENTED BY

STATE GOV'T COUNTY/ LOCAL GOV'T MPO/RPO

Regional

VANPOOL

REGION TYPE

URBAN SUBURBAN RURAL

DESCRIPTION

Vanpools are a type of transit where a group of 5 to 15 people share a van to travel together from a common community location, such as a park-and-ride lot or a transit station, to a place of work. Types of vanpool programs include:

- **Owner/operator arrangements** where an employee owned vehicle is used for vanpooling. The owner must check with his or her insurance carrier regarding liability issues. Costs are shared among the commuters.
- **Employer sponsored programs** where the vehicle is owned by the employer or operated through a lease with a private vanpool vendor. Employers would typically provide maintenance, insurance, and other support services.
- **Third party lease programs** are facilitated via a monthly lease between the vanpool participants and a third-party vanpool vendor. The vendor provides the vehicle, maintenance, insurance, and other support services.

Vanpool programs work best in areas that are not served well by transit and for long commutes. Primary strategies to attract vanpool participants include ride matching service, guaranteed ride home services, preferential parking programs including parking cash-out programs, and tax-free benefits.

PROS

- Potential cost savings to the employee (tax savings, reduced commute costs relative to a Single Occupant Vehicle (SOV) trip) and the employer (tax savings).
- Relatively low start-up cost.
- Could help in employee retainage.
- Potentially reduces VMT of a group that may not be able to afford a car.

CONS

- Program success may depend on the support programs, such as ride matching, guaranteed ride home services and incentive programs, along with the vanpool program.
- May not be feasible in very spread out communities in low density work locations.

POTENTIAL VMT REDUCTION IMPACT

As of March 2020, The San Diego Association of Governments (SANDAG) Vanpool Program, has a total number of 614 vanpools participating. The average trip distance of the vanpools is 51.35 miles and the mode vehicle capacity is 7 seats. Daily one way VMT reduction is approximated to be 178,469 to 242,467 miles. (Boonvanich) This accounts for about a 0.2-0.3% reduction in San Diego County VMT. It should be noted that the vanpool coverage area may differ from the county area.

IMPLEMENTATION CONSIDERATIONS

Requires a way to attract riders/drivers and maintain ridership and drivers within a vanpool from month to month. Requires matching new riders to vanpool routes and forming new vanpools as needed. Requires collecting and managing a fee structure that covers van maintenance, fuel, van insurance, and overhead costs. Most of the direct cost of running a vanpool program is administration support and marketing, while the vanpool fees should fully cover vehicle related costs.

NORTH CAROLINA EXAMPLES

- Piedmont Authority for Regional Transportation (PART)
  https://partnc.org/157/Vanpool
- GO Triangle
  https://gotriangle.org/vanpool-faq
- Charlotte Area Transit System
  https://www.charlottenc.gov/CATS/Get-to-Know-CATS/Alternative-Commuting/Vanpool

OTHER EXAMPLES

- Rural and Mountain Community Vanpools: A Brochure prepared for the Colorado Department of Transportation
  https://www.codot.gov/programs/commuterchoices/documents/cdot_brochure_print.pdf
- Washington State
  http://t4america.org/maps-tools/local-successes/washington-rural-transit/
- Commute with Enterprise (Example Private Partner)
  https://www.enterprise.com/en/commute.html

SOURCES

"Vanpool | Connecting The Workforce To Work", The University Of Nebraska, Center For Public Affairs Research, 2017.
https://documentstndot.s3.amazonaws.com/NDOR_Documents/vanpool+infographic.pdf

"Flexible Transportation: A Solution for Reducing Greenhouse Gas Emissions in San Diego", Siraphob Boonvanich, UC San Diego, June 2020.
https://escholarship.org/content/qt5cn95623/qt5cn95623_noSplash_d756867494366b1a4dafce2786d332db.pdf

FHWA Commuter Choice Decision System.
https://ops.fhwa.dot.gov/PrimerDSS/cc-options/vanpool/vanpool.htm

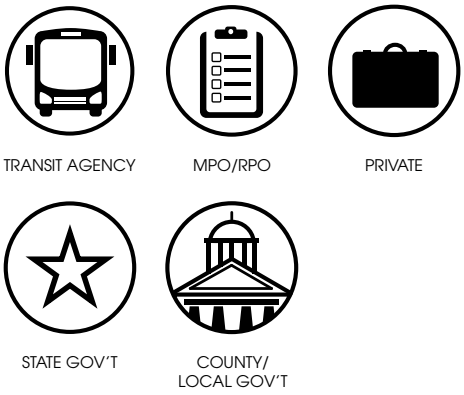
TYPE OF TRIPS TARGETED

Commuter

POTENTIAL APPLICATION LOCATIONS

Urban and suburban areas

IMPLEMENTED BY



TRANSIT AGENCY MPO/RPO PRIVATE

STATE GOV'T COUNTY/ LOCAL GOV'T

INTERNET BASED STRATEGIES

REGION TYPE

URBAN SUBURBAN RURAL

DESCRIPTION

Internet-based strategies may reduce VMT by providing online service as substitutes to making trips to a physical location. These can include services from both private and public sources. Internet-based private services include online banking/financial services, telehealth, online retail, online fitness instruction, online secondary education, and general customer service. Internet-based public services can include some DMV services, court services, parking services, tax services, permitting, notary, voter registration, transit ticketing, and record requests. Successful online services are clear and easy to use, run on well-supported web platforms, and are frequently accompanied by telephone services to provide human clarification when needed.

Planning organizations can encourage other public agencies to move eligible services online, or even formalize online based service prioritization in the form of legislation.

PROS

- May reduce trips to access services, with the longest trips being reduced in rural areas.
- Expands access to services, especially for disabled, elderly, and rural residents.

CONS

- Requires internet, and frequently broadband, access and computer literacy.
- Requires proper implementation and user support to be successful.
- Internet based strategies are highly dependent on computer literacy and internet access, and in some cases dependent on broadband access.

POTENTIAL VMT REDUCTION IMPACT

Online retail does not necessarily reduce VMT as shopping trips would be replaced by more delivery trips. The ratio between shopping trips and delivery trips is dependent on numerous factors as well as premium shipping options such as same day delivery in which packages are delivered from nearly empty vehicles. (Day) Also, increasing one's propensity to shop online has been shown to increase one's propensity to also shop in person by a 0.214 ratio. (Zhou and Wang) This may be due to shoppers wanting to see or test out products in brick and mortar stores before going online to shop for the best price.

No research was found on the VMT impacts of other internet based services such as online banking or telehealth. Unlike online retail, these services do not always require a product to be transported to the customer's residence; so potential VMT reductions per service are higher. However, as these internet based services become more popular, brick and mortar locations offering the same services may shut down; the number of bank branches in the United States has decreased by 11.5% since 2009, potentially due in part to the increase in online banking. (Holmes) When these locations close, it inherently increases the average trip length for service trips that do continue in person.

IMPLEMENTATION CONSIDERATIONS

Internet based services will continue to gain traction on their own accord as banks, doctors, and others find new ways to provide their services to their customers. The impact of these internet-based services is dependent on the spread of broadband services and high speed internet.

NORTH CAROLINA EXAMPLES

- North Carolina Judicial Branch **https://www.nccourts.gov/services**
- North Carolina Department of Motor Vehicles **https://www.ncdot.gov/dmv/offices-services/online/Pages/default.aspx**

OTHER EXAMPLES

- Telemedicine: Teladoc **https://www.teladoc.com/**
- Online banking: Ally Bank **https://www.ally.com/bank/online-banking/**

SOURCES

"Explore the Relationship between Online Shopping and Shopping Trips: An Analysis with the 2009 NHTS Data." Zhou, Yiwei, and Xiaokun (Cara) Wang. Transportation Research Part A: Policy and Practice, vol. 70, 2014, pp. 1–9., doi:10.1016/j.tra.2014.09.014.

"Amazon Nixed 'Green' Shipping Proposal to Avoid Alienating Shoppers." Day, Matt. Bloomberg.com, Bloomberg, 5 Mar. 2020 **www.bloomberg.com/news/articles/2020-03-05/amazon-nixed-green-shipping-proposal-to-avoid-alienating-shoppers**

"How Bank Closures Could Be Giving Rise to Digital Currencies." Holmes, Frank. Forbes, 24 July 2019.

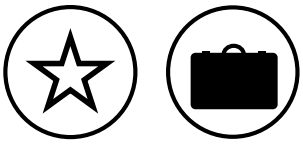
TYPE OF TRIPS TARGETED

Non-Commuter trips

POTENTIAL APPLICATION LOCATIONS

Statewide

IMPLEMENTED BY



STATE GOV'T PRIVATE

INFORMATION SERVICE: BROADBAND EXPANSION

REGION TYPE

URBAN SUBURBAN RURAL

DESCRIPTION

Broadband is defined by the FCC as reliable high-speed internet with download speeds of at least 25 megabits per second. Broadband internet can be delivered through digital subscriber line (DSL), cable modems, fiber, wireless, satellite, and broadband over powerline. Broadband coverage is a key aspect of facilitating teleworking and distance learning. State efforts to expand broadband access are primarily focused on connecting broadband to homes and small businesses.

PROS

- Broadband can support a telework program to reduce vehicle miles traveled, support distance learning, and can connect residents in rural areas to government services and remote medical appointments (telehealth).

CONS

- Broadband can be expensive and difficult to install. Rural areas with a small, spread out population or geographic features like mountains or hills make expanding broadband challenging.
- Internet service providers are unlikely to expand broadband services to areas where deployment costs are high.

POTENTIAL VMT REDUCTION IMPACT

A study of broadband in Kentucky by Connected Nation found that broadband users reported driving an average of 67 fewer miles per month and close to 800 fewer miles per year. (Victoria Transport Policy Institute)

About 66% of respondents reported driving an average of 102 fewer miles per month due to their internet usage. (Connected Nation)

IMPLEMENTATION CONSIDERATIONS

According to North Carolina's state broadband plan, "Connecting North Carolina": 93% of households in North Carolina have access to broadband; 53 of 100 counties have a 90% deployment rate; less than 50% of households have access to fixed wireless service; and, 99% of people in North Carolina's tribal lands lack access to broadband.

Larger service providers are less likely to expand into rural areas since deployment costs are high and the expansion in customer base is small. Large service providers are even less likely to expand into rural areas that already have one broadband option, since the number of customers who would switch to a competing service is even smaller. Governments at all levels need to provide incentives to attract broadband to underserved communities and/or provide legislative frameworks for telecommunication co-ops to provide broadband service (Trostle & Mitchell).

NORTH CAROLINA EXAMPLES

- Connecting North Carolina State Broadband Plan
  https://cms6.revize.com/revize/uppercoastalplain/NC-Broadband-Plan_2017_Online_FINAL_PNGs3www.pdf
- North Carolina GREAT Broadband Grant Program
  https://www.ncbroadband.gov/grants/great-grant#:~:text=The%20N.C.%20Department%20of%20Information,unserved%20areas%20of%20North%20Carolina

OTHER EXAMPLES

- FCC National Broadband Plan
  https://transition.fcc.gov/national-broadband-plan/national-broadband-plan.pdf
- Alabama broadband accessibility act
  https://adeca.alabama.gov/wp-content/uploads/Alabama-Broadband-Accessibility-Act.pdf
- California Broadband Council
  https://broadbandcouncil.ca.gov/

SOURCES

"The Economic Impact of Stimulating Broadband Nationally", Connected Nation, Inc., 21 February 2008.
http://www.itu.int/net/wsis/stocktaking/docs/activities/1287068791/Connected_Nation.pdf

"Using Telecommunications to Substitute for Physical Travel", Victoria Transport Policy Institute, September 6, 2019.
https://www.vtpi.org/tdm/tdm43.htm

"North Carolina Connectivity: The Good, The Bad, and The Ugly", H. R. Trostle & Christopher Mitchell, Community Nets, Institute for Local Self-Reliance, October 2016.
https://ilsr.org/wp-content/uploads/2016/10/NC-Broadband-Report_10_2016-1.pdf

"Connecting North Carolina State Broadband Plan", Broadband Infrastructure Office, Undated.
https://cms6.revize.com/revize/uppercoastalplain/NC-Broadband-Plan_2017_Online_FINAL_PNGs3www.pdf

TYPE OF TRIPS TARGETED

Commuter trips, school trips, some trips to access services

POTENTIAL APPLICATION LOCATIONS

Urban areas, suburban areas, rural areas, tribal lands

IMPLEMENTED BY

STATE GOV'T COUNTY/ LOCAL GOV'T PRIVATE

TELECOMMUTING/ TELEWORK

REGION TYPE

URBAN SUBURBAN RURAL

DESCRIPTION

Telecommuting or telework is a telecommunications strategy that uses the internet as an alternative to traditional commutes to work in a single occupancy vehicle. The employee can work from home using high-speed internet rather than commuting into an office. Telework allows for more flexible schedules and may reduce the burden on commuting. It may also reduce vehicle miles traveled, especially during rush hour. Telework can be part of a successful employer rewards program to avoid peak road congestion.

PROS

- Provides an option for rural areas that do not have access to alternatives to traditional commuting.
- Easy to implement, can be done through individual employers or state and local government led programs.

CONS

- In rural regions broadband connectivity can be poor, limiting telework opportunities.
- While telecommuting will reduce commuter VMT, some research suggests no effect on lowering total VMT or potentially increases in total VMT.

POTENTIAL VMT REDUCTION IMPACT

One study found that a 3.04% decrease in commuting trips in the Chicago area could have the potential to reduce vehicle miles traveled by 0.69%. This model also assumed that a decrease in commuter trips would cause a slight increase in non commuter trips as out of-home discretionary activities would increase with schedule flexibility. (Shabanpour, "Analysis of telecommuting behavior and impact on travel demand and the environment.")

A second study, using data from the United Kingdom's National Travel Survey, found that home-based teleworking tended to increase weekly distances traveled. Specifically, if the worker in a single worker household frequently telecommuted (at least three times a week), the household generated about 58 additional miles per week compared to if the worker did not frequently telework. This can be attributed to teleworkers being more likely to live in the suburbs, own a car, and make longer trips while being less likely to chain their trips. (Abreu e Silva) Part of this can be illustrated by the lower car usage in the United Kingdom; 30.6% of households do not own a car (compared to 8% in the United States) and 61.8% of trips are in a car (compared to 90.4% in the United States). (Giuliano) In many parts of the United States, even in urban areas, car access is seen as a necessity while it appears to be more of a choice in the United Kingdom.

IMPLEMENTATION CONSIDERATIONS

The infrastructure costs are mostly related to broadband implementation in areas where it has not yet been added.

Teleworkers or their employers may need to buy specific equipment for teleworking, such as laptops, monitors, printers, and office furniture. No significant policy hurdles are foreseen, although employer incentives may help, as well as public education regarding the benefits of teleworking. Federal, state, and local government agencies can set the example by letting their employees telework when possible.

NORTH CAROLINA EXAMPLES

- NC Telework created by Triangle J COG **https://nctelework.org/**
- GoTriangle **https://gotriangle.org/telework**

OTHER EXAMPLES

- Agile Mile Inc. (formerly NuRide) **https://agilemile.com/**
- US Federal Government **https://www.telework.gov/**

SOURCES

"Analysis of telecommuting behavior and impact on travel demand and the environment." Shabanpour, Ramin, et al. TRB, 2018.

"Developing an Integrated Framework for Assessing Potential Impacts of Telecommuting." Shabanpour, Ramin, et al. TRB, 2018.

"Does home based telework reduce household total travel? A path analysis using single and two worker British households.", Abreu e Silva, João, et al. Journal of Transport Geography, 2018.

"Car ownership, travel and land use: a comparison of the US and Great Britain" Giuliano, Genevieve, et al. Journal of Transport Geography, 2006.

TYPE OF TRIPS TARGETED

Commuter trips

POTENTIAL APPLICATION LOCATIONS

All areas

IMPLEMENTED BY

STATE GOV'T COUNTY/ LOCAL GOV'T PRIVATE

PROVIDING AFFORDABLE HOUSING

REGION TYPE

URBAN SUBURBAN RURAL

DESCRIPTION

Affordable housing programs are administered by government agencies to provide subsidized rental homes for low income households. Typically, a tenant in an affordable housing unit pays monthly rent equal to 30 percent of their monthly income.

These programs allow low income workers to live closer to their jobs, even if their jobs are in areas with high property values. In urban areas, such as Raleigh or Charlotte, affordable housing may bring low income workers close enough to their downtown jobs that they walk, bike, or take mass transit to work. In tourist areas, it may allow service workers to live closer to where they work.

PROS

- Provides an opportunity for low income workers to live closer to jobs in high property value areas.
- Specifically reduces VMT of a group of people that are most likely to have difficulty affording a car.

CONS

- Workers may prefer to live further away from their jobs if the affordable housing is substandard.

POTENTIAL VMT REDUCTION IMPACT

A modeling study for The California Housing Partnership compared developing location-efficient neighborhoods for affordable housing or market rate housing. Putting affordable housing in efficient locations will reduce VMT 4% more than market rate housing because affordable housing units are smaller on average, so more of them can be built than market rate units. The reduction is directly proportionate to the increased housing unit density. In this instance, affordable housing is supporting location-efficient neighborhoods, such as transit oriented developments, to reduce VMT.

IMPLEMENTATION CONSIDERATIONS

Affordable housing requires significant costs in real estate acquisition and management.

NORTH CAROLINA EXAMPLES

- Asheville
  https://www.ashevillenc.gov/department/community-economic-development/community-development/affordable-housing/
- "Strategies to Support Affordable Housing", North Carolina Department of Transportation, May 2019.

OTHER EXAMPLES

- San Diego
  https://static1.squarespace.com/static/5a6bd016f9a61e52e8379751/t/5a80f33bec212d81181be01d/1518400319715/Climate+Action+-+Affordable+Housing+And+VMT+Reduction.pdf

SOURCES

"Income, Location Efficiency, And VMT: Affordable Housing As A Climate Change Strategy", The California Housing Partnership. Gregory L. Newmark and Peter M. Haas. 2015.
https://chpc.net/wp-content/uploads/2016/05/CNT-Working-Paper-revised-2015-12-18.pdf

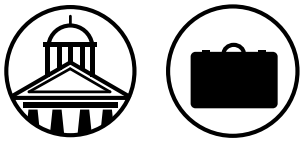
TYPE OF TRIPS TARGETED

Commuter

POTENTIAL APPLICATION LOCATIONS

Tourist areas (such as the Outer Banks and other beach communities and Asheville), urban areas (such as Raleigh and Charlotte)

IMPLEMENTED BY



COUNTY/ LOCAL GOV'T PRIVATE

Land Use

COMPLETE STREETS

REGION TYPE

URBAN SUBURBAN RURAL

DESCRIPTION

Complete Streets is a concept that designs streets to be comfortably used by all types of users, not just cars. Ideally, complete streets provide infrastructure that can be used by people walking and biking, using transit and driving in cars. They are designed to operate safely for all users, regardless of age, ability, or mode of transportation. Complete streets may include sidewalks and crosswalks, accessible pedestrian signals, curbs and curb extensions, median islands, bike lanes, special transit lanes, comfortable and easily accessible transit stops, narrower travel lanes, and other measures.

PROS

- Makes trips safer for all users.
- Promotes better health by encouraging walking and biking trips.

CONS

- Not a solution for all corridors; some existing non-car trip demand needs to be present.
- Can increase car congestion during peak periods because less right-of-way is dedicated to cars.
- More expensive to design, build and maintain compared to a traditional street.

POTENTIAL VMT REDUCTION IMPACT

Complete Streets promote increased roadway connectivity, which has been shown to reduce VMT per capita (Moreland-Russell et al., 2013). The Victoria Transport Policy Institute found that quantifiable VMT reductions of complete street programs were related to connectivity efforts within a complete street program. Ewing and Cervero (2010) conclude that the elasticity of vehicle travel with respect to connectivity is -0.12, so a 10% increase in intersection or street density reduces vehicle travel 1.2%. The LUTAQH (Land Use, Transportation, Air Quality and Health) research project also found that a 10% increase in intersections per square mile reduces average household VMT by about 0.5% (Larry Frank & Company 2005).

IMPLEMENTATION CONSIDERATIONS

Businesses and residents along the corridor may be reluctant to support conversion to complete streets if parking is reduced, though studies have shown that the increased foot and bicycle traffic has economic benefits. The perspective that complete streets reduce VMT through increased connectivity is also supported by the US DOT.

NORTH CAROLINA EXAMPLES

- North Carolina DOT Complete Streets **https://connect.ncdot.gov/projects/BikePed/Pages/Complete-Streets.aspx**

OTHER EXAMPLES

- Smart Growth America **https://smartgrowthamerica.org/tag/complete-streets-case-studies/**

SOURCES

"Evaluating Complete Streets The Value of Designing Roads For Diverse Modes, Users and Activities", Todd Litman, Victoria Transport Policy Institute, 24 August 2015.
https://www.vtpi.org/compstr.pdf

"Travel and the Built Environment: A Meta-Analysis", Reid Ewing and Robert Cervero, Journal of the American Planning Association, Vol. 76, No. 3, Summer 2010, pp. 265-294.
http://reconnectingamerica.org/assets/Uploads/travelbuiltenvironment20100511.pdf

"A Study of Land Use, Transportation, Air Quality and Health in King County, WA", Frank & Company, King County Larry, 2005.
http://urbandesign4health.com/wp-content/uploads/2012/03/LUTAQH_exec_summary_092705.pdf

"Complete Streets Policies", US Department of Transportation, Last updated: Monday, August 24, 2015.
https://www.transportation.gov/mission/health/complete-streets-policies

"BENEFITS OF COMPLETE STREETS Complete Streets Stimulate the Local Economy", Smart Growth America and the National Complete Streets Coalition.
https://smartgrowthamerica.org/resources/evaluating-complete-streets-projects-a-guide-for-practitioners/#:~:text=In%20this%20study%20of%2037%20projects%2C%20Smart%20Growth,traffic%2C%20depending%20in%20part%20on%20the%20project%20goal.

"Diffusion of Complete Streets policies Across US communities", Sarah Moreland-Russell, Amy Eyler, Colleen Barbero, J Aaron Hipp, and Heidi Walsh, National Library of Medicine, June 2013.
https://pubmed.ncbi.nlm.nih.gov/23529062/

TYPE OF TRIPS TARGETED

All

POTENTIAL APPLICATION LOCATIONS

All

IMPLEMENTED BY

STATE GOV'T COUNTY/ LOCAL GOV'T MPO/RPO

TRANSIT ORIENTED DEVELOPMENT

REGION TYPE

URBAN SUBURBAN

DESCRIPTION

A Transit-Oriented Development (TOD) is a compact, mixed-use community centered around a transit station that, by design, invites residents, workers, and shoppers to drive their cars less and ride mass transit more. Since these mixed-use developments are densely developed, they also promote walking and other non-motorized modes of travel. Generally, TODs within a half mile of the actual transit station are the most successful in achieving travel mode shifts from cars.

PROS

- Promotes transit trips, and in general, provides more mobility choices for residents.
- Can make new transit lines more viable by increasing residential (and employment) density near stations.
- Can promote economic development in an area with new transit.

CONS

- There is some discussion that people attracted to compact development in transit oriented or mixed-use development do so because they seek a less car dependent environment, so overall VMT reduction may be minimal.

POTENTIAL VMT REDUCTION IMPACT

A recent study in Perth, Australia and published by EJTIR has shown that average daily vehicle kilometers traveled (VKT) was reduced by 8% following the completion of a TOD. (Olaru)

A study of 17 TODs in 5 different US metropolitan areas by the University of California Berkeley showed that the average daily vehicle trips per dwelling in a TOD was 44% less (3.754 trips vs 6.715) than estimated by the Institute of Transportation Engineers (ITE) Trip Generation Manual. (Cervero et al)

IMPLEMENTATION CONSIDERATIONS

May require changes to zoning codes (allowing high density development and reducing parking requirements). Requires cooperation from transit agencies, local municipalities, and private developers.

NORTH CAROLINA EXAMPLES

- Durham
  https://www.durhamnc.gov/DocumentCenter/View/7069/Compact-Neighborhoods-An-Introduction?bidId=
- Go Triangle Transit-Oriented Development Planning Study
  https://gotriangle.org/tod/guidebook/about
- Charlotte TOD Ordinance and rezoning of 1500 parcels along the city's Blue Line
  https://upforgrowth.org/news_insights/charlottes-approach-to-increasing-housing-opportunities-near-transit/#:~:text=Last%20April%2C%20Charlotte%2C%20North%20Carolina%20approved%20a%20new,to%20guide%20future%20development%20for%20a%20fast-growing%20Charlotte.

OTHER EXAMPLES

- Washington, DC
- Portland, OR
- Denver, CO
- Salt Lake City, UT
- Cleveland, OH
  http://urbanscale.com/blog/how-your-city-can-succeed-in-transit-oriented-development/

SOURCES

"Designing TOD precincts: accessibility and travel patterns", Doina Olaru & Carey Curtis, European Journal of Transport and Infrastructure Research (EJTIR), 15(1): 6-26. 2015.
https://espace.curtin.edu.au/bitstream/handle/20.500.11937/29606/235478_235478.pdf?sequence=2&isAllowed=y

"Vehicle Trip Reduction Impacts of Transit-Oriented Housing" Cervero, Robert & Arrington, G. B., University of California Berkeley, Journal of Public Transportation, 11 (3): 1-17. 2008.
https://scholarcommons.usf.edu/jpt/vol11/iss3/1/

TYPE OF TRIPS TARGETED

All

POTENTIAL APPLICATION LOCATIONS

Cities and along rail and bus rapid transit routes in suburbs

IMPLEMENTED BY

STATE GOV'T

COUNTY/ LOCAL GOV'T

PRIVATE

TRANSIT AGENCY

CONNECTIVITY

REGION TYPE

URBAN SUBURBAN

DESCRIPTION

Connectivity refers to the density of connections and directness of links in roadway networks. A well-connected network has many intersections and short blocks with minimal dead-ends or cul-de-sacs. Travel distance decreases and route options increase as connectivity increases. Increased connectivity allows for more direct travel between destinations. Connectivity can apply both internally to streets within a neighborhood or area and externally to other arterials and other neighborhoods. Connectivity is most applicable in high-density urban or suburban areas. It is best implemented by local governments, transportation management associations, developers, or neighborhood associations. A common example of connectivity is a fused grid street design, which uses public squares at the end of cul-de-sacs to provide pedestrian and bicycle connections.

PROS

- Increased connectivity can improve accessibility, increase route options, improve walkability, and reduce vehicle travel.

CONS

- Additional land is needed for new links. There may be additional conflicts with adjacent land uses, such as when a new connection is added through existing property.
- Residents may fear connectivity will make their road a pass-through route akin to an arterial.

POTENTIAL VMT REDUCTION IMPACT

As cited by the Victoria Transport Policy Institute in their research on roadway connectivity, a Canada Mortgage and Housing Corporation study on connectivity in urban neighborhoods in the Puget Sound region in Washington found the highest proportion of pedestrian trips (18%) in areas where paths are relatively more direct to nearby retail and recreational destinations on foot than by car. Areas with high levels of both pedestrian and vehicle connectivity have about 14% pedestrian mode share, and those with poor pedestrian connectivity have the lowest proportion (10%) of pedestrian trips. A Fused Grid increases home-based walking trips by 11.3%. A 10% increase in relative pedestrian continuity (network density) associates with a 9.5% increase in odds of walking. A Fused Grid's 10% increase in relative connectivity for pedestrians is associated with a 23% decrease in vehicles miles of local travel.

When the Victoria Transport Policy Institute researched connectivity as an aspect of complete streets, they found several studies have quantified roadway connectivity impacts on travel activity. Ewing and Cervero (2010) conclude that a 10% increase in intersection or street density reduces vehicle travel 1.2%. The LUTAQH (Land Use, Transportation, Air Quality and Health) research project also found that a 10% increase in intersections per square mile reduces average household VMT by about 0.5% (Larry Frank & Company 2005).

IMPLEMENTATION CONSIDERATIONS

Increased connectivity is difficult to implement as a retrofit practically and politically; it is best included in initial planning.

NORTH CAROLINA EXAMPLES

- Charlotte
  http://ww.charmeck.org/Planning/Subdivision/SubdivisionOrdinanceCity.pdf
- Cary
  https://codelibrary.amlegal.com/codes/cary/latest/cary_nc/0-0-0-53416

OTHER EXAMPLES

- Pennsylvania
  https://www.dot.state.pa.us/public/pubsforms/Publications/PUB%20731.pdf
- Utah
  https://mountainland.org/cur-benefits/

SOURCES

"Roadway Connectivity Creating More Connected Roadway and Pathway Networks", Victoria Transport Policy Institute, Updated 2 January 2017.
https://www.vtpi.org/tdm/tdm116.htm

"Giving Pedestrians an Edge—Using Street Layout to Influence Transportation Choice", Canada Mortgage and Housing Corporation, 2008.
https://publications.gc.ca/collections/collection_2008/cmhc-schl/nh18-23/NH18-23-108-013E.pdf

"Evaluating Complete Streets, The Value of Designing Roads For Diverse Modes, Users and Activities", Todd Litman, Victoria Transport Policy Institute, 24 August 2015
https://www.vtpi.org/compstr.pdf

"Travel and the Built Environment: A Meta-Analysis", Reid Ewing and Robert Cervero, Journal of the American Planning Association, Vol. 76, No. 3, Summer 2010, pp. 265-294.
http://reconnectingamerica.org/assets/Uploads/travelbuiltenvironment20100511.pdf

"A Study of Land Use, Transportation, Air Quality and Health in King County, WA", Frank & Company, King County Larry, 2005.
http://urbandesign4health.com/wp-content/uploads/2012/03/LUTAQH_exec_summary_092705.pdf

TYPE OF TRIPS TARGETED

All trips

POTENTIAL APPLICATION LOCATIONS

Urban neighborhoods, suburban neighborhoods

IMPLEMENTED BY

STATE GOV'T COUNTY/ LOCAL GOV'T MPO/RPO

DEVELOPMENT IMPACT MITIGATION

REGION TYPE

URBAN SUBURBAN

DESCRIPTION

Development Impact Mitigation is a strategy in which government entities require developers to mitigate the traffic impact their projects will cause when they are fully built and generating traffic. These measures are meant to ensure that the transportation network can handle the additional demand developments may cause. Some measures the developer may take, such as widening roads or converting a non signalized intersection to a signalized intersection, encourage driving to the development and do not reduce VMT. Other measures, however, such as providing bicycle storage, a comfortable bus shelter, or new transit routes encourage people to take alternative modes to the development which reduces VMT compared to if those measures are not enacted.

PROS

- Can be used to require developers to find solutions to reduce their projects' VMT impact.
- Can be very impactful when applied to large development projects.

CONS

- VMT impacts are typically limited to people going to or from the completed development.
- The success of these VMT-reducing measures is dependent on the compatibility with the surrounding area. For instance, bicycle storage will not encourage bicycling if the road network surrounding the development is too dangerous for bicyclists.

POTENTIAL VMT REDUCTION IMPACT

Typically, only people going to or from this new development in the future are impacted by development impact mitigation.
The potential VMT reduction is based on the size of the new development (such as its area or number of employees) as well as the mitigation strategies implemented. The VMT impact for these mitigation strategies, such as providing an employee shuttle, allowing part of the workforce to telecommute, and subsidizing public transportation costs are discussed separately.

IMPLEMENTATION CONSIDERATIONS

It may be difficult for municipalities to require VMT reduction measures that are strong enough to make an impact. Policies that place increasing burden on developers are more likely to receive criticism for being anti-growth and a hindrance to economic activity, while stronger policies are also what are likely to produce meaningful VMT reductions.

NORTH CAROLINA EXAMPLES

- University of North Carolina **https://facilities.unc.edu/files/2015/12/TIA_Executive_Summary.pdf**
- Marine Corp Base Camp Lejeune

OTHER EXAMPLES

- Massachusetts **http://www.mapc.org/wp-content/uploads/2017/10/TDM-FINAL-REPORT-7_15_0.pdf**

SOURCES

"Transportation Demand Management Case Studies and Regulations", Metropolitan Area Planning Council, July 2015.
http://www.mapc.org/wp-content/uploads/2017/10/TDM-FINAL-REPORT-7_15_0.pdf

"Implementing SB 743; An Analysis of Vehicle Miles Traveled Banking and Exchange Frameworks", Ethan Elkind, Ted Lamm, and Eric Prather. ITS-Berkeley, October 2018.
https://www.law.berkeley.edu/wp-content/uploads/2018/09/Implementing-SB-743-October-2018.pdf

TYPE OF TRIPS TARGETED

Dependent on the development

POTENTIAL APPLICATION LOCATIONS

Universities as well as urban and suburban areas

IMPLEMENTED BY

STATE GOV'T COUNTY/ LOCAL GOV'T MPO/RPO

JOBS/ HOUSING BALANCE

REGION TYPE

URBAN SUBURBAN RURAL

DESCRIPTION

Jobs/Housing Balance is the concept that VMT can be greatly reduced if the quantity and quality of housing in an area matches the employment opportunities in that area. The reduction is a result of reducing the required distance traveled between an individual's residence and workplace. Jobs/ Housing Balance has also been correlated to higher TDM program adoption rates, especially carpooling.

Balance is achieved by stimulating either housing or job production in areas that are out of proportion. Strategies that encourage housing production include economic inducement, infill housing, parking reduction requirements, brownfield redevelopment, transit-oriented development, finance reform, tax credits, mixed use development, and zoning revisions. Strategies that encourage job production include targeted education/ research, community-based job training, venture capital investment, airport investment and promotion, and fiber optic cable investments.

PROS

- Significantly reduces required commuting distances.
- Proximity of workers to their jobs can promote biking, walking and other alternative modes of commuting.

CONS

- Takes significant time to implement and for the impacts to take effect.
- Requires significant legislation, planning, and zoning changes.
- Need to be aware of skills mismatch which occurs when workers live close to jobs that do not match the skillset of those jobs.

POTENTIAL VMT REDUCTION IMPACT

An employment to housing ratio in the range of 0.75 to 1.5 is considered beneficial for reducing vehicle miles traveled. Ratios higher than 1.5 indicate that there may be more workers commuting into the area because of a surplus of jobs. (EnviroAtlas) A ratio under 0.75 indicates that people living in that area typically have to commute out of it due to a low number of jobs.

Cervero and Duncan in a 2006 study found that every 10% increase in the number of jobs in the same occupational category within 4 miles of one's residence was associated with a 3.3% decrease in daily work-related vehicle miles traveled. A recent study funded by the Air Resources Board examined the impact of job accessibility within 5 miles and more than 5 miles from a person's residence and found that in land use types that range from urban locations with poor transit to single family suburbs (roughly inner and outer suburbs), job access within five miles was an important determinant of VMT (Salon, 2014).

IMPLEMENTATION CONSIDERATIONS

Planning goals/policies may need to be revised. Typically land use policies have a delayed impact on VMT.

NORTH CAROLINA EXAMPLES

- The City of Raleigh's 2030 Comprehensive Plan Update Policy ED5.10 seeks to improve the area's 1.3 jobs-housing ratio **https://cityofraleigh0drupal.blob.core.usgovcloudapi.net/drupal-prod/COR22/CPUSection06EconomicDevelopment.pdf**

OTHER EXAMPLES

- California **https://www.sciencedirect.com/science/article/pii/S0967070X11001314** **https://scag.ca.gov/sites/main/files/file-attachments/neweconomyjobshousingbalance.pdf**

SOURCES

"Employment to Housing Ratio Fact Sheet", EnviroAtlas. **https://enviroatlas.epa.gov/enviroatlas/DataFactSheets/pdf/Supplemental/Employmenthousingratio.pdf**

"Which Reduces Vehicle Travel More: Jobs-Housing Balance or Retail-Housing Mixing?", Cervero, R., & Duncan, M., UC Berkeley: University of California Transportation Center, 2008. **https://escholarship.org/uc/item/1s110395#main**

"How do local actions affect VMT? A critical review of the empirical evidence", Salon, D., Boarnet, M. G., Handy, S., Spears, S., & Tal, G., Transportation Research Part D: Transport and Environment, 2012. 17(7), 495-508.

"Quantifying the Effect of Local Government Actions on VMT" Salon, Deborah. 2014. Sacramento, CA: California Air Resources Board and the California Environmental Protection Agency. **https://escholarship.org/uc/item/2z48105j#main**

"Jobs/housing balance and employer-based travel demand management program returns to scale: Evidence from Los Angeles Transport Policy", Zhou, J., Wang, Y., Schweitzer, L., Vol 20, March 2012, Pages 22-35. **https://www.sciencedirect.com/science/article/pii/S0967070X11001314**

TYPE OF TRIPS TARGETED

Commuter trips, school trips, some trips to access services

POTENTIAL APPLICATION LOCATIONS

Urban areas, suburban areas, rural areas, tribal lands

IMPLEMENTED BY

STATE GOV'T COUNTY/ LOCAL GOV'T MPO/RPO

MIXED LAND USE

REGION TYPE

URBAN SUBURBAN

DESCRIPTION

Mixed Land Use is a zoning strategy in which multiple land uses are intermingled within a zone. Land uses include residential, commercial, entertainment, and institutional uses. This strategy can reduce the distance between homes and workplaces and other destinations, which encourages people to drive shorter distances and possibly switch to either walking or bicycling. Mixed Land Use provides travelers the opportunity to "bundle" trip purposes. For instance, if a business office is adjacent to a grocery store, office workers may go grocery shopping after work, thereby removing the need to make a separate grocery shopping trip on the weekend.

PROS

- Provides more accessible living to people who cannot drive or do not own a car.
- Provides housing opportunities for a diverse income range.
- Would target all types of trips – not just work trips.
- Once a Mixed Land Use area is fully developed, it may be able to sustain itself.

CONS

- VMT reductions may not be seen in the short-term as communities get accustomed to Mixed Land Use zones and adjust their behaviors.
- Requires significant "buy-in" from the community and zoning board.

POTENTIAL VMT REDUCTION IMPACT

In a Transportation Research Board (TRB) study based in Massachusetts, Mixed Land Use was one of the variables that had the largest impact on the level of passenger VMT. The study found that by adjusting this variable, as well as others, Massachusetts could reduce their "business-as-usual" 2040 VMT by 13.6%. (McCahill)

A 2001 study released by the Arizona Department of Transportation found that higher density and mixed-use developments designed to be walkable and accessible to regional transit could reduce residents' VMT by 25%. (US Department of Housing and Urban Development)

IMPLEMENTATION CONSIDERATIONS

The Zoning Board needs to adjust the zoning policy to enact a Mixed Land Use zone. This process requires "buy-in" from numerous stakeholders in the community. Zoning adjustments can cause significant changes to the character of a neighborhood which residents may oppose.

Companies and institutions also must be willing to conduct business in a Mixed Land Use zone for it to succeed. Otherwise, parts of the zone will be vacant, and residents will have to travel outside of the Mixed Land Use zone to fulfill their needs.

OTHER EXAMPLES

- Cary, North Carolina, NC **https://www.carync.gov/projects-initiatives/cary-community-plan/fenton-mixed-use-development**
- Charlotte, North Carolina, NC **https://croslandsoutheast.com/project/commonwealth/**
- Atlantic Station, Atlanta, GA **https://www.epa.gov/smartgrowth/atlantic-station-atlantic-steel-site-redevelopment-project**

SOURCES

Transportation Research Record Journal of the Transportation Research Board. Bill Holloway, Eric Sundquist, Chris McCahill. 2017. **https://trid.trb.org/view/1437848**

Short- and Long-Term Effects of Land Use on Reducing Personal Vehicle Miles of Travel: Longitudinal Multilevel Analysis in Austin, Texas, Sage Journals, Wenjia Zhang, Ming Zhang. 2015. **https://journals.sagepub.com/doi/10.3141/2500-12**

US Department of Housing and Urban Development, Arizona Study Suggests Dense, Mixed Use Development Patterns reduce VMT and Congestion, October 2012. **https://archives.huduser.gov/scrc/sustainability/newsletter_092712_3.html**

US Environmental Protection Agency, Mixed Use Trip Generation Model **https://www.epa.gov/smartgrowth/mixed-use-trip-generation-model#:~:text=The%20EPA%20team%20put%20the,and%20for%20an%20entire%20day.**

TYPE OF TRIPS TARGETED

All, except freight

IMPLEMENTED BY

STATE GOV'T COUNTY/ LOCAL GOV'T MPO/RPO

PRIVATE

ACCESS PRIORITY /RESTRICTION

REGION TYPE

URBAN

DESCRIPTION

Access priority and access restriction are public policy and regulatory strategies that focus on prioritizing transit and other modes of transportation over single-occupancy vehicles. There are several types of access priority and restriction:

- Route deviation: The service has a defined path and schedule, but the vehicle may deviate from the path to pick up or drop off riders. Maximum deviation varies by service and can range from a quarter of a mile to a mile.
- Transit lanes that give priority to transit. These include segregated bus lanes which are fully separated from the main road and reserved for transit and queue jump lanes which enable transit to overtake queuing vehicles at a signal.
- Transit signal priority uses technologies to reduce the time at traffic signals for transit vehicles.
- Car-free streets or car-free zones limit personal vehicle access. Some cities in Europe have banned cars in city centers.

PROS

- Access priority can make transit a quicker and more attractive travel mode.
- Vehicle restrictions can reduce vehicle miles traveled, traffic congestion, road and facility costs, and vehicle accidents.

CONS

- If an access priority/restriction program is poorly designed, vehicle use may shift to other routes and off-peak times.
- An ineffective vehicle access/restriction program that reduces access in urban areas may encourage sprawl by encouraging businesses and vehicles to choose areas without restrictions.
- Without strong political support, access priority and restriction programs are hard to implement.
- Access priority and restriction programs can increase traffic congestion in other areas around the restricted area.
- If access restrictions are not enforced over time, motorists will ignore them. This is especially prevalent in the case of High Occupancy Vehicle (HOV) lanes.

POTENTIAL VMT REDUCTION IMPACT

One study looked at bus priority schemes. Seattle King County's E-Line Corridor Prioritization reduced bus journey time by 5.4 minutes. Dublin, Ireland's Stillorgan Road Quality Bus Corridor increased peak hour bus speeds, and buses were 30% faster than cars. Ridership increased by 176% and car use fell by 42.56% between 1997 and 2007. London's A100 Tower Bridge Road/Tooley Street project had a net savings in journey time of $490,057 in the year after the project.

IMPLEMENTATION CONSIDERATIONS

Access restriction measures must be carefully balanced and consider all unique attributes of an area.

NORTH CAROLINA EXAMPLES

- Triangle Region – Bus On Shoulder **https://www.ncdot.gov/divisions/integrated-mobility/innovation/Pages/bus-on-shoulder-system.aspx**

OTHER EXAMPLES

- Denver 16th Street Mall – Car-free Street **https://www.denver.org/things-to-do/denver-attractions/16th-street-mall/**
- Seattle King County Washington – Bus Priority Lanes - **https://kingcounty.gov/~/media/depts/metro/about/planning/speed-reliability-toolbox.pdf**
- Oslo and Barcelona – Car-free cities - **https://www.sciencedirect.com/science/article/pii/S0160412016302161**

SOURCES

"The identification and management of bus priority schemes: A study of international experiences and best practices", Deborah Mundy et. al, Imperial College London, Railway and Transport Strategy Center, April 2017.
https://www.imperial.ac.uk/media/imperial-college/research-centres-and-groups/centre-for-transport-studies/rtsc/The-Identification-and-Management-of-Bus-Priority-Schemes---RTSC-April-2017_ISBN-978-1-5262-0693-0.pdf

"Car free cities: Pathway to healthy urban living", Mark J. Nieuwenhuijsen and Haneen Khreis, Environment International, September 2016.
https://doi.org/10.1016/j.envint.2016.05.032

TYPE OF TRIPS TARGETED

Primarily commuter trips

POTENTIAL APPLICATION LOCATIONS

Urban city centers, congested commuter and transit routes

IMPLEMENTED BY

STATE GOV'T

COUNTY/ LOCAL GOV'T

TRANSIT AGENCY

TRIP REDUCTION ORDINANCE

REGION TYPE

URBAN SUBURBAN

DESCRIPTION

A Trip Reduction Ordinance is a requirement adopted by a state, region, or city to manage congestion and reduce vehicle miles traveled by promoting alternatives to single-occupancy vehicles. Most of these ordinances date back to the 1990s when the US Congress passed the Clean Air Act, endorsing trip reduction ordinances to increase non-automobile travel. Trip reduction ordinances include programs that require developers to reduce the drive-alone rate for their developments as well as state or city mandated employer-based programs to reduce the drive-alone rate among commuters.

A common form of trip reduction ordinance is an employer-based trip reduction program. These programs are implemented by employers to reduce single-occupancy employee commuting trips. The employer program can include any of a variety of TDM measures including employer-subsidized transit passes, company-run vanpool services, or employer-run shuttle service to transit stations. 250 employees is often the minimum number of employees needed to participate in the program.

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PROS

- Trip reduction ordinances are typically not a heavy-handed regulation and are usually easy to implement.
- Trip reduction ordinance measures can be customized to the location for best results.
- Trip reduction programs increase usage of alternative modes of transportation.

CONS

- There are a variety of strategies that a trip reduction ordinance or program can use. Identifying the right ones for the area can be complicated.
- Without government support and private sector support, trip reduction ordinances can easily be overturned.

POTENTIAL VMT REDUCTION IMPACT

A study on the Washington State Commute Trip Reduction ordinance by Wu and Shen found that trip reduction policies can effectively influence employee mode choice, although different policies have varied effects. The Washington State Commute Trip Reduction ordinance can reduce the probability of commuters driving alone between 1.76% and 3.43%. A trip reduction program with at least six different options can reduce the probability of driving alone by 18%.

A study from Seattle Department of Transportation found that employers participating in the Washington State Commute Trip Reduction program have contributed to an 11% reduction in Seattle's drive-alone rate. 64% of commuters in Seattle who work for employers in the Washington State Commute Trip Reduction program use transit, biking, walking, or rideshare to get to work.

IMPLEMENTATION CONSIDERATIONS

Policies that place increasing burden on private companies are more likely to receive criticism for being anti-growth and a hindrance to economic activity, while stronger policies are also what are likely to produce meaningful VMT reductions.

NORTH CAROLINA EXAMPLES

- Durham Commute Trip Reduction Program **https://www.dconc.gov/Home/ShowDocument?id=4872**

OTHER EXAMPLES

- Washington State Commute Trip Reduction Ordinance **https://www.wsdot.wa.gov/transit/ctr/home**
- Santa Monica, CA **https://www.smgov.net/Departments/PCD/Transportation/Employers/**
- Rockville, MD **https://www.rockvillemd.gov/DocumentCenter/View/591/TDM_Plan_03-21-11_Final_Adopted?bidId=**

SOURCES

"The Effects of Commute Trip Reduction Program on Employee Mode Choice", Wu, Xiatian & Shen, Qing, Transportation Research Board, 7 December 2018. **https://trid.trb.org/View/1572907**

"Commute Trip Reduction (CTR) Overview", Transportation Benefits Toolkit, Commute Seattle. **https://commuteseattle.com/wp-content/uploads/2017/03/CSToolkit_TBT_CTR-Overview.pdf**

TYPE OF TRIPS TARGETED

General ordinance - all trips. Employer-based trip reduction program - commuter trips

POTENTIAL APPLICATION LOCATIONS

Statewide, urban areas

IMPLEMENTED BY

COUNTY/ LOCAL GOV'T

Pricing

GAS TAX INCREASE

REGION TYPE

URBAN SUBURBAN RURAL

DESCRIPTION

Gas taxes or fuel taxes are a pricing strategy commonly used to fund highway and roadway facility maintenance. All US states and the US federal government have a gas tax. In North Carolina, the gas tax varies with state population and energy prices. Some states allow local governments to levy additional fuel taxes. Many states are now revising the definition of fuel to include non-gas alternative fuels.

PROS

- Can raise substantial revenue, especially when linked to inflation.
- Collection of tax is easy (included at time of purchase).
- No new cost to administer gas tax.
- Low potential for evasion of tax.

CONS

- The increase must be substantial enough to change behavior.
- May encounter political obstruction.
- As vehicles become more efficient, alternative fuels are used, and inflation rises, the gas tax is less effective at reducing VMT.
- If a gas tax increase causes the price of gasoline to vary greatly from neighboring states, it may cause drivers to refuel out of state if it is part of their trip instead of driving less. This applies mostly to the southern suburbs of Charlotte as well as through traffic on I-77, I-85, and I-95.

POTENTIAL VMT REDUCTION IMPACT

One analysis by the Metropolitan Area Planning Council showed that an 18-cent increase in the gas tax in the Boston metropolitan area may cause a VMT reduction of just under 0.5% (Gately and Reardon, 2021).

IMPLEMENTATION CONSIDERATIONS

The infrastructure cost for increasing the gas tax is negligible since North Carolina already has a gas tax and the infrastructure in place to collect it. The difficult part of implementing a gas tax increase is the public opposition to it.

NORTH CAROLINA EXAMPLES

- North Carolina changed the state gas tax to consider inflation and state population – General Assembly of North Carolina Session Law 2015-2 Senate Bill 20. **https://www.ncleg.net/Sessions/2015/Bills/Senate/PDF/S20v7.pdf?sessionId=1500312975876&referrer=https://w**

OTHER EXAMPLES

- Urban Institute Motor Fuel Taxes **https://www.urban.org/policy-centers/cross-center-initiatives/state-and-local-finance-initiative/state-and-local-backgrounders/motor-fuel-taxes**
- Institute on Taxation and Economic Policy **https://itep.org/most-states-have-raised-gas-taxes-in-recent-years-0419/#:~:text=Georgia%3A%20A%206.7%2Dcent%20increase,power%20in%20the%20years%20ahead**
- Federal Taxes. **https://itep.org/federal-inaction-on-the-gas-tax-is-costing-us-dearly/**

SOURCES

Gately, Conor, and Tim Reardon. "The Impacts of Land Use and Pricing in Reducing Vehicle Miles Traveled and Transport Emissions in Massachusetts." Metropolitan Area Planning Council, 22 Jan. 2021.

"Price Elasticity of Demand for Gasoline." Moffatt, Mike. ThoughtCo, 23 June 2019, **www.thoughtco.com/price-elasticity-of-demand-for-gasoline-1147841.**

State-Level Strategies for Reducing Vehicle Miles of Travel. University of California. Michelle Byars, Yishu Wei, Susan Handy. 2017. **https://d3n8a8pro7vhmx.cloudfront.net/climateplan/pages/44/attachments/original/1509403808/2017-PTA-Handy_UCDavis_VMT_Report_1.pdf**

The NC Motor Fuels Tax, www.ncdot.gov/about-us/how-we-operate/finance-budget/nc-first/Documents/nc-first-brief-edition-1.pdf. **https://www.ncdot.gov/about-us/how-we-operate/finance-budget/nc-first/Documents/nc-first-brief-edition-1.pdf**

TYPE OF TRIPS TARGETED

All Trips

POTENTIAL APPLICATION LOCATIONS

Statewide

IMPLEMENTED BY

STATE GOV'T

Pricing

PARKING PRICING

REGION TYPE

URBAN

DESCRIPTION

Parking pricing refers to charging a fee to park in public (municipal) lots and curbside spaces and private lots. Types of parking pricing strategies that could potentially reduce VMT include:

- Price on-street parking. This could encourage people to use alternative modes of transportation.
- Price parking so that it is equal to or greater than the cost of transit to encourage transit use.
- Have a local parking pricing plan that charges similar fees for parking at a given time. This can be applied on a static basis or can be demand-responsive, charging based on the demand. The goal of demand responsive parking pricing is to charge a price that is low enough that the driver will decide to park there without further "circling" for cheaper spots, but also high enough that customers are likely to leave quickly, allowing their space to be occupied by another vehicle. A parking pricing strategy for employers would be to charge employees for parking in the employer owned lots.

PROS

- Travelers have a choice; they can opt to drive and find parking or use a different mode of travel.
- Demand responsive parking pricing can reduce traffic and congestion by reducing "circling" to look for alternative spots if it is priced correctly.

CONS

- Not always effective without an overall parking management strategy. There needs to be consistent pricing in an area, otherwise drivers will gravitate to the cheaper parking spaces first. If the parking price is set too low, people may drive instead of using other modes of transportation.
- Requires alternative transportation modes to be successful.
- Demand-responsive parking pricing requires expensive Smart meters and parking sensors.

POTENTIAL VMT REDUCTION IMPACT

One study predicted that charging employees $3 per day for parking would decrease VMT by 1.9 to 2.9%. (Parking Pricing and Fees)

In San Francisco, CA, VMT dropped between 22% and 26% in neighborhoods where demand-responsive parking pricing was implemented. In 2018, this was expanded to all San Francisco neighborhoods (Joy and Schreffler). After 2018, reported parking search time went down by 43% and average hourly parking rates dropped by 4%. San Francisco's pilot was one of the first to show that parking pricing could lower cruising and the time to find a parking spot. (Jose)

In Washington, DC, a parking pricing pilot done by the District Department of Transportation found that congestion in the pilot areas fell by 5%, compared to a 3% decrease in congestion in DC overall. Metrorail ridership has fallen consistently, but ridership at stations in the pilot area remained consistent once the pilot began. Bikeshare ridership increased by 36% after the pilot as well. (Dey)

IMPLEMENTATION CONSIDERATIONS

Increasing parking rates in an area may be contentious as it will cause parking customers to pay more for a product that used to be cheaper. This may be easier to handle if alternative modes of transportation are available in the area. Paid parking also requires infrastructure to allow payment, although this has become easier recently with the creation of parking apps such as ParkMobile

NORTH CAROLINA EXAMPLES

- Concord, NC – Downtown Parking Study **https://apps.concordnc.gov/legacy/PlanningWeb/AreaPlans/DowntownMasterPlan/Parking_Study_2015.pdf**
- Raleigh, NC – Hillsborough Street Corridor Parking Study **https://www.hillsboroughstreet.org/_files/docs/parking_study_report-20180831-final-min.pdf**

OTHER EXAMPLES

- SFPark **https://www.sfmta.com/demand-responsive-parking-pricing**
- Annual Report 2017 On-Street Paid Parking Occupancy. Seattle Department of Transportation. **https://www.seattle.gov/Documents/Departments/SDOT/About/DocumentLibrary/Reports/SDOT_AnnualReport2017.pdf**
- Pricing Parking Best Practices: Background Memo. Portland Bureau of Transportation. **https://www.portland.gov/transportation/equitable-mobility-taskforce/documents/pricing-parking-best-practices-background-0/download**

SOURCES

"Yellow Brick Roadmap to Demand-Based Parking Pricing: Findings from Washington, D.C.", Dey, Soumya S., et al., Transportation Research Record: Journal of the Transportation Research Board, vol. 2673, no. 12, 2019, pp. 339–353., doi:10.1177/0361198119863113.

"Traveler Response to Transportation System Changes Handbook, Third Edition: Chapter 13, Parking Pricing and Fees." 2005, doi:10.17226/23415

"Evaluation of Demand Responsive Parking Pricing in San Francisco: Effects on Vehicular Travel, Air Pollution, and Fuel Consumption", Joy, Barbara, and Eric Schreffler. Transportation Research Board, 2015.

"San Francisco Adopts Demand-Responsive Pricing Program to Make Parking Easier", Jose, Ben. San Francisco Municipal Transportation Agency, 27 Feb. 2020.

"Impacts of Parking Pricing and Parking Management on Passenger Vehicle Use and Greenhouse Gas Emissions: Policy Brief", Spears, S., Boarnet, M., Handy, S., 30 Sept. 2014.

TYPE OF TRIPS TARGETED

Commuter trips, short trips between parking facilities

POTENTIAL APPLICATION LOCATIONS

Urban city centers, town centers

IMPLEMENTED BY

STATE GOV'T | COUNTY/ LOCAL GOV'T | PRIVATE

ROAD PRICING AND CORDON PRICING

REGION TYPE

URBAN SUBURBAN RURAL

DESCRIPTION

Road Pricing means that vehicles are charged a fee to use a roadway. Traditional road pricing includes toll roads and other toll facilities such as toll bridges and tunnels. Congestion Pricing, sometimes referred to as Value Pricing, is a subset of Road Pricing and levies differential tolls depending on the time of day such that fees for use are higher during congested periods. Congestion Pricing can be applied on traditional toll facilities as well as in Express Lanes, which are tolled lanes adjacent to free lanes. Some Express Lane facilities allow high occupancy vehicles over a certain occupancy requirement to travel for a reduced rate or for free, thereby encouraging ridesharing. In Cordon Pricing, a toll is paid by a vehicle to enter an "area" such as a downtown.

PROS

- Road Pricing users choose to pay for the trip or find a toll-free alternative.
- Cordon pricing may result in a mode switch to public transit, biking, or walking, thereby reducing VMT.

CONS

- May not actually reduce VMT if tolls are set low (which may happen if tolls are artificially low for political reasons).
- If tolls are too high, drivers may divert to free routes, which may be longer in distance and contribute to higher VMT.
- Electronic toll collection is infrastructure dependent and costs could be high, particularly for cordon pricing.

POTENTIAL VMT REDUCTION IMPACT

Converting High Occupancy Vehicles (HOV) lanes to tolled Express Lanes may increase VMT as it can lead to a decrease in HOV use by as much as one third (as it did on the I-15 corridor in San Diego) in the lane and the highway corridor as a whole. (Burris). Also, a priority of express lanes is to provide reliability, not necessarily VMT reduction, though Express Lanes can enhance bus transit by providing a more reliable travel time. In London, cordon pricing showed a 18% drop in traffic entering and 15% less traffic circulating within the cordon area as compared to pre-cordon pricing activity. Bus ridership increased by 38% because of reliability and improved trip times. About 50% of the car trips no longer in the cordon zone switched to public transit within the zone, about 25% were diverted out of the cordon zone and the rest were attributed to carpool, walk and bike trips. The initial results were maintained over time despite population growth. There were almost 10% fewer trips in 2015 as compared to 2000, despite a 20% increase in population. The charge was equivalent to about $14.50 in 2020. (Provonsha and Sifuentes).

IMPLEMENTATION CONSIDERATIONS

Converting HOV lanes into tolled Express Lanes or incorporating cordon pricing incurs a significant infrastructure cost as toll technology must be added to the road network and a back office must be set up if one does not exist yet. Determining the parameters of cordon pricing can be complex and may not be suitable for an urban area depending on its roadway network. Currently, the North Carolina Turnpike Authority can operate only eleven toll projects in the state.

NORTH CAROLINA EXAMPLES

- I-77 Express Lanes
  https://www.i77express.com/
- I-485 Express Lanes
  https://www.ncdot.gov/projects/i-485-express-lanes/Pages/default.aspx
- US 74 Express Lanes
  https://www.ncdot.gov/projects/us-74-express-lanes-i-277/Pages/default.aspx

OTHER EXAMPLES

Cordon pricing:

- London
  https://tfl.gov.uk/modes/driving/congestion-charge
- New York City
  https://new.mta.info/project/CBDTP

HOV Lanes converted to Express Lanes:

- I-85 Express Lanes in Atlanta
  https://www.peachpass.com/where-can-i-use-peach-pass/i-85-express-lanes/
- I-66 in Northern Virginia
  https://vai66tolls.com/

SOURCES

"Road Pricing in London, Stockholm, and Singapore", Provonsha, Emily, and Nickolas Sifuentes. Tri-State Transportation Center, 2017.
https://tstc.org/wp-content/uploads/2018/03/TSTC_A_Way_Forward_CPreport_1.4.18_medium.pdf

"The Impact of HOT Lanes on Carpools", Burris, Mark, et al. Texas Transportation Institute,
https://www.sciencedirect.com/science/article/pii/S0739885914000055

"The Mythology of HOT Lanes" Posey, Kevin. Streetsblog USA, 27 Sept. 2016,
usa.streetsblog.org/2016/09/27/the-mythology-of-hot-lanes/

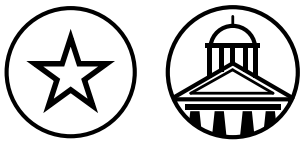
TYPE OF TRIPS TARGETED

All, but primarily peak period trips.

POTENTIAL APPLICATION LOCATIONS

High volume corridors and urban city centers

IMPLEMENTED BY



STATE GOV'T COUNTY/ LOCAL GOV'T

Pricing

VMT FEE OR TAX

REGION TYPE

URBAN SUBURBAN RURAL

DESCRIPTION

Vehicle Mileage Traveled (VMT) fees are levied based upon the average mileage that a vehicle is driven in a set period of time (year) and are envisioned as a replacement for gas taxes. Gas taxes, which tax the user on a per gallon basis, have been the main source of income for the nation's transportation funding. Unfortunately, officials have been reluctant to increase the gas tax, and because fuel efficiency and alternative fuel vehicle use have increased and because fuel costs have also not increased at the rate of inflation, receipts have not increased with inflation. VMT fees or taxes are more equitable, as users pay directly for the miles they travel and those that have more gas dependent vehicles are not disproportionately shouldering the burden. Depending on the rate of the fee levied, VMT fees or taxes could result in fewer miles driven, reducing overall VMT.

PROS

- Equitable cost per vehicle based on miles driven (type of vehicle not a factor).
- Would target all types of trips and could be assessed for freight trips too.
- Depending on how miles are tracked, congestion pricing could be tied to a VMT fee or tax.

CONS

- Cost to drive a vehicle could go up – could potentially affect low income persons more.
- Program could be difficult to implement (how to monitor mileage use while not allowing odometer tampering) and would be more costly to implement (billing required).
- Politically difficult to implement.

POTENTIAL VMT REDUCTION IMPACT

In the Minnesota Pilot Program (2006), 130 participants were given devices that recorded mileage and time of travel. Prices per mile were assigned randomly to each participant, ranging from $0.05 to $0.25 per mile. The findings indicated that per mile pricing results in measurable reductions in driving (about 4.4 compared to the unpriced group). The largest effect was on weekend driving (8.1% decrease) and on peak weekday travel (6.6% decrease), as some participants substituted mass transit for vehicle use. A key finding was that households willing to change their driving behavior will do so with low per mile cost incentives. Also, households unable to change their behavior do not do so even under relatively higher cost incentives (Buxbaum).

In 2013, A GPS tracking device was installed on volunteered vehicles (limited to 5,000 cars and light-duty commercial vehicles) in Oregon for about $250 per vehicle. Drivers were charged $0.015 per mile regardless of their vehicle type and model. Participants received monthly bills of their road-use charges and had the state gasoline tax refunded when they purchased gasoline at pumps in Oregon.

The participating drivers drove 12 % less when they were paying the VMT tax (and refunded for the gas tax) than when they were paying the gas tax. Some participants noted they reduced their driving because they were more aware of short trips and the number of miles driven. It is unknown if this is a short-term impact and if the VMT tax would have a similar impact as the gas tax on driving decisions. (Whitty)

IMPLEMENTATION CONSIDERATIONS

The infrastructure cost is significant as a new tax framework would have to be implemented, based on odometer readings or mandated GPS devices. Odometer readings have the benefit of already being part of automobile technology, but would charge drivers for miles outside of North Carolina. GPS devices allow for specific VMT taxes by zone (either North Carolina or a cordon area) and time (to discourage driving during rush hour). However, they are not standard features in all vehicles and may be considered by some to be an invasion of privacy. The public may also consider a VMT tax an increase to its tax burden. Implementation would require legislative action at the state level and the involvement of state agencies (including the Department of Revenue and the Department of Transportation).

NORTH CAROLINA EXAMPLES

- NC Clean Energy Technology Center **https://nccleantech.ncsu.edu/category/policy-and-markets/**
- NC First Commission **https://www.ncdot.gov/about-us/how-we-operate/finance-budget/nc-first/Documents/nc-first-brief-edition-12.pdf**

OTHER EXAMPLES

- Minnesota **https://www.lrrb.org/media/reports/200639A.pdf**
- Oregon **https://www.myorego.org/wp-content/uploads/2017/07/RUFPP_finalreport.pdf**

SOURCES

"Pay-As-You-Drive Experiment Findings" Buxbaum, Jeffrey. MN Department of Transportation, 2006
https://www.lrrb.org/media/reports/200639A.pdf

"Oregon's Mileage Fee Concept and Road User Fee Pilot Program". Whitty, James. Oregon Department of Transportation, 2007,
https://www.myorego.org/wp-ontent/uploads/2017/07/RUFPP_finalreport.pdf

TYPE OF TRIPS TARGETED

All trips

POTENTIAL APPLICATION LOCATIONS

Statewide

IMPLEMENTED BY

STATE GOV'T

Application Based

MOBILITY AS A SERVICE

REGION TYPE

URBAN SUBURBAN

DESCRIPTION

Mobility as a Service (MaaS) is the combination of most (if not all) transportation modal options into one application (app). The objective of MaaS is to provide community members with a central app that they can use for all trip planning in a region, with the app providing intermodal trip options for customers' trips from their initial origin to their final destination. The apps may have inputs for the customer trip characteristics, such as whether they are traveling with heavy equipment or if they are using a wheelchair. Some MaaS apps may offer subscription packages, in which payment to the MaaS app could include transit fares, bikeshare costs, and a credit with Transportation Network Companies (TNCs) such as Uber or Lyft.

PROS

- MaaS apps can solve the first mile/last mile problem by providing customers with guidance on how to complete every leg of their trips. If the apps work well in this regard, they may attract additional riders from transit out of personal vehicles.
- MaaS applications would generate valuable data that would allow alternative transportation groups to study how they are serving their clients well and how they can serve them better.

CONS

- If a MaaS app is operated by a TNC, the app may siphon transit ridership to a TNC vehicle since it will generate more revenue for the TNC.
- MaaS apps require alternative transportation options to provide alternatives to its customers besides personal vehicles. A MaaS app is not helpful to a city without public transit.
- A MaaS app is as good as its coverage of transportation options. If a MaaS app includes the local bikeshare and transit options, but does not include any TNCs, it may not adequately serve its customers.

POTENTIAL VMT REDUCTION IMPACT

Unknown. This concept is very new, with only a few international examples implemented. Inspiratia, the fastest-growing online provider of data on global infrastucture and transport, even claims that there are no existing examples of fully realized MaaS.

IMPLEMENTATION CONSIDERATIONS

MaaS apps provide a valuable service by simplifying intermodal journeys. However, they also rely on the presence of alternative modes to reduce VMT. MaaS apps are just starting development in the US, and 29 TNC and transit agency partnerships are laying the groundwork for these kinds of services which were identified in a 2018 study for the Chaddick Institute for Metropolitan Development at DePaul University.

NORTH CAROLINA EXAMPLES

- CATS First Mile / Last Mile Partnership with Lyft (MaaS potential)
  https://www.masstransitmag.com/technology/press-release/12406980/charlotte-area-transit-system-cats-cats-announces-first-mile-last-mile-partnership-with-lyft

OTHER EXAMPLES

- Nationwide TNC/Transit Partnerships (MaaS potential)
  https://las.depaul.edu/centers-and-institutes/chaddick-institute-for-metropolitan-development/research-and-publications/Documents/Partners%20in%20Transit_Live1.pdf

WORLDWIDE EXAMPLES

- Helsinki
  https://whimapp.com/about-us/
- Citymapper App
  https://citymapper.com
- Transitapp
  https://transitapp.com

SOURCES

"MaaS: The Mobility Revolution Coming to North America", Inspiratia,
https://docslib.org/doc/6820223/maas-the-mobility-revolution-coming-to-north-america

"Partners In Transit: A Review of Partnerships between Network Companies and Public Agencies in the United States", Chaddick Institute for Metropolitan Development at DePaul University, 1 August 2018.
https://las.depaul.edu/centers-and-institutes/chaddick-institute-for-metropolitan-development/research-and-publications/Documents/Partners%20in%20Transit_Live1.pdf

TYPE OF TRIPS TARGETED

All, except freight

POTENTIAL APPLICATION LOCATIONS

Cities and nearby suburbs

IMPLEMENTED BY

STATE GOV'T COUNTY/ LOCAL GOV'T TRANSIT AGENCY

Application Based

RIDE-MATCHING APPLICATIONS

REGION TYPE

URBAN SUBURBAN

DESCRIPTION

Mobile ride-matching (or ridesharing) applications help travelers find other travel partners for trips. These applications may focus on matching carpoolers for recurring commuter trips, however, most app based ride matching focuses on dynamic carpooling allowing users to arrange ad-hoc rides on demand or on very short notice. These travelers may include customers of a Transportation Network Company (TNC) for single events (or trips), or intercity travelers with private cars making the same trip. These ride matching applications consider their customers' origin, destination, and schedule to determine what potential carpools or drivers are compatible with them.

PROS

- Increases travel options for area residents.
- Increases the virtual network for customers to find potential carpools.
- Ride-matching applications require less infrastructure and have a lower cost to implement and maintain than other measures such as public transit.
- Many potential customers already have TNC applications on their phones and would only have to select the ridesharing option (such as UberPOOL) to utilize the service.

CONS

- There are numerous applications competing for patronage. If multiple applications are used for the same purpose, they are inherently less efficient.
- A critical mass of potential customers is necessary for matches to occur and for the applications to be effective.
- In the case of TNC applications, if the ride-matching fare is too close to the solo travel fare, customers are more likely to choose solo travel.

POTENTIAL VMT REDUCTION IMPACT

Ride-matching applications can support ridesharing services to reduce VMT but the impact of ride matching alone is hard to quantify.

Some studies, like one by Schaller Consulting in 2018, show that having "pool" options in TNC applications actually increases driving by about 160%, because those people would have taken transit otherwise.

IMPLEMENTATION CONSIDERATIONS

Ride-matching and rideshare services may be met with sentiments of "stranger danger" and small individual incidents can result in a poor reputation for the service or even lawsuits if not properly protected.

NORTH CAROLINA EXAMPLES

- Share the Ride NC
  https://www.sharetheridenc.org/Public/Home.aspx

OTHER EXAMPLES

- New Jersey (NJ Rideshare)
  https://www.njrideshare.com/rp2/Home/Home
- Northern Virginia
  https://commuterconnec.wpengine.com/ridesharing/
- Uber
  https://www.uber.com/
- Lyft
  https://www.lyft.com/
- Hitch
  https://www.ridehitch.com/

SOURCES

"The New Automobility: Lyft, Uber and the Future of American Cities", Schaller Consulting, 25 July 2018.
http://www.schallerconsult.com/rideservices/automobility.pdf

"On-Demand high-capacity ride-sharing via dynamic trip-vehicle assignment", Alonso-Mora, J., Samaranayake, A., Frazzoli, E., Rus, D., PNAS 17 Jan 2017 114(3) 462-467
https://www.pnas.org/content/114/3/462

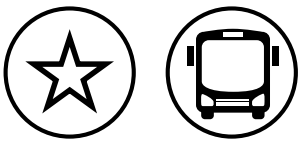
TYPE OF TRIPS TARGETED

All trips

POTENTIAL APPLICATION LOCATIONS

Urban and Suburban Areas, Towns, universities

IMPLEMENTED BY



STATE GOV'T TRANSIT AGENCY

Support

COMPACT DEVELOPMENT /CLUSTERING

REGION TYPE

URBAN SUBURBAN RURAL

DESCRIPTION

Compact development is recognized as dense development; residential areas with high ratios of residents per area and employment areas that have high ratios of jobs over an area. Clustering is defined as locating related activities close to one another. Concentrated residential and employment areas can provide density needed for successful transit services and ridesharing to occur between the two. Clustering necessary services (schools, groceries, municipal services) near or within residential areas or employment centers can promote trip chaining and non-motorized trip making (walking).

PROS

- Can promote non-motorized trip-making in all area types.
- It is an important part of transit-oriented development and mixed-use development.

CONS

- There is some discussion that people attracted to compact development in transit oriented or mixed-use development do so because they seek a less car dependent environment, so overall VMT reduction may be minimal.
- Trips are more concentrated and may result in localized congestion issues.

POTENTIAL VMT REDUCTION IMPACT

Compact development is a vital part of both transit-oriented and mixed-use development. By itself, compact development does not have a material impact on VMT but can make other Transportation Demand Management (TDM) measures such as ridesharing more successful. One modeling study in the Greater Cincinnati area, published by Urban Rail Transit, showed that when dense, mixed use city centers are developed rather than an employment focused city center with surrounding residential growth, the +20 year VMT forecast is reduced by approximately 7.5%.

IMPLEMENTATION CONSIDERATIONS

May be hard to implement where less dense development is championed by residents. May need local policy and code changes to allow for different development types and densities. Difficult and costly to implement where utility limitations exist, such as municipal water capacity for high rise buildings, or limited internet bandwidth for multiple users.

NORTH CAROLINA EXAMPLES

- Durham
  https://www.durhamnc.gov/DocumentCenter/View/7069/Compact-Neighborhoods-An-Introduction?bidId=

OTHER EXAMPLES

- Pennsylvania
  https://www.chescoplanning.org/MuniCorner/Tools/CompactDev.cfm

SOURCES

"Integrating Land Use and Socioeconomic Factors into Scenario-Based Travel Demand and Carbon Emission Impact Study", Wei, Heng et al, Urban Rail Transit, 2017.
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7425664/

"Compact development and preference heterogeneity in residential location choice behaviour: A latent class analysis", Liao, Felix Haifeng & Farber, Steven & Ewing, Reid. (2014). Urban Studies. 52. 314-337.
https://www.researchgate.net/publication/275504971_Compact_development_and_preference_heterogeneity_in_residential_location_choice_behaviour_A_latent_class_analysis

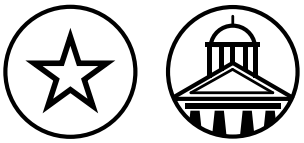
TYPE OF TRIPS TARGETED

All

POTENTIAL APPLICATION LOCATIONS

All

IMPLEMENTED BY



STATE GOV'T COUNTY/ LOCAL GOV'T

Support

FACILITY AMENITIES

REGION TYPE

URBAN SUBURBAN

DESCRIPTION

Facility amenities include a wide variety of services that support alternative modes like walking, biking, and transit. They can include long and short-term bike parking, bicycle storage, bicycle maintenance facilities (tire pumps and light tools), electric recharging, changing and restrooms with shower facilities, pedestrian shade/cooling stations, transit stop shuttles, or satellite parking with shuttle service. Amenities are usually most appropriately located at trip-end or trip-start points. These locations include apartment complexes, office buildings, consumer businesses, banks, schools, etc. These amenities are usually provided as an incentive to attract residents, patrons, students, or employees.

PROS

- Alleviates common complaints about taking alternative modes.
- Sends a message that alternative modes are prioritized by catering to the needs of their users.

CONS

- Requires action of private stakeholders.
- Only applicable where alternative modes are already available/viable.

IMPLEMENTATION CONSIDERATIONS

Facility amenities are implemented by individual businesses, developers, landlords, employers, or schools and somewhat outside of a planning organization's reach to influence adoption.

NORTH CAROLINA EXAMPLES

- University of North Carolina **https://facilities.unc.edu/files/2015/12/TIA_Executive_Summary.pdf**
- Marine Corp Base Camp Lejeune

OTHER EXAMPLES

- Massachusetts **http://www.mapc.org/wp-content/uploads/2017/10/TDM-FINAL-REPORT-7_15_0.pdf**

SOURCES

"Become a Bicycle Friendly Workplace", Bike to Work Metro DC. **https://www.biketoworkmetrodc.org/employer-resources/become-a-bicycle-friendly-workplace**

"Determinants of bicycle commuting in the Washington DC region: The role of bicycle parking, cyclist showers, and free car parking at work", Buehler, R., Elsevier Transportation Research Part D, 2012, 525-531 **https://ralphbu.files.wordpress.com/2015/03/determinantsofbicyclecommuting.pdf**

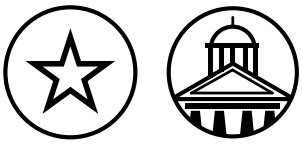
TYPE OF TRIPS TARGETED

All

POTENTIAL APPLICATION LOCATIONS

Universities, large employers

IMPLEMENTED BY



STATE GOV'T COUNTY/ LOCAL GOV'T

Support

GUARANTEED RIDE HOME

REGION TYPE

URBAN SUBURBAN RURAL

DESCRIPTION

For those who typically use alternative transportation modes (carpooling, transit, bicycling), Guaranteed Ride Home programs reimburse preregistered commuters for taxi or Transportation Network Company (TNC) service fares when emergencies arise. One obstacle to using alternative transportation modes is that the modes are generally less flexible than driving to work alone; carpooling requires all members to depart at the same time, public transit may be unavailable outside of peak hours, and bicycling may be unsafe or prohibited in some areas after sunset. If commuters know that they can take a taxi or a TNC vehicle at no extra expense should an emergency occur, they would be more likely to utilize alternative transportation modes.

Typically, participants must be pre registered to partake in a Guaranteed Ride program. They must take an alternative form of transportation to work and must have an emergency to utilize the program. Depending on the program, qualifying emergencies include:

- Injury, illness, or crisis for the program participant or family member
- Supervisor requests that the participant works overtime
- The driver of the participant's carpool has an emergency

Most of these programs are implemented by transit agencies, TMA's (Transportation Management Agencies), individual cities or counties, and some large employers. The program may provide prepaid taxi vouchers or involve a reimbursement framework. Typically, there are monetary limits on how much a commuter can spend on the program in one month or one year, although these limits are rarely reached.

PROS

- Increases usage of alternative modes of transportation, especially on public transit systems where peak period service are significantly more frequent than during the off-peak periods.
- Provides peace of mind for the commuters because if they have an emergency, they can get to where they need to go without any additional cost.

CONS

- Does not work on its own; relies on the presence of alternative modes of transportation.
- May require commuter to cover the upfront cost of the taxi or TNC service and be reimbursed later.

POTENTIAL VMT REDUCTION IMPACT

A study by Nelson\Nygaard in 2015 on the Alameda County, CA Guaranteed Ride Home program showed that 9% of enrolled commuters switched from driving alone to carpooling, walking, or public transit after joining the program. A previous version of the study on the same program conducted in 2013 showed that 14% of Guaranteed Ride Home enrolled commuters switched away from driving alone after joining the program.

IMPLEMENTATION CONSIDERATIONS

Costs are generally low. There may be some administrative costs depending on the program. Actual use of these programs can be quite low and most programs have restrictions on how many times the service can be used per year. Other restrictions may include the type of commuter trip covered (walk, bike, transit) and the frequency of use of the alternative mode. Most programs that are administered by the county or other public agency (including TMAs).

A 2007 Federal Transit Administration (FTA) study estimated the average mean annual cost per registered commuter at $1.69 and the average cost per claim at $36.95.

NORTH CAROLINA EXAMPLES

- Piedmont Authority for Regional Transportation
  https://www.partnc.org/158/Emergency-Ride-Home
- Go Triangle
  https://gotriangle.org/erh
- Share the Ride NC (STRNC)
  https://www.sharetheridenc.org/Public/PublicPage.aspx?ItemName=AboutERH&FileType=HTML

OTHER EXAMPLES

- Alameda County, CA.
  https://grh.alamedactc.org/
- Washington, DC Area
  https://www.commuterconnections.org/about-us/
- Orange County, CA.
  https://www.octa.net/Getting-Around/Rideshare/Employers/Guaranteed-Ride-Home-Program/

SOURCES

"Guaranteed Ride Home Programs: A Study of Program Characteristics, Utilization, and Cost", William B. Menczer, Federal Transit Administration 2007.
https://scholarcommons.usf.edu/cgi/viewcontent.cgi?article=1263&context=jpt

"Guaranteed Ride Home Program Evaluation 2015", Nelson/Nygaard, Alameda County Transportation Commission, June 2016. .
http://grh.alamedactc.org/wp-content/uploads/2016/06/ALAMEDA-CTC-GRH-Evaluation-2015-FINAL.pdf

"Guaranteed Ride Home Program Evaluation 2013", Nelson\Nygaard, Alameda County Transportation Commission, July 2014.
http://grh.alamedactc.org/wp-content/uploads/2014/07/GRH_Program_Eval_2013_FINAL-web.pdf

TYPE OF TRIPS TARGETED

Commuter trips

POTENTIAL APPLICATION LOCATIONS

Areas with alternative transit options

IMPLEMENTED BY

PRIVATE MPO/RPO TRANSIT AGENCY

Support

INCENTIVE PROGRAMS

REGION TYPE

URBAN SUBURBAN RURAL

DESCRIPTION

Incentive programs provide an additional monetary, convenience, or intangible incentive to individuals who adopt certain TDM measures or behaviors. Generally, incentive programs provide an extra "push" to increase adoption rates of implemented TDM measures. Alternatively, incentives can be provided for individuals who reduce their personal VMT, regardless of how they achieved that goal. Successful incentive programs usually incorporate elements of "gamification", competition, or social recognition.

Cash incentives could be in the form of micro-payments, scheduled lottery-style drawings, or instant "scratch-off" style winnings. Other monetary incentives could include gift cards, vouchers, or high value coupons, which are usually for local businesses. Monetary incentives are usually earned by either gaining "entries" to win or exchanging "points" that are accrued over time. An example would be gaining an entry for a $100 weekly lottery for every mile logged biking with an app, or alternatively gaining one "point" for every biking mile logged and exchanging 100 points for a $10 gift card to a local bike shop. Successful monetary incentive programs partner with private businesses and organizations to carry the financial cost of incentives.

Non-monetary incentives can come in a wide variety of forms, and are frequently related to the TDM measure being rewarded. An example could be reserving conveniently located parking spaces for vanpools.

PROS

- Can cultivate a culture around TDM measures.
- Targets "on the fence" TDM participants.

CONS

- Certain models could have budgeting issues if participation is greater than expected.
- May reward current behaviors more than inspiring new adoption.

POTENTIAL VMT REDUCTION IMPACT

According to a report by Federal Highway Administration (FHWA) in 2018, in the Commonwealth of Massachusetts, a third party incentive program called NuRide (now called Agile Mile) saved more than 175 million miles of driving from 2010-2018. In San Antonio, TX, where the service launched in 2008, nearly half a million walking trips have been taken rather than driven, 1.6 million transit trips have been made, and 4.5 million rides have been shared as of June 2018.

IMPLEMENTATION CONSIDERATIONS

Requires marketing and publicity to support the program. Money/prizes for rewards need to be sufficiently and sustainably funded.

NORTH CAROLINA EXAMPLES

- Go Triangle
  https://gotriangle.org/goperks
- Mode Makers

OTHER EXAMPLES

- Agile Mile (previously NuRide) – Various Locations
  https://agilemile.com/
- Bologna, Italy
  https://ops.fhwa.dot.gov/publications/fhwahop18071/fhwahop18071.pdf (pg 35)

SOURCES

"Expanding Traveler Choices Through the Use of Incentives: A Compendium of Examples", Jocelyn Bauer, Lisa Kinner Bedsole, Kayce Snyder, Michelle Neuner, Michael C. Smith, Federal Highway Administration U.S. Department of Transportation, December 2018.
https://ops.fhwa.dot.gov/publications/fhwahop18071/fhwahop18071.pdf

"Nudging the Commute: Using Behaviorally-Informed Interventions to promote Sustainable Transportation in Cities", Harvard Business School, Working Paper 21-002, 2020.
https://behavioralpolicy.org/articles/nudging-the-commute-using-behaviorally-informed-interventions-to-promote-sustainable-transportation/

TYPE OF TRIPS TARGETED

All, primarily commuter trips.

POTENTIAL APPLICATION LOCATIONS

Employment sites, universities, cities, and municipalities

IMPLEMENTED BY

STATE GOV'T COUNTY/ LOCAL GOV'T PRIVATE

Support

PARKING MANAGEMENT

REGION TYPE

URBAN

DESCRIPTION

Parking Management strategies are policies and programs that produce more efficient use of parking resources. Parking management strategies can reduce development costs, increase affordability, encourage multi-modal planning, encourage use of alternative modes, and reduce VMT. Common parking management strategies include:

- Shared Parking: a parking facility serves multiple users and destinations. This is most successful if different destinations have different peak periods. Some examples are shared parking rather than reserved spaces, shared parking among destinations, public parking facilities, and in lieu fees. Reducing available parking inherently promotes less vehicle use/increased use of alternative travel modes.
- Remote Parking: Remote or satellite parking is the use of off-site parking facilities. This can be shared parking or park and ride lots. Employers or destinations need to provide incentives to encourage motorists to use distant facilities.
- Unbundled Parking: Parking is rented or sold separately from residential or office space. This is a popular policy in transit oriented developments.

PROS

- Can encourage non-automobile modes, including transit, walking, and biking.
- Can decrease short trips from one parking destination to another in a localized area.
- Can reduce the costs related to building/ maintaining parking facilities.

CONS

- Reduced parking is often seen as a negative to business owners.
- This strategy works best in areas where alternative modes of transportation are easily available. Otherwise, if parking demand is greater than supply, drivers will circle the streets looking for a parking spot, increasing VMT.

IMPLEMENTATION CONSIDERATIONS

Effective parking management requires collaboration between private entities whose employees, customers, etc. will use the parking area.

NORTH CAROLINA EXAMPLES

- Concord, North Carolina Parking Study **https://apps.concordnc.gov/legacy/PlanningWeb/AreaPlans/DowntownMasterPlan/Parking_Study_2015.pdf**

OTHER EXAMPLES

- Fees in Lieu of Parking – Northampton, Massachusetts and Oak Bluffs, Massachusetts **http://www.mapc.org/wp-content/uploads/2017/10/TDM-FINAL-REPORT-7_15_0.pdf**
- Emory University Remote Parking **https://transportation.emory.edu/commuter-transit**

SOURCES

"Demand Management Case Studies and Regulations", Metropolitan Area Planning Council, 2015.
http://www.mapc.org/wp-content/uploads/2017/10/TDM-FINAL-REPORT-7_15_0.pdf

"Parking Management: Comprehensive Implementation Guide", Litman, Todd, Victoria Transport Policy Institute, 19 November 2023.
www.vtpi.org/park_man_comp.pdf

"Bundling of Residential Parking in High-Quality Transit Areas", Matutue, J., Pincetl, S., California Center for Sustainable Communities at UCLA.
https://next10.org/sites/default/files/3.%20Bundling%20of%20Residential%20Parking%20in%20High-Quality%20Transit%20Areas.pdf

TYPE OF TRIPS TARGETED

Commuter trips, short trips between parking facilities

POTENTIAL APPLICATION LOCATIONS

Urban city centers, town centers

IMPLEMENTED BY

STATE GOV'T | COUNTY/ LOCAL GOV'T | TRANSIT AGENCY

Support

PUBLIC EDUCATION AND PROMOTION

REGION TYPE

URBAN SUBURBAN

DESCRIPTION

Public education and promotion strategies focus on promoting and educating the public on TDM measures and non-vehicular modes of travel. Effective public education and promotion requires delivering different messages to different people, with an emphasis on people who are most likely to change their behavior. Public education and promotion campaigns should emphasize benefits to participants. Partnerships with other institutions, municipal agencies and private companies can be beneficial to these marketing programs. A report from the Victoria Transport Policy Institute found that consumer surveys indicated that around 25-50% of drivers would consider using travel alternatives and are interested in learning about them.

PROS

- Public education and promotion can support other strategies to reduce vehicle miles traveled, including non-motorized mode support, vanpool and carpool, transit, and biking and walking.

CONS

- Requires that the alternative or measure promoted is well implemented. Promoting a TDM measure or alternative that is not fully implemented, or poorly implemented, can backfire by causing people to dismiss the option in the future because they "already tried it" and were dissatisfied. This can expand into a general "bad reputation" for a TDM measure or alternative mode as those sentiments spread by word of mouth.

IMPLEMENTATION CONSIDERATIONS

Marketing programs depend primarily on support and funding from agencies or businesses. Investing in professional marketing teams or services is an essential component to starting and growing a TDM marketing program. Public education on travel alternatives to driving requires that those alternatives exist.

NORTH CAROLINA EXAMPLES

- BikeWalk NC
  https://www.bikewalknc.org/safety-education/education-resources-for-bicyclists/
- NC Vision Zero
  https://ncvisionzero.org/safety-focus-areas/pedestrians/
- Mode Makers
- Charlotte Area Transit System, "Riding with Collaboration: How Partnerships Can Help TDM Programs"
  https://www.youtube.com/watch?v=U4EkrQnoI3I

OTHER EXAMPLES

- Bike New York
  https://www.bike.nyc/digital-resources-bike-education/
- Lime Scooters
  https://www.li.me/why/safety

SOURCES

"TDM Marketing: Information and Encouragement Programs", Victoria Transport Policy Institute, TDM Encyclopedia, 6 September 2019.
https://www.vtpi.org/tdm/tdm23.htm

"Applying a European Marketing Strategy to TDM Programs in the U.S. Project Brief", Winters, P., Lester, A., National Institute for Transportation and Communities, October 2018.
https://ppms.trec.pdx.edu/media/project_files/1057_Project_Brief.pdf

"Promotional Strategies for TDM Agencies", Florida State University College for Business, 2016 Florida Commuter Transportation Summit.
https://www.commuterservices.com/wp-content/uploads/2016/04/Promotional-Strategies-for-TDM-Professionals-screen.pdf

TYPE OF TRIPS TARGETED

All trips

POTENTIAL APPLICATION LOCATIONS

Large urban regions, towns, commercial centers, universities

IMPLEMENTED BY

STATE GOV'T COUNTY/ LOCAL GOV'T TRANSIT AGENCY

Support

RIDE-MATCHING SERVICES

REGION TYPE

URBAN SUBURBAN RURAL

DESCRIPTION

Ride-matching services help potential carpoolers or vanpoolers find other travel partners for regularly scheduled, routine trips. It is a common part of commuter trip reduction programs. It often accompanies a rideshare program. Ride-matching services are more effective over larger areas and these are more effective if there is one regional ride-matching program. Small ride-matching programs may use ride notice boards or match potential partners by hand. Larger programs may use computerized matching systems that match travelers based on origin, destination, and schedule. Ride-matching is common for commuter trips but can be used for recurring recreational trips, trips to medical appointments, or trips to and from school.

PROS

- Increases travel options and options for vanpool or carpool.
- Ride-matching services have a low-cost to implement.

CONS

- Ride-matching enhances rideshare services which may encourage people to move further away from their jobs and increase commute length and may promote vehicle use and ownership.

IMPLEMENTATION CONSIDERATIONS

The matching method of such a program must have sufficiently advanced software or active staff to sustain matching services. The program must attract and retain a sufficient pool of participants to be viable. Ride-matching and rideshare services may be met with sentiments of "stranger danger" and individual incidents can result in a poor reputation for the service or even lawsuits if not properly protected.

NORTH CAROLINA EXAMPLES

- Share the Ride NC
  https://www.sharetheridenc.org/Public/Home.aspx

OTHER EXAMPLES

- Rideshare Online – Washington and Oregon
  http://www.rideshareonline.com/
- Rural Maine
  http://dune.une.edu/theses/65

SOURCES

CUTR National Center for Transit Research TDM Ridematching Software.
https://www.nctr.usf.edu/programs/ridematching-software/

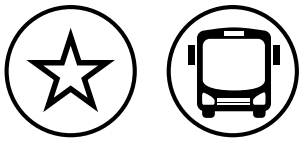
TYPE OF TRIPS TARGETED

Primarily commuter trips, also other recurring trips

POTENTIAL APPLICATION LOCATIONS

Suburban Areas, Towns, Low-Density Rural Areas

IMPLEMENTED BY



STATE GOV'T TRANSIT AGENCY

Support

TRANSIT FARE SUBSIDIES

REGION TYPE

URBAN SUBURBAN RURAL

DESCRIPTION

Transit fare subsidies are funds used to directly offset the individual cost for riders to take transit and can come in many forms. Discounts can be offered to low income households, individuals with disabilities, youth, or seniors to improve mobility. Providing discounts to these groups to make transit their most affordable option also helps transit systems maintain a viable level of ridership. Discounts can also be offered to high frequency riders to promote commuting via transit.

A discounted rate can be provided to employers or schools who provide transit passes to their employees or students. This is usually when an employer or school provides an unlimited transit pass to employees or students and then the employer or school pays the transit authority either a greatly reduced per trip fare or an agreed upon lump sum per participating employee or student. These kinds of discounts can incentivize individuals to change their commuting mode and provide a way for employers to attract and maintain employees or property managers to attract and keep tenants.

PROS

- Attracts new transit riders.
- Incentivizes frequent transit usage (commuting).
- Provides employers, property managers, developers, or schools an incentive to offer to employees, tenants, or students.

CONS

- Only possible in areas with existing transit systems.
- Increases transit ridership without proportionally increasing fare income.

POTENTIAL VMT REDUCTION IMPACT

The Neighborhood EcoPass (NECO), the neighborhood annual transit pass program in Boulder, CO, has been attributed with much of the city's success in reducing Single Occupant Vehicle (SOV) mode share by 7.5% for all trips from 1990 to 2018. Additionally, the city has also seen a 32.3% reduction in work trips by Single Occupant Vehicle (SOV) in the same time period.

IMPLEMENTATION CONSIDERATIONS

Potential significant costs in subsidy funding is required on a consistent basis. Requires financial management and oversight.

NORTH CAROLINA EXAMPLES

- Go Triangle
  https://gotriangle.org/fares-passes/discount-qualifications
- Charlotte
  https://www.charlottenc.gov/CATS/Get-to-Know-CATS/Alternative-Commuting/ETC/Commuter-Tax-Benefit

OTHER EXAMPLES

- New York City, NY
  https://www1.nyc.gov/site/dca/workers/workersrights/commuter-benefits-law-for-workers.page#:~:text=Under%20NYC's%20Commuter%20Benefits%20Law,to%20pay%20for%20transit%20expenses.
- Boston, MA
  https://www.mbta.com/fares/reduced
- Boulder, CO
  https://bouldercolorado.gov/services/ecopass-program
- University of Washington
  https://transportation.uw.edu/getting-here/transit/u-pass

SOURCES

"Modal Shift in the Boulder Valley: 1990-2015", National Research Center, City of Boulder Transportation Division, May 2016
https://www-static.bouldercolorado.gov/docs/Modal_Shift_1990-2015_Report_2016-05-27-1-201708041213.pdf

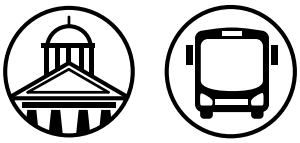
TYPE OF TRIPS TARGETED

All

POTENTIAL APPLICATION LOCATIONS

Charlotte, Raleigh, other locations with significant transit presence

IMPLEMENTED BY



COUNTY/ LOCAL GOV'T TRANSIT AGENCY

Support

VANPOOL FARE SUBSIDIES

REGION TYPE

URBAN SUBURBAN RURAL

DESCRIPTION

Vanpool fare subsidies are funds that are used to directly offset the individual cost for commuters to participate in a vanpool program. Subsidies can be paid out directly to commuters in the form of a refund or can be paid out to the vanpool organizing agency/company and passed onto the commuter in the form of a discount. Subsidies can also be offered to existing vanpools that are experiencing fluctuation in ridership by monetarily "filling" empty seats while waiting for new members to prevent the vanpool from dissolving. Determining if a vanpool is qualified for a subsidy is usually based on the county of their origin and/or destination.

Subsidizing vanpool fares can help attract the needed riders to achieve these goals. Providing vanpool subsidies can also make vanpooling an affordable option for low-income commuters, with base rates for vanpools being around $150 per month per rider, though rates vary widely based on distance and number of occupants.

PROS

- Attracts new vanpool riders into the program, including low-income commuters.
- Prevents existing vanpools from dissolving.

CONS

- Requires a long-term financial commitment.
- Requires administrative effort to determine eligibility and manage payouts.
- Vanpool participants may leave the program suddenly and dissolve many existing vanpools if the subsidies are defunded.

POTENTIAL VMT REDUCTION IMPACT

In California, a plan to reduce new vanpool fares by $350/month for five years saw an increase of 17 new vanpools in the first two months in an area where almost 500 already operate. The program required $9.5 million in funding.

IMPLEMENTATION CONSIDERATIONS

Potential significant costs in subsidy funding is required on a consistent basis. Requires financial management and oversight.

NORTH CAROLINA EXAMPLES

- Go Triangle
  https://gotriangle.org/vanpool-faq

OTHER EXAMPLES

- California
  https://mtc.ca.gov/whats-happening/news/new-subsidy-program-fuels-bay-area-vanpooling

SOURCES

"New Subsidy Program Fuels Bay Area Vanpooling", Metropolitan Transportation Commission, 24 January, 2019
https://mtc.ca.gov/whats-happening/news/new-subsidy-program-fuels-bay-area-vanpooling

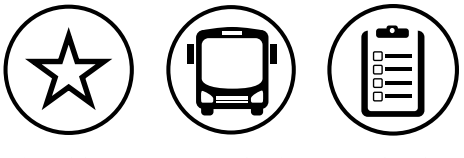
TYPE OF TRIPS TARGETED

Commuter

POTENTIAL APPLICATION LOCATIONS

Any existing or starting vanpool program

IMPLEMENTED BY



STATE GOV'T TRANSIT AGENCY MPO/RPO

PRIVATE

3.0 TESTING PHASE

3.1 MODELING PACKAGE DEVELOPMENT

The Summary Pages were used to develop a ranking matrix of the primary TDM measures, shown in Table 8, that was provided to the Technical Advisory committee members. The primary measures included measures that would result in a VMT reduction if implemented individually. Secondary measures support or encourage the use of primary measures. For example, a Guaranteed-Ride-Home Program will not reduce VMT by itself; it is a program that improves the attractiveness of other TDM measures like transit services or vanpools. People may be more likely to switch their trips to transit or vanpools knowing that they have a way home if they have to stay at work late. Secondary measures were not ranked.

Information in the ranking matrix included:

- Whether the measure is applicable in urban, suburban or rural areas,
- Who implements the measure,
- The type of trips targeted,
- The area targeted (city, state, metro area, corridor, site specific),
- A comparative assessment of the infrastructure costs, and
- A range of time that results could be realized within after implementation.

A general range of potential VMT reduction gleaned from the literature review was also provided to the Technical Advisory committee members. Using this information, the Technical Advisory Committee members were asked to rank the measures in order of VMT reduction potential.

This exercise instigated discussion regarding common targeted trip type, implementation timelines, timing of the results and cost issues between and among the measures. For example, the group realized that for transit oriented development and parking pricing measures to be successful, transit has to be reliable and as such, a transit-based package was developed. Similarly one push back to TDM is that measures are “too expensive”, so a Low-Cost Package was developed to understand the impact of these measures.

Four packages were developed: a Forward-Thinking Package, a Transit-Based Package, an Environmental Package, and a Low-Cost Package. The TDM measures included in each package are shown in Table 9. These packages were evaluated using existing regional travel demand models in the state to estimate the potential VMT reduction.

INFORMATIONAL RANKING MATRIX

APPLICABILITY
1 - Not Applicable
3 - Very Applicable

VMT REDUCTION RANKING
1 - Greatest Potential
26 - Least Potential

	Primary Measures																									
	Access priority	Affordable housing	Alternative mode sharing	Car sharing	Complete streets	Compressed work week	Connectivity	Custom transit	Development impact mitigation	Employee Parking cash-out	Gas tax increase	HOV facilities	Information services-Broadband Expansion	Internet-based strategies	Mixed land use	Non-motorized mode support	Park and ride lots	Parking pricing	Public transit	Road pricing	Telecommuting-telework	Transit-oriented development	Transportation management association	Trip reduction ordinance	Vanpools	VMT tax
Applicability																										
Urban	3	3	3	3	3	3	2	2	3	3	3	3	1	3	3	3	1	3	3	3	3	3	3	3	3	3
Suburban	2	2	2	2	2	3	3	3	3	2	3	3	1	3	2	3	3	2	3	2	3	3	3	3	3	3
Rural	1	1	1	1	1	3	2	3	1	1	3	2	3	3	1	1	2	1	1	1	3	1	1	1	2	3
Who Implements																										
State Government	●		●		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●			●	●
County Government	●	●					●	●				●	●		●		●				●			●		
City/Town Government	●	●	●		●		●	●	●				●		●	●		●	●	●	●	●	●	●	●	
MPO/RPO			●		●		●	●	●						●	●			●				●		●	
Private		●	●	●		●				●		●	●	●	●			●			●	●	●		●	
Transit Agency	●							●									●		●			●			●	
Trip Purposes Targeted																										
Commuter	●	●	●	●	●	●	●	●	●	●	●	●	●		●	●	●	●	●	●	●	●	●	●	●	●
Recreational	●		●	●	●		●	●	●		●	●	●		●	●		●	●	●		●	●			●
Work-Related (Non-Commute)	●			●	●		●	●	●		●		●	●	●	●		●	●	●		●	●	●		●
Errands	●		●	●	●		●	●	●		●		●	●	●	●		●	●	●		●	●	●		●
Shopping	●		●	●	●		●	●	●		●		●	●	●	●		●	●	●		●	●	●		●
Visitor (Tourist)	●		●	●	●		●	●			●	●				●		●	●	●						
Area Targeted																										
State						●					●			●							●					●
Region/County						●		●					●						●				●	●		
Metro Area/City	●	●	●	●		●		●									●	●	●	●			●	●	●	
Corridor/Neighborhood	●	●	●	●	●	●	●	●				●			●	●		●		●		●	●	●		
Site Specific (Large employers, universities)			●	●				●	●	●		●				●									●	
Infrastructure Costs	$$$	$$$	$	$	$$$	o	$$$	$$$	o	o	o	$$$	$$$$	o	$	$$	$$	$$	$$$$	$$$	o	$$$	$	$	$	$$
When do we see results? (in years)	5-10	>10	<5	<5	>10	<5	>10	<5	>10	<5	<5	5-10	5-10	5-10	>10	<5	5-10	<5	5-10	5-10	<5	>10	<5	<5	<5	<5
Technical Advisory Committee Ranking (1=most effective)	13	23	14	21	22	7	11	24	26	6	8	17	3	19	16	12	20	10	1	18	2	5	25	15	9	4

Table 8: Ranking Matrix of Primary TDM Measures

	Packages to Model			
TDM Measure	**Forward-Thinking**	**Transit-Based**	**Environmental**	**Low-Cost**
Public transit		●	●	
Telecommuting-telework	●		●	●
Information services-Broadband Expansion	●			
VMT tax	●			
Transit-oriented development		●		
Employee Parking cash-out		●		●
Compressed work week				●
Gas tax increase			●	
Vanpools			●	●
Parking pricing		●		●
Non-motorized mode support			●	

Table 9: TDM Measures included in each Modeling Package

3.2 MODELING PROCESS

Two metropolitan areas to test the TDM packages were chosen: the French Broad River Metropolitan Planning Organization (FBRMPO) area which covers the Asheville area and the Capital Area Metropolitan Planning Organization (CAMPO) area which covers the Raleigh/Durham/ Chapel Hill area. These two areas were strategically chosen for the development areas they cover. The FBRMPO Travel Demand Model (hereafter referred to as the Asheville model) covers primarily a rural area with a smaller urban center, while the CAMPO Triangle Regional Model (hereafter referred to as the Triangle model) covers primarily urban land uses with some rural coverage. In the Asheville model, over half of the VMT is driven on rural roadways and only 14 percent of the VMT is driven on urban roadways. The Triangle model has the opposite distribution with over half of the VMT occurring in urban areas and only 14 percent occurring in rural areas. In both models, about 30 percent of the total VMT occurs in the suburbs. The distribution of street links in the networks by area type are similar to the distribution of VMT; most of the Asheville model's links are rural while most of the Triangle model's links are urban. In both models, the aggregate rural street distance takes up a bigger proportion of total street distance than rural VMT's proportion of all VMT; almost 70 percent of the Asheville model's road mileage is rural (12 percent higher than the rural VMT proportion), while over 36 percent of the Triangle model's road mileage is rural (22 percent higher than the rural VMT proportion). This is logical as rural areas are more spread out and require longer roadway segments to travel.

Table 10 compares the number of links, street distance covered, and Base Case VMT by area type in each model. Note that the "Base Case" refers to the model results without any TDM measure packages.

The four packages include the following primary TDM measures:

- Increased teleworking telecommuting
- Broadband expansion in rural areas
- A VMT tax
- Transit oriented development (TOD)
- More frequent public transit service
- Employee parking cash-out program
- Compressed work week
- Increased Gas tax
- Vanpool service
- Increased parking pricing in urban areas
- Increased non-motorized mode support

Because the models were different, with different equations and processes, the adjustments to simulate the effect of each of the TDM measures were model-specific but followed similar background assumptions. The models were run for one future year with each package. The future year for the Asheville model was 2040 and the future year for the Triangle model was 2045. The results were then compared to the Base Case condition (without the TDM measures) to understand the potential VMT reduction that could be achieved with each package. The adjustments made to each model are discussed in the next section.

	Amounts		Percent of Total	
	Asheville	Triangle	Asheville	Triangle
Base Case VMT				
Urban	2,653,000	45,963,000	14%	54%
Suburban	5,610,000	26,446,000	29%	31%
Rural	10,858,000	11,956,000	57%	14%
Total	19,121,000	84,365,000		
Number of Links				
Urban	1,337	9,751	26%	59%
Suburban	1,165	4,063	23%	25%
Rural	2,547	2,575	50%	16%
Total	5,049	16,389		
Distance (mi.)				
Urban	234	2,078	11%	34%
Suburban	404	1,887	19%	31%
Rural	1,448	2,217	69%	36%
Total	2,086	6,182		

Table 10: VMT, Model Links and Link Distances by Area Type and Model

3.2.1 Asheville Modeling Adjustments

The following adjustments were made to the Asheville model to test the TDM packages:

3.2.1.1 Increased Teleworking-Telecommuting

Stantec decreased the Home-Based Work (HBW) and Non-Home-Based Work (NHBW) trips by 4 percent for origin-destination (O-D) pairs without a rural destination or origin. Stantec also increased Home-Based Other (HBO) trips by 0.4 percent for the same O-D pairs.

In 2018, about 11.3 percent of workers residing in Asheville worked from home[6]. Since about 37 percent of American jobs can be done at home[7], about 31 percent of workers who have the potential to work from home already do so. If the portion of potential telecommuters that do so increases to 40 percent (in other words, if the average potential telecommuter works from home two days per week), the decrease in people commuting is about 4 percent. An analysis of telecommuting behaviors[8] indicates that the number of HBO trips increases as the number of HBW trips decreases with an elasticity between -0.007 and -0.16. Stantec assumed an elasticity of -0.1. As such, a 4 percent decrease in HBW trips causes a 0.4 percent increase in HBO trips. NHBW trips are assumed to vary by the same percentage as HBW trips. O-D pairs with rural origins or destinations were not impacted by this measure as it was assumed that rural residents do not have the broadband capacity to work from home (covered in the next measure).

3.2.1.2 Broadband Expansion in Rural Areas

Stantec decreased the HBW and NHBW trips by 5 percent for O-D pairs with a rural origin or destination. Stantec also increased HBO trips by 0.5 percent for the same O-D pairs.

About 56.5 percent of Madison County (north of Asheville) has access to internet download speeds of 100 mbps[9]. Stantec assumed that everyone else in the county cannot telecommute due to its lack of accessibility to faster internet speeds and that this percentage is typical for rural traffic analysis zones (TAZs). If broadband were expanded to all rural residents and they began telecommuting at the same rate as Asheville residents (11.3 percent), the number of commuters would be reduced by about 5 percent ((1 – 56.5%) * 11.3%). The relationship between HBW, NHBW, and HBO described in the "Increased Teleworking-Telecommuting" section was used to estimate the change in NHBW and HBO trips.

3.2.1.3 VMT Tax

Stantec increased the vehicular operational cost in the model by 2.4 cents per mile.

The North Carolina First Commission is conducting a Mileage Based User Fee (MBUF) Pilot Study in North Carolina[10]. The purpose of the pilot is to analyze if MBUFs/VMT Taxes can eventually replace gas taxes as a revenue source for transportation infrastructure costs. Since the purpose of this study is to reduce VMT, the modeled VMT Tax in this study was set higher than the pilot's MBUF; The 2.4 cents per mile is 50 percent higher than the price set in the MBUF Pilot Study.

6. 2018 American Community Survey (https://data.census.gov/cedsci/table?g=0400000US37_1600000US3702140&d=ACS%205-Year%20Estimates%20Data%20Profiles&tid=ACSDP5Y2018.DP03)
7. National Bureau of Economic Research (https://www.nber.org/papers/w26948)
8. Analysis of telecommuting behavior and impacts on travel demand on the environment, Shabanpour et. al (https://www.researchgate.net/publication/324486219_Analysis_of_telecommuting_behavior_and_impacts_on_travel_demand_and_the_environment)
9. https://broadbandnow.com/North-Carolina
10. https://tetcoalitionmbuf.org/faqs/

3.2.1.4
Transit Oriented Development (TOD)

The impact of TOD was applied to one corridor to estimate the VMT effect. **Stantec increased the household density to six units per acre for the TAZs close to Mission Hospital (in the vicinity of Biltmore Avenue, McDowell Street, Hospital Drive, and Doctors Drive). Stantec removed an equal number of households from TAZs outside of this area (excluding Downtown Asheville).** Transit Oriented Development generally requires six residential units per acre[11]. Stantec chose this area for the TOD because multiple bus routes already serve the area.

3.2.1.5
More Frequent Public Transit

Stantec doubled the transit frequency of the Asheville Rides Transit (ART) system.

Most bus routes currently have hourly headways or longer, while three routes operate at 30 minute headways. By doubling the frequency of the entire transit system, three routes would operate at headways of 15 minutes, which is the maximum desirable wait time if a bus is missed[12].

3.2.1.6
Employee Parking Cash Out Program

Stantec applied a $3.50 daily parking cost to HBW trips bound for urban TAZs.

A study from 2006[13] analyzed four parking cash out programs in areas with little to no public transportation with an average monthly incentive of $47 (in 1995 dollars). Accounting for inflation, the number of workdays in a typical month, and factoring out the approximately 5 percent of employees who already pay for parking (and are thereby ineligible), Stantec estimated a daily incentive of about $3.50 for an employee cash-out program. This was applied as a cost to those who continue to drive to work.

3.2.1.7
Compressed Work Week

Stantec decreased the number of HBW trips by 3 percent.

About 57 percent of workers have flexible work schedules[14]. If half of these workers worked compressed work weeks such that they work nine 9-hour days and take the tenth day off, the number of commuters on a given weekday would be reduced by about 3 percent.

3.2.1.8
Gas Tax Increase

Stantec increased the vehicular operational cost by $0.01 per mile. This assumes a gas tax increase of $0.20 per gallon and a fleet fuel economy of 20 miles per gallon.

Given current gas prices in North Carolina, a $0.20 per gallon price increase is equivalent to about a 10 percent increase in the price of gasoline. Under this scenario, gasoline in North Carolina would be more expensive than anywhere else in the southeast, but still cheaper than gas in the northeast.

11. https://www.vtpi.org/tdm/tdm45.htm
12. Transit Capacity Manual, Part 5 (http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_webdoc_6-e.pdf)
13. https://www.vtpi.org/tdm/tdm8.htm
14. https://www.bls.gov/news.release/flex2.nr0.htm

3.2.1.9
Vanpool Service

Stantec removed a total of 67 HBW trips from O-D pairs with a trip length over 25 miles in the AM period. An equal removal was also made for the reverse commute in the PM period.

If an Asheville vanpool program has twice the vans per capita as the Charlotte metropolitan area, there would be 17 vans[15]. Assuming the minimum number of commuters is 5 (like Charlotte), there are at least 84 vanpool participants. Since the vanpools require one driver per van, 67 HBW trips were removed from the commute.

3.2.1.10
Increased Parking Pricing

Stantec increased the hourly parking price to $2.50 for NHB and HBO trips in urban areas.

The current parking pricing in Asheville is that the first hour is free, the second hour costs $2.50, and additional hours cost $1.25. Increasing the hourly parking price to $2.50 would effectively double the cost.

3.2.1.11
Increased Non-Motorized Mode Support

Stantec improved the non motorized utility value by 0.15.

Essentially, this change makes the non-motorized modes more appealing and will attract a greater share of trips. Stantec's assumption is that a significant program will need to be implemented to improve the sidewalk network, including pedestrian-actuated signals and proper sidewalk configurations along with dedicated bike lanes that would have an impact primarily in urban and suburban areas. While the percentage change is significant (on the order of 15 percent), this assumption is reasonable given that trips via these modes are effectively a small amount of the overall trips.

3.2.2 The Triangle Modeling Adjustments

The intent was to make similar changes to the Triangle model as were made to the Asheville model, but because the two models had different equations and algorithms within, the methods to test the TDM measures had to be adjusted. In addition, an obstacle was identified when testing the alternatives that increased the price of driving a personal vehicle in the Triangle model. In the peak period, when auto costs were increased, VMT increased for auto trips. This is counterintuitive, as one would expect trip making behavior to decrease with an increase in price. This behavior was only observed in the peak periods, not the off-peak periods. Discussions with the CAMPO modelers established that a fix within the model would likely take more time than the project schedule allowed.

As such the peak period results for the packages that included price increases for auto usage needed to be post-processed. For those packages, the relationship or ratio of off-peak to peak changes in the Asheville model was determined and then applied to the off-peak results from the Triangle model. This process likely underestimates the results that could be realized in the Triangle region as many of the pricing strategies would impact primarily urban areas and the Triangle region has more urban regions than the Asheville region. For future work in this analysis, utilizing the Charlotte area model to test the packages in a more urban area may be more desirable due to the obstacles encountered with the Triangle model. It should also be noted that the CAMPO region is currently working on a complete overhaul of their travel demand model.

15. https://charlottenc.gov/cats/commuting/vanpool/Pages/current-vanpools.aspx

The following changes were made to the Triangle model to test the TDM measures. The pricing measures that had to be post-processed to determine the peak period VMT impacts are noted with an asterisk (*).

3.2.2.1 Increased Teleworking-Telecommuting

Stantec decreased the Home-Based Work (HBW) and Non-Home-Based Work (NHBW) trips by 7 percent for origin-destination (O-D) pairs without a rural destination or origin. Stantec also increased Home-Based Other (HBO) trips by 0.7 percent for the same O-D pairs.

In 2018, about 8.9 percent of workers residing in Raleigh worked from home[16]. Since about 37 percent of American jobs can be done at home[17], about 23 percent of workers who have the potential to work from home already do so. If the portion of potential telecommuters that do so increases to 40 percent (in other words, if the average potential telecommuter works from home two days per week), the decrease in people commuting is about 7 percent. An analysis of telecommuting behaviors[18] indicates that the number of HBO trips increases as the number of HBW trips decreases with an elasticity between -0.007 and -0.16. For this work, Stantec assumed an elasticity of -0.1. As such, a 7 percent decrease in HBW trips causes a 0.7 percent increase in HBO trips. NHBW trips are assumed to vary by the same percentage as HBW trips. O-D pairs with rural origins or destinations are not impacted by this measure as it was assumed that rural residents do not have the broadband capacity to work from home (this is covered in the next measure).

3.2.2.2 Broadband Expansion in Rural Areas

Stantec decreased the HBW and NHBW trips by 1.8 percent for O-D pairs with a rural origin or destination. Stantec also increased HBO trips by 0.18 percent for the same O-D pairs.

Chatham County, west of Raleigh, has the lowest percent coverage of broadband in the CAMPO region, 79.5 percent[19]. Stantec assumed that the remaining 20.5 percent of the county cannot telecommute due to its lack of accessibility to faster internet speeds and that this percentage is typical for rural traffic analysis zones (TAZs) in this metropolitan area.

Stantec also assumed that the rural areas in the region have similar broadband accessibility to Chatham County. If broadband were expanded to all rural residents and they began telecommuting at the same rate as Raleigh residents (8.9 percent), the number of commuters would reduce by about 1.8 percent ((1 – 79.5%) * 8.9%). The relationship between HBW, NHBW, and HBO described in the "Increased Teleworking-Telecommuting" section was used to estimate the change in NHBW and HBO trips.

3.2.2.3 VMT Tax*

Stantec increased the vehicular operational cost in the model by 2.4 cents per mile.

The North Carolina First Commission is conducting a Mileage Based User Fee (MBUF) Pilot Study in North Carolina[20]. The purpose of the pilot is to analyze if MBUFs/VMT Taxes can eventually replace gas taxes as a revenue source for transportation infrastructure costs. Since the purpose of this study is to reduce VMT, the modeled VMT Tax in this study was set higher than the pilot's MBUF; The 2.4 cents per mile is 50 percent higher than the price set in the MBUF Pilot Study.

16. 2018 American Community Survey (https://data.census.gov/cedsci/table?g=0400000US37_1600000US3702140&d=ACS%205-Year%20Estimates%20Data%20Profiles&tid=ACSDP5Y2018.DP03)
17. National Bureau of Economic Research (https://www.nber.org/papers/w26948)
18. Analysis of telecommuting behavior and impacts on travel demand on the environment, Shabanpour et. al (https://www.researchgate.net/publication/324486219_Analysis_of_telecommuting_behavior_and_impacts_on_travel_demand_and_the_environment)
19. https://broadbandnow.com/North-Carolina
20. https://tetcoalitionmbuf.org/faqs/

3.2.2.4
Transit Oriented Development (TOD)

Stantec used the planning work recently completed by CAMPO to test how transit-oriented development would impact VMT. The assumptions modeled in the Equitable Transit-Oriented Development scenario of the December 2019 Commuter Corridors Study[21] completed for CAMPO were used to measure the effect of TODs.

The purpose of the Commuter Corridors Study "was to understand the underlying causes of traffic congestion along major commuter corridors in the region, explore the emerging growth and mobility trends, and test hypothetical future scenarios in terms of their impacts on mobility, safety, accessibility, and the environment". One of the scenarios tested for the study was the Equitable Transit-Oriented Development (ETOD) scenario. This scenario assumed 50 percent additional growth in multi-family, office and retail use within a half-mile of each planned transit station in the region, lower growth in non-station areas to stay within the base future forecasts and a 100 percent increase in transit frequency for future transit routes in the region.

3.2.2.5
More Frequent Public Transit

Stantec leveraged the planning work recently completed by CAMPO to test more frequent public transit in the area. The transit networks and frequency modeled in the Equitable Transit-Oriented Development scenario of the December 2019 Commuter Corridors Study were used.

The purpose of the Commuter Corridors Study "was to understand the underlying causes of traffic congestion along major commuter corridors in the region, explore the emerging growth and mobility trends, and test hypothetical future scenarios in terms of their impacts on mobility, safety, accessibility, and the environment". One of the scenarios tested for the study was the Equitable Transit-Oriented Development (ETOD) scenario. This scenario assumed a 100 percent increase in transit frequency for future transit routes in the region.

3.2.2.6
Employee Parking Cash Out Program*

Stantec applied a $3.50 daily parking cost to HBW trips bound for urban TAZs.

A study from 2006[22] analyzed four parking cash out programs in areas with little to no public transportation with an average monthly incentive of $47 (in 1995 dollars). Accounting for inflation, the number of workdays in a typical month, and factoring out the approximately 5 percent of employees who already pay for parking (and are thereby ineligible), Stantec estimated a daily incentive of about $3.50 for an employee cash-out program. This was applied as a cost to those who continue to drive to work.

3.2.2.7
Compressed Work Week

Stantec decreased the number of HBW trips by 3 percent.

About 57 percent of workers have flexible work schedules[23]. If half of these workers worked compressed work weeks such that they work nine 9-hour days and take the tenth day off, the number of commuters on a given weekday would be reduced by about 3 percent.

21. https://www.campo-nc.us/programs-studies/corridor-studies/commuter-corridors-study
22. https://www.vtpi.org/tdm/tdm8.htm
23. https://www.bls.gov/news.release/flex2.nr0.htm

3.2.2.8 Gas Tax Increase*

Stantec increased the vehicular operational cost by $0.01 per mile.

This assumed a gas tax increase of $0.20 per gallon and a fleet fuel economy of 20 miles per gallon. Given current gas prices in North Carolina, this is equivalent to about a 10 percent increase in the price of gasoline. Under this scenario, gasoline in North Carolina would be more expensive than anywhere else in the southeast, but still cheaper than gas in the northeast.

3.2.2.9 Vanpool Service

Stantec removed a total of 124 HBW trips from O-D pairs with a trip length over 25 miles in the AM period. An equal removal was also made for the reverse commute in the PM period.

Currently (as of January 2020), there are 41 vanpools with 290 riders (approximately 7 riders per vanpool) in Raleigh. If the Triangle vanpool program increases by 50 percent, there would be approximately 62 vans, an additional 21 vanpools. Assuming the average number of commuters continues to be nearly 7 per van, there would be an additional 145 vanpool participants. Since the vanpools require one driver per van, 21 of the 145 new vanpool participants are not removed from the HBW trips.

3.2.2.10 Increased Parking Pricing*

Stantec increased the hourly parking price to $3.00 for NHB and HBO trips in urban areas.

The current parking pricing in the urban CBDs in the model (Raleigh/Chapel Hill/Durham) is between $1.50 and $2.00.

3.2.2.11 Non-Motorized Mode Support

Stantec increased the non motorized path density in the Triangle Model by 10 percent.

As such, the model networks would have 10 percent more sidewalks and bicycle lanes, which would encourage more travelers to utilize non motorized modes instead of cars.

3.3 MODEL RESULTS

The models estimated the change in daily VMT and, as such, the statistics herein refer to changes in daily VMT unless otherwise noted. Total VMT reductions in the Asheville model ranged from 0.5 percent to 0.9 percent while in the Triangle model, total VMT reductions ranged from 2.0 percent to 3.4 percent. There are multiple potential reasons for why the Triangle model had greater VMT reductions than the Asheville model, including:

- The models are inherently different in their structure. In some instances, this required different model adjustments to model the packages.
- The Triangle region is more urban than the Asheville region.
- The public transit adjustments for the Triangle model were based on a previous modeling scenario completed for a CAMPO study and were larger in scope than the adjustments made for the Asheville model.

It should also be noted that should these packages be run on other travel demand models, the results would differ from these results as every model has different assumptions within and every area model has different characteristics in terms of networks, existing transit and land use.

Overall, the VMT reduction ranges from these two models provide an estimate for potential reductions should any of these packages be enacted in a specific region or statewide. At first glance, a 0.5 percent to 3.4 percent reduction in VMT seems small, however it is a regional reduction and local reductions could be higher. It is also worth noting that the 2019 annual VMT for North Carolina was about 123 billion. A 1 percent reduction in VMT would be about 1.2 billion VMT, which is equivalent to about 100,000 average North Carolinians being taken off the road[24]. Also, since many TDM measures target commuter trips, peak hour VMT reductions were higher and it is likely these reductions were realized on primary commuting routes.

24. According to the Eno Center for Transportation, North Carolinians travel about 11,600 miles per capita in 2017.

3.3.1 Asheville Area Results

The changes in daily VMT by area type in the Asheville model for the four TDM packages, as compared to the 2040 Base Case, are summarized in Table 11 and shown in Figure 14.

PACKAGE COMPONENTS	Packages to Model			
	Forward- Thinking	Transit-Based	Environmental	Low- Cost
Public transit		●	●	
Telecommuting-telework	●		●	●
Information services-Broadband Expansion	●			
VMT tax	●			
Transit-oriented development		●		
Employee Parking cash-out		●		●
Compressed work week				●
Gas tax increase			●	
Vanpools			●	●
Parking pricing		●		●
Non-motorized mode support			●	
Area Type	**Percent Reduction in VMT**			
Urban	-1.1%	-0.7%	-1.6%	-1.5%
Suburban	-1.0%	-0.5%	-1.1%	-0.9%
Rural	-0.8%	-0.3%	-0.6%	-0.5%
Total	-0.9%	-0.5%	-0.9%	-0.8%

Table 11: Asheville Area 2040 VMT Changes as Compared to the Base Case

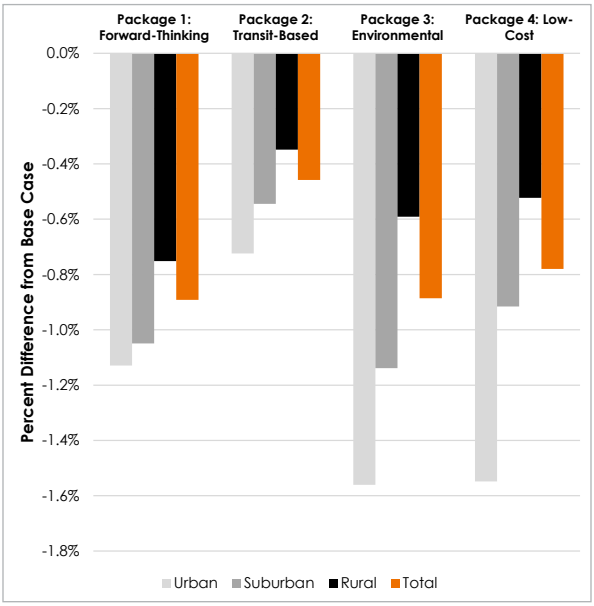


Figure 14: VMT Reduction Results from the Asheville Model

For the Forward-Thinking Package in the Asheville model, total VMT decreased by 0.9 percent from the Base Case, with urban, suburban, and rural VMT decreasing by 1.1 percent, 1.0 percent, and 0.8 percent, respectively. Urban VMT may have decreased the most on a percentage basis because urban areas are more likely to attract employees (and their commuting trips) than other area types. Therefore, increased telecommuting likely has the greatest impact on urban VMT. This package had the greatest impact on decreasing rural VMT in the Asheville model, likely due to the impact of both the broadband expansion - which was just applied to rural areas - and the VMT tax. Since rural trips are generally longer that non-rural trips, the impact of the VMT tax, which takes distance into account, would likely impact rural trips more than urban trips.

For the Transit-Based Package, total VMT decreased by 0.5 percent from the Base Case, with urban, suburban, and rural VMT decreasing by 0.7 percent, 0.5 percent, and 0.3 percent, respectively. Overall, this package had the smallest effect in the Asheville area. Transit is more concentrated in urban areas and the Ashville area is not very urban. Urban VMT showed the greatest decreases because increasing transit frequencies will have the greatest impact on where transit is already located, which is mostly urban areas. Also, the parking costs in this package were only applied to urban areas, so these measures would only affect urban-suburban and urban-rural trip pairs. For these reasons, the Transit-Based Package had the smallest effect on both suburban and rural VMT in the Asheville area.

For the Environmental Package, total VMT decreased by 0.9 percent from the Base Case, with urban, suburban, and rural VMT decreasing by 1.6 percent, 1.1 percent, and 0.6 percent, respectively. Total VMT decreases in this package were similar to the Forward-Thinking Package. In particular, this package saw the greatest VMT decreases in urban areas. Many of the components of this package including transit improvements, telecommuting and non-motorized support would impact urban areas more. The increased non-motorized mode utility impacted shorter trips for which non-motorized modes are possible. Since these shorter trips are more likely to be in urban areas, it logically follows that the largest VMT reductions would be in urban areas.

For the Low-Cost Package, total VMT decreased by 0.8 percent from the Base Case, with urban, suburban, and rural VMT decreasing by 1.5 percent, 0.9 percent, and 0.5 percent, respectively. The parking costs and increased telecommuting, as previously mentioned, are most likely to impact urban areas and therefore create the largest percent VMT reduction in urban areas. Overall, this package ranked in the middle of the pack in terms of decreases in total VMT but not very far from the higher- priced Forward-Thinking and Environmental Packages, which is of note.

3.3.2 Triangle Area Results

The changes in daily VMT in the Triangle model for the four TDM packages by area type as compared to the 2040 Base Case are summarized in Table 12 and shown in Figure 15.

PACKAGE COMPONENTS	Packages to Model			
	Forward- Thinking	Transit-Based	Environ-mental	Low- Cost
Public transit		●	●	
Telecommuting-telework	●		●	●
Information services-Broadband Expansion	●			
VMT tax	●			
Transit-oriented development		●		
Employee Parking cash-out		●		●
Compressed work week				●
Gas tax increase			●	
Vanpools			●	●
Parking pricing		●		●
Non-motorized mode support			●	
Area Type	**Percent Reduction in VMT**			
Urban	-2.3%	-2.9%	-5.1%	-2.8%
Suburban	-1.9%	-0.4%	-0.9%	-2.4%
Rural	-1.6%	-1.7%	-2.2%	-2.1%
Total	-2.0%	-2.0%	-3.4%	-2.6%

Table 12: Triangle Area 2040 VMT Changes as Compared to the Base Case

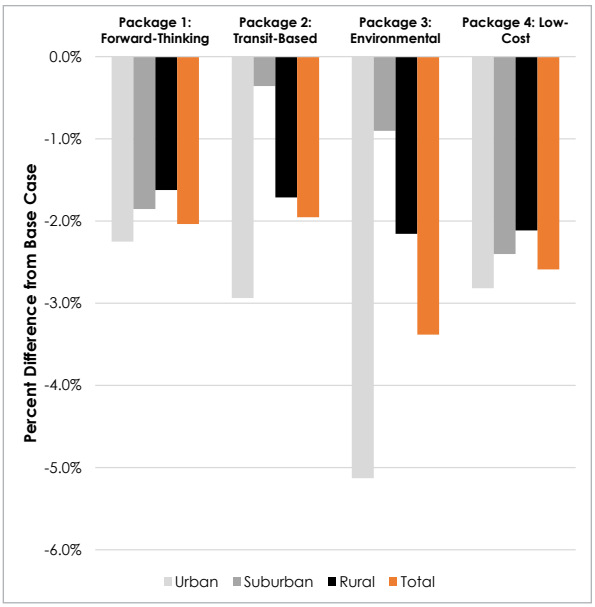


Figure 15: VMT Reduction Results from the Triangle Model

For the Forward-Thinking Package in the Triangle model, total VMT decreased by 2.0 percent from the Base Case, with urban, suburban, and rural VMT decreasing by 2.3 percent, 1.9 percent, and 1.6 percent, respectively. Urban VMT decreased the most on a percentage basis because urban areas are more likely to attract employees (and their commuting trips) than other area types. Therefore, increased telecommuting may have its greatest impact on urban VMT.

For the Transit-Based Package in the Triangle model, total VMT decreased by 2.0 percent from the Base Case, with urban, suburban, and rural VMT decreasing by 2.9 percent, 0.4 percent, and 1.7 percent, respectively. The VMT reduction is greater in rural areas than in suburban areas. This may be due to a slightly different network and the TAZ area type re-assignment that was inherited in the ETOD model files in this package.

For the Environmental Package in the Triangle model, total VMT decreased by 3.4 percent from the Base Case, with urban, suburban, and rural VMT decreasing by 5.1 percent, 0.9 percent, and 2.2 percent, respectively. This package saw the greatest reductions in urban VMT when compared to the other packages. The "outlier" TDM measure in this package is the non-motorized mode support. As described earlier, the path density for this type of short trip (which is predominantly in urban areas) was increased by 10 percent in all areas.

Because of the significant change for urban VMT, it is likely that this change was large; a smaller increase in path density would have resulted in lower VMT decreases in all areas but mostly in urban areas.

For the Low-Cost Package in the Triangle model, total VMT decreased by 2.6 percent from the Base Case, with urban, suburban, and rural VMT decreasing by 2.8 percent, 2.4 percent, and 2.1 percent, respectively. The parking costs and increased telecommuting are most likely to impact urban areas and therefore create the largest percent VMT reduction in these areas. The combination of telecommuting and the compressed work week would bring both rural and suburban VMT down as well since suburban-urban and rural-urban trips tend to be longer than urban-urban trips.

3.4 MODEL RUN RESULTS COMPARED TO LITERATURE REVIEW RESULTS

3.4.1 Forward-Thinking Package

Depending on the model, the Forward-Thinking Package caused VMT reductions of 1.1 to 2.3 percent in urban areas, 1.0 to 1.9 percent in suburban areas, and 0.8 to1.6 percent in rural areas and overall VMT reductions of 0.9 to 2.0 percent. Figure 16 shows the VMT percent difference from the Base Case to the Forward-Thinking Package by area type.

The Forward-Thinking Package contained three measures: increased broadband and internet access in rural areas, increased telecommuting in non-rural areas, and a VMT tax. There are inherently different approaches and models used in the literature compared to what was in the Forward-Thinking Package. However, the Forward Thinking Package model results appear to be in the same range as the results from the literature scan for the components of this package. Figure 17 shows the Forward-Thinking Package results compared to its components' results from the literature scan.

- In a model of the Chicago region, increased telecommuting caused a 3.04 percent decrease in the number of home based work trips and yielded a 0.69 percent decrease in VMT (this also included a slight percent increase in non work, home based trips) (Shabanpour, 2018).
- A study on broadband in Kentucky indicated that 66 percent of respondents reported driving an average of 102 fewer miles per month due to their internet usage (Connected Nation). For these households, this VMT reduction could be about 0.5 to 1 percent, based on average VMT by household for the state (BTS).
- In regard to a VMT tax, in a Minnesota Pilot Program, a $0.05 to $0.25 per mile charge on driving yielded a 4.4 percent reduction in driving in those participants (Buxbaum).

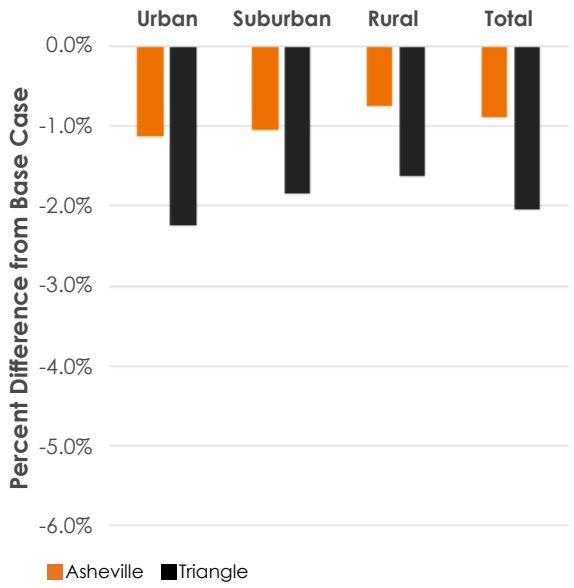


Figure 16: VMT Percent Difference from Base Case to Forward-Thinking Package

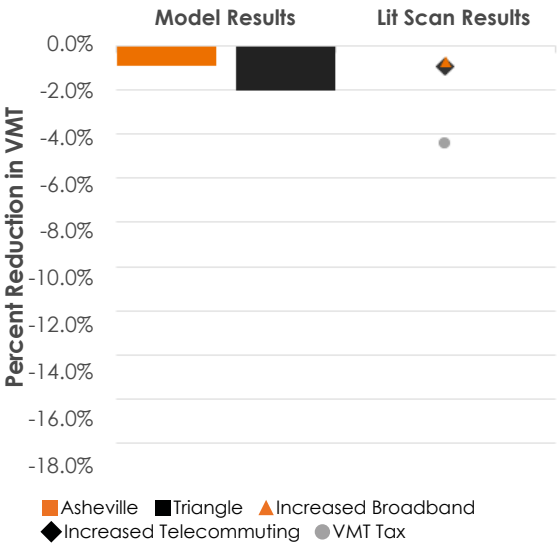


Figure 17: Forward-Thinking Package Model Results Compared to Component Results from Literature Scan

Note: The scatter plots are the research results of each measure being implemented independently. The bars are the modeled results of implementing a combination of these measures, although not necessarily to the same extent.

3.4.2 Transit-Based Package

Depending on the model, the Transit-Based Package resulted in VMT reductions of 0.7 to 2.9 percent in urban areas, 0.4 to 0.5 percent in suburban areas, and 0.3 to 1.7 percent in rural areas. For the entire modeled regions, VMT reductions were 0.5 to 2.0 percent. Figure 18 shows the VMT percent difference from the Base Case for the Transit-Based Package by area type.

The Transit-Based Package contained four measures: increased public transit, construction of transit-oriented development (TOD), implementation of an employee parking cash-out program, and increased parking pricing.

- The implementation of light rail or bus rapid transit can yield a corridor level VMT reduction of 1 to 2 percent (Smart Growth America).

- For TOD, research in the Baltimore and Washington, DC area shows that households within such a development have 20 to 21 percent less VMT than those outside of TODs. If the households around a dozen Washington Metro stations without TODs began to operate as if they were part of a TOD, overall VMT in the Washington, DC region may decrease 0.41 percent (Jeihani and Zhang, 2013).

- For employee parking cash out programs, a model of nine American cities showed an average commuter VMT reduction of about 10.4 percent if the program is fully adopted (Greenberg et al.). Another study found that charging employees $3 (in 1995 $'s) for daily parking would decrease VMT by an average of about 2.5 percent (Traveler Response to Transportation System Changes, 2005). There are two potential reasons for the greater VMT reduction for these employee parking cash-out programs compared to the Transit-Based Package model results:
  - The literature focused only on commuting and not VMT for other purposes, thereby excluding some VMT that could not be removed from the cash-out program when savings were calculated.

  - The model in the literature focused only on VMT in cities, whereas the Transit-Based Package model also included the VMT from suburban and rural areas in the regions. This is important because suburban and rural trips tend to be longer and less able to be substituted with public transit or other modes.

Overall, the model results for the Transit-Based Package are within the same range as the results from the literature scan for its component parts except for the employee parking cash out program. Based upon the reasons above, the model results garnered from this study for the Transit-Based Package appear to be reasonable because this study covers a larger and more diverse area than documented in the literature. Figure 19 shows the Transit-Based Package results compared to its components' results from the literature scan.

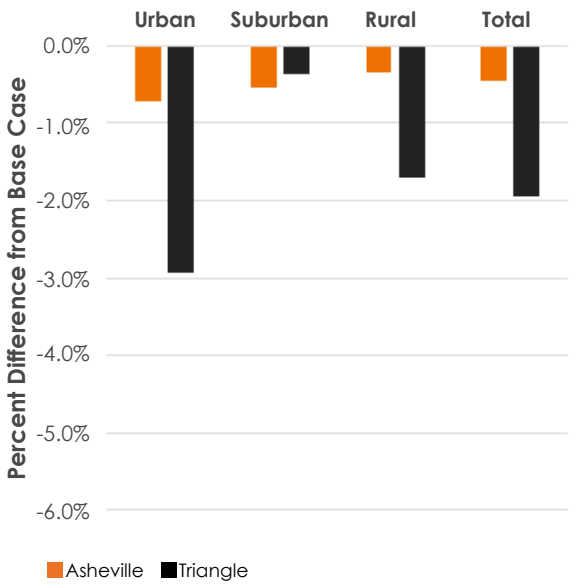


Figure 18: VMT Percent Difference from Base Case to Transit-Based Package

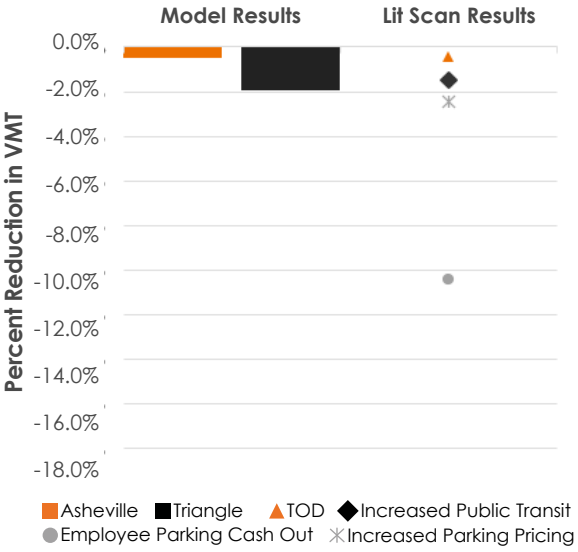


Figure 19: Transit-Based Package Model Results Compared to Component Results from Literature Scan

3.4.3 Environmental Package

Depending on the model, the Environmental Package caused VMT reductions of 1.6 to 5.1 percent in urban areas, 0.9 to 1.1 percent in suburban areas, and 0.6 to 2.2 percent in rural areas. For the entire modeled regions, VMT reductions were 0.9 to 3.4 percent. Figure 20 shows the VMT percent difference from the Base Case to the Environmental Package by area type.

The Environmental Package contained five measures: increased public transit, increased telecommuting in non-rural areas, a gas tax increase, an increase in the number of vanpools, and non-motorized mode support.

- For public transit, the implementation of light rail or bus rapid transit can yield a corridor level VMT reduction of 1-2 percent (Smart Growth America). In a model of the Chicago region, increased telecommuting caused a 3.04 percent decrease in the number of home based work trips and yielded a 0.69 percent decrease in VMT (this also included a slight percent increase in non work, home based trips) (Shabanpour, 2018).

- For the gas tax, the Boston area's Metropolitan Area Planning Council used VisionEval to estimate that an 18 cent increase in the gas tax may cause a VMT reduction just under 0.5 percent (Gately and Reardon, 2021).

- The vanpool program for San Diego County has been found to reduce total daily VMT by between 178,000 and 243,000, or about 0.2 to 0.3 percent (Boonvanich, 2020).

- Finally, as a relative measure for non-motorized mode support, the Center for Clean Air Policy Guidebook estimates a 2.5 percent reduction in total VMT for all bicycle-related measures combined (CAPCOA).

Overall, the model results for the Environmental Package are within the same proximity as the results from the literature scan for its component parts, although the non motorized mode support VMT reduction of 2.5 percent is on the higher side. This is because the research estimated the reduction due to all bicycle related measures to date. Since the Environmental Package is not constructing a new non motorized system from scratch but instead increasing the non-motorized path density by about 10 percent, it makes sense that the literature's estimate may be higher than the Environmental Package results. Figure 21 shows the Environmental Package results compared to its components' results from the literature scan.

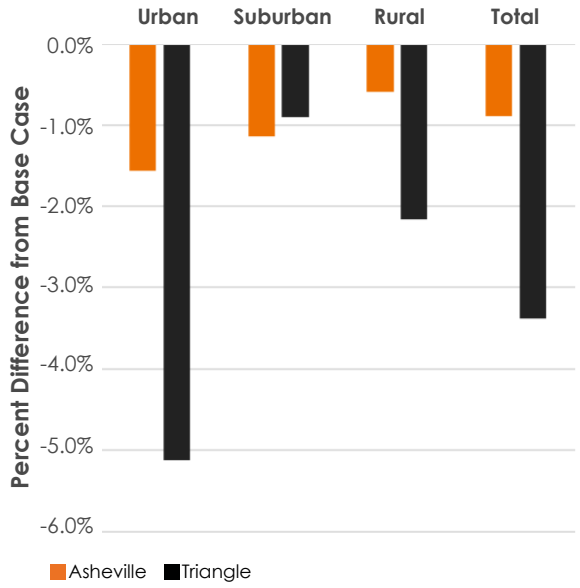


Figure 20: VMT Percent Difference from Base Case to Environmental Package

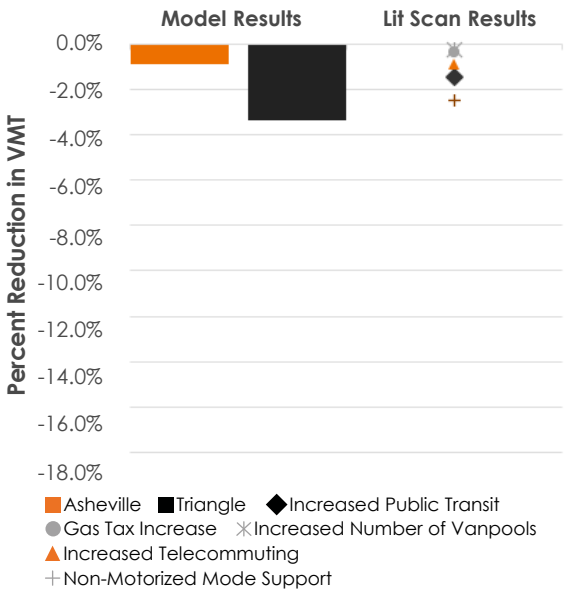


Figure 21: Environmental Package Model Results Compared to Component Results from Literature Scan

3.4.4 Low-Cost Package

Depending on the model, the Low-Cost Package caused VMT reductions of 1.5 to 2.4 percent in urban areas, 0.9 to 2.0 percent in suburban areas, and 0.5 to 1.5 percent in rural areas. For the entire modeled regions, VMT reductions were 0.8 to 2.2 percent. Figure 22 shows the VMT percent difference from the Base Case to the Low- Cost Package by area type.

The Low-Cost Package contained five measures: increased telecommuting in areas non-rural areas, implementation of an employee parking cash-out program, implementation of compressed work weeks, an increase in the number of vanpools, and increased parking pricing.

- In a model of the Chicago region, increased telecommuting caused a 3.04 percent decrease in the number of home based work trips and yielded a 0.69 percent decrease in VMT (this also included a slightly percent increase in non-work, home-based trips) (Shabanpour, 2018).

- For employee parking cash-out programs, a model of nine American cities showed an average commuter VMT reduction of about 10.4 percent if the program is fully adopted (Greenberg et al.). For compressed work weeks, a survey in Los Angeles found that employees who switched from working 5-day/40 hour weeks to 4 day/40-hour weeks drove about 17 percent fewer VMT after the implementation (Ho and Stewart, 1992).

- For vanpools, the vanpool program for San Diego County has been found to reduce total daily VMT by between 178,000 and 243,000, or about 0.2 to 0.3 percent (Boonvanich, 2020).

- For increased parking pricing, a study found that charging employees $3 (in 1995 $'s) for daily parking would decrease VMT by an average of about 2.5 percent (Traveler Response to Transportation System Changes, 2005).

Overall as shown in Figure 23, the model results for the Low-Cost Package are within the same range as the results from the literature scan for its component parts except for the employee parking cash out program and the compressed work week.

For the compressed work week, the reason for the significant difference is that the VMT reduction was measured only for those who experienced a compressed work week, not for the entire region. For the employee cash-out program there are two potential reasons for the greater VMT reduction in the literature compared to the Low-Cost Package model results:

- The literature focused only on commuting and not VMT for other purposes, As such, excluding some VMT from the total in the calculation resulted in higher VMT savings for the cash-out programs compared to this study.

- The model in the literature focused only on VMT in cities, whereas the Low-Cost Package model also included the VMT from suburban and rural areas in the regions. This is important because suburban and rural trips tend to be longer and less able to be substituted with public transit or other modes.

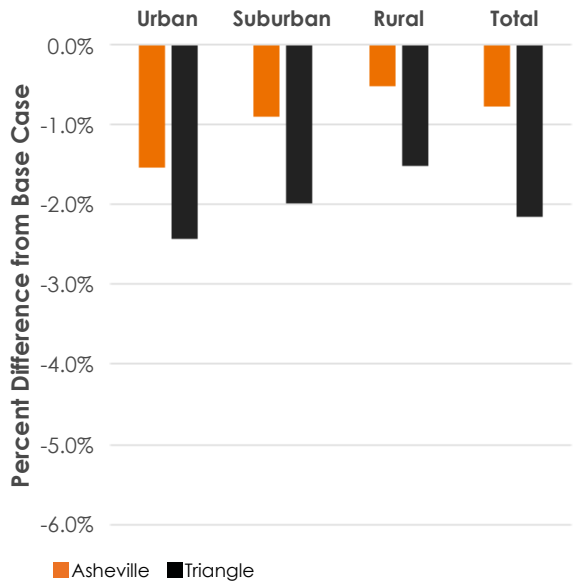


Figure 22: VMT Percent Difference from Base Case to Low-Cost Package

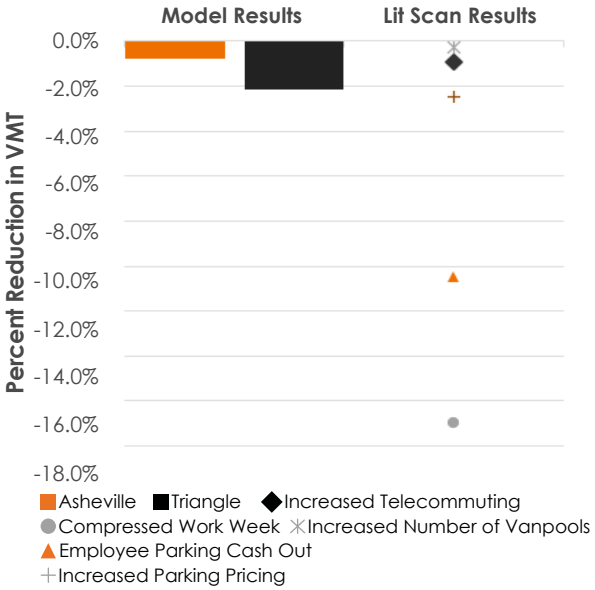


Figure 23: Low-Cost Package Model Results Compared to Component Results from Literature Scan

4.0 SUMMARY AND NEXT STEPS

Utilizing the Asheville and Triangle models, Stantec estimated total daily VMT reductions of 0.5 percent to 3.4 percent, depending on the TDM package and the area analyzed. Typically, urban areas had the greatest percent reductions in VMT, while rural areas had the lowest percent reductions. The reductions in the Triangle model were greater than in the Asheville model, potentially due to the Triangle region's more urban characteristic, but also potentially due to the intrinsic difference between the model structures. For this reason, it is possible that the VMT reductions may differ if the packages were run on other North Carolina traffic models. However, given the VMT reductions observed and modeled in the literature, the daily VMT reductions results are reasonable.

The breakdown of daily VMT reduction for Asheville by area type are:

- Urban: 0.7% to 1.6%
- Suburban: 0.5% to 1.1%
- Rural: 0.3% to 0.8%

The breakdown of daily VMT reduction for the Triangle region by area type are:

- Urban: 2.3% to 5.1%
- Suburban: 0.4% to 2.4%
- Rural: 1.6% to 2.2%

This report has been shared with the 37 Metropolitan Planning Organizations and Regional Planning Organizations within North Carolina to use to further discussions on how to implement TDM measures and plans that will reduce VMT in the state. It provides:

- A summary of the many existing TDM measures currently implemented within the state by location. Planners can identify other locations where particular measures are active and reach out to discuss the experience.
- A comprehensive overview of many TDM measures that may potentially reduce VMT within the state in the TDM Summary Pages. These summary pages include an overview of the measure, pros and cons, potential VMT reductions as documented in a literature review and examples of implementation in North Carolina and around the world along with other pertinent information. These pages are a quick way to access information.
- An initial indication of the range of VMT improvement that can be achieved by implementing TDM measures in rural, suburban and urban areas.

NCDOT will use the results of this study to guide a VMT reduction task force, comprised of members from MPO and RPOs, local governments, non-government organizations (NGOs), the private sector, and other interested parties. The task force will help determine the VMT reduction strategies likely to succeed in different regions across the state, how those strategies can be most effectively implemented, and potential funding opportunities.

5.0 PLANNING FOR MODE CHOICE ENABLEMENT

According to the 2022 North Carolina Department of Environmental Quality (NCDEQ) Greenhouse Gas (GHG) Inventory, transportation emissions in North Carolina constitute 36 percent of the total GHG emissions, making it the largest contributor in the state. Of these emissions, 88 percent are attributed to on-road vehicles, including passenger cars, delivery vehicles, and freight trucks.

Executive Order (EO) 246, signed by Governor Cooper in 2022, establishes ambitious goals, including a 50 percent reduction in greenhouse emissions compared to 2005 and the adoption of 1.25 million zero-emission vehicles (ZEVs), both by 2030. While vehicle miles traveled (VMT) reduction may seem like a small part of the equation when realizing the impact that transitioning to ZEVs and cleaner alternative fuels has on transportation emissions, it is likely that we will not be able to reach the goals in EO 246 without reducing VMT.

EO 246 called for the development of a Deep Decarbonization Pathways Analysis (Pathways Analysis) to help the state achieve its climate goals. The analysis therein used modeled illustrative, visionary pathways to achieve emissions targets. The analysis is aimed toward helping policymakers and stakeholders understand the biggest opportunities to reduce emissions as well as explore the tradeoffs between different emission-reduction strategies. A reference scenario was identified in the analysis that reflects technology trends and policies within the state such as population growth, adoption of ZEVs by customers, and efficient household appliances, however, this reference scenario achieves a 46 percent reduction in greenhouse emissions by 2030, falling short of the 50 percent goal set in EO 246. To bridge the gap and achieve these goals the Pathways Analysis developed three Net-Zero Alternatives: a high electrification scenario, a high decarbonized fuels scenario and a high carbon storage scenario. While these scenarios focus on higher levels of electrification, decarbonized fuels, and negative emissions technologies, they all assume a 1.2 percent reduction of VMT from the reference scenario, as derived from the results of this VMT Reduction Study.

To further advance the goals of EO 246, The North Carolina Clean Transportation Plan (NCCTP) was prepared by the North Carolina Department of Transportation (NCDOT) and serves as a guidance document that outlines a coordinated strategy for accelerating decarbonization within the transportation sector. This comprehensive plan was collaboratively developed with input from various stakeholders and aims to prepare North Carolina for a clean transportation future while ensuring equitable outcomes for all. The NCCTP provides an actionable and forward-thinking plan that underscores North Carolina's commitment to a sustainable and environmentally conscious transportation future.

As part of the NCCTP, working groups were convened to drill down on how to achieve the goal of GHG reduction. A Vehicle Miles Reduction Work Group developed a specific plan geared toward VMT that recommended strategies under four thematic focus areas: governance, infrastructure, funding and finance, and communications and engagement. Other resources for stakeholders include this VMT Reduction Study and the VMT Reduction Toolkit.

In order to set a measurable goal for VMT reduction, it is important to understand the recent trends in VMT, especially since events such as the COVID-19 pandemic altered traffic patterns and VMT in significant and unexpected ways.

5.1 CURRENT VMT TRENDS

This VMT Reduction Study analyzed transportation available at that time which generally pre-dated 2020, the year the pandemic began. In that year, VMT dropped precipitously as people followed stay-at-home orders, worked from home when possible, shopped from home and avoided crowded social situations. As restrictions were lifted and vaccines were rolled out, travel returned, but not at the level seen pre-pandemic. The share of people working from home in North Carolina more than doubled from 6.7 percent in 2019 before the pandemic to 16.8 percent in 2022, as shown in Figure 1. As a result of this shift, commute mode shares in North Carolina notably changed; the driving alone to work share reduced from about 81 percent before the pandemic to about 71 percent in 2022. Transit share for commute trips also reduced from almost 10 percent prior to the pandemic to 9 percent in 2022.

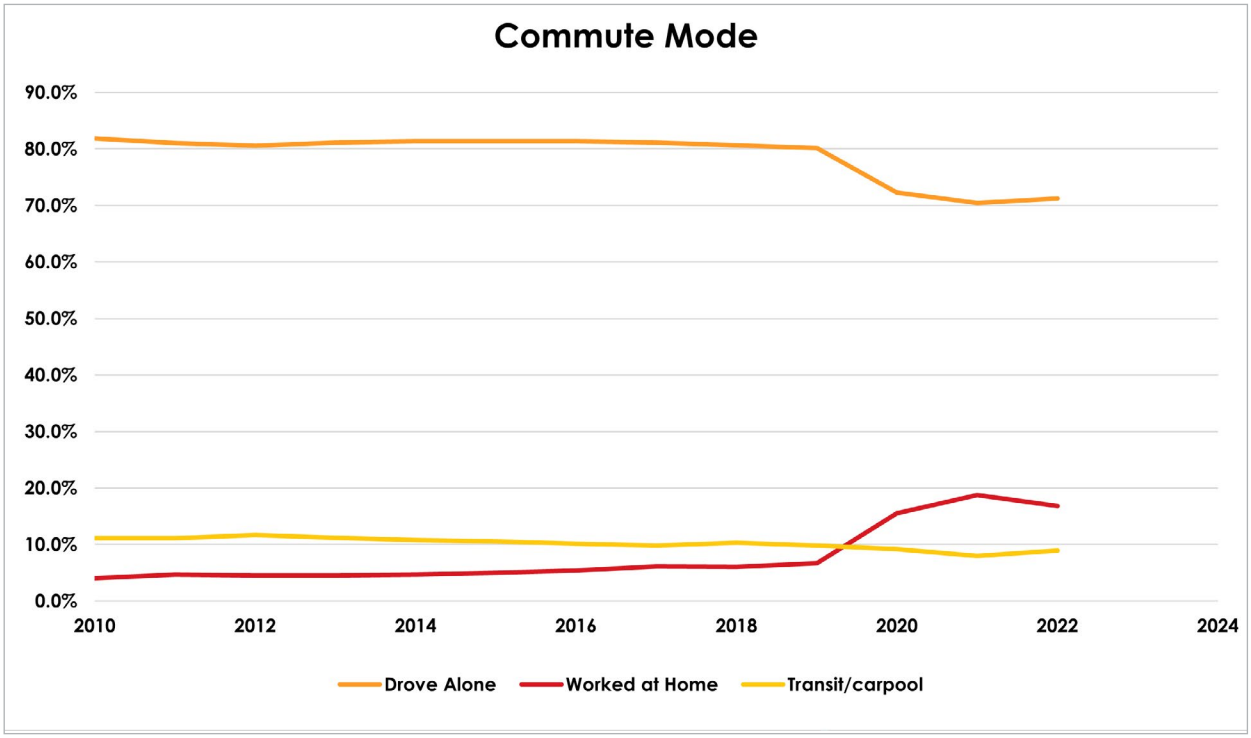


Figure 24: North Carolina Commute Mode

Source: USDOT Bureau of Transportation Statistics

As shown in Figure 2, between 2014 and 2019, total VMT in both the United States and North Carolina grew significantly to their individual peaks in 2019. Then in 2020, VMT plunged precipitously as a result of the pandemic. Total VMT in the United States and North Carolina in 2023 was still less than pre-pandemic. The trend in VMT is increasing; in North Carolina total VMT grew by 2.3 percent between 2021 and 2023 and the United States total VMT grew by 2.6 percent. Much of this VMT growth in North Carolina is due to the high rate of population increase. Between 2010 and 2020, the state's population grew by 903,905 persons, the sixth largest increase of all states. After the pandemic, this growth continued, and North Carolina had the third largest increase in population growing by 382,000 persons between 2020 and 2023. Most of this additional population moved to areas in the state with a population over 100,000.

VMT per capita, which normalizes the increase in VMT due to the increasing population is shown in Figure 3. Since 2020, VMT per capita has seen a much flatter trend than total VMT in both the United States and North Carolina. The United States average VMT per capita actually peaked in 2004, while in North Carolina it peaked in 2019. Post-pandemic, VMT per capita in North Carolina moderated and in 2023 was about 95 percent that of 2019. In 2023, VMT per capita in the United States was about three percent less than 2019.

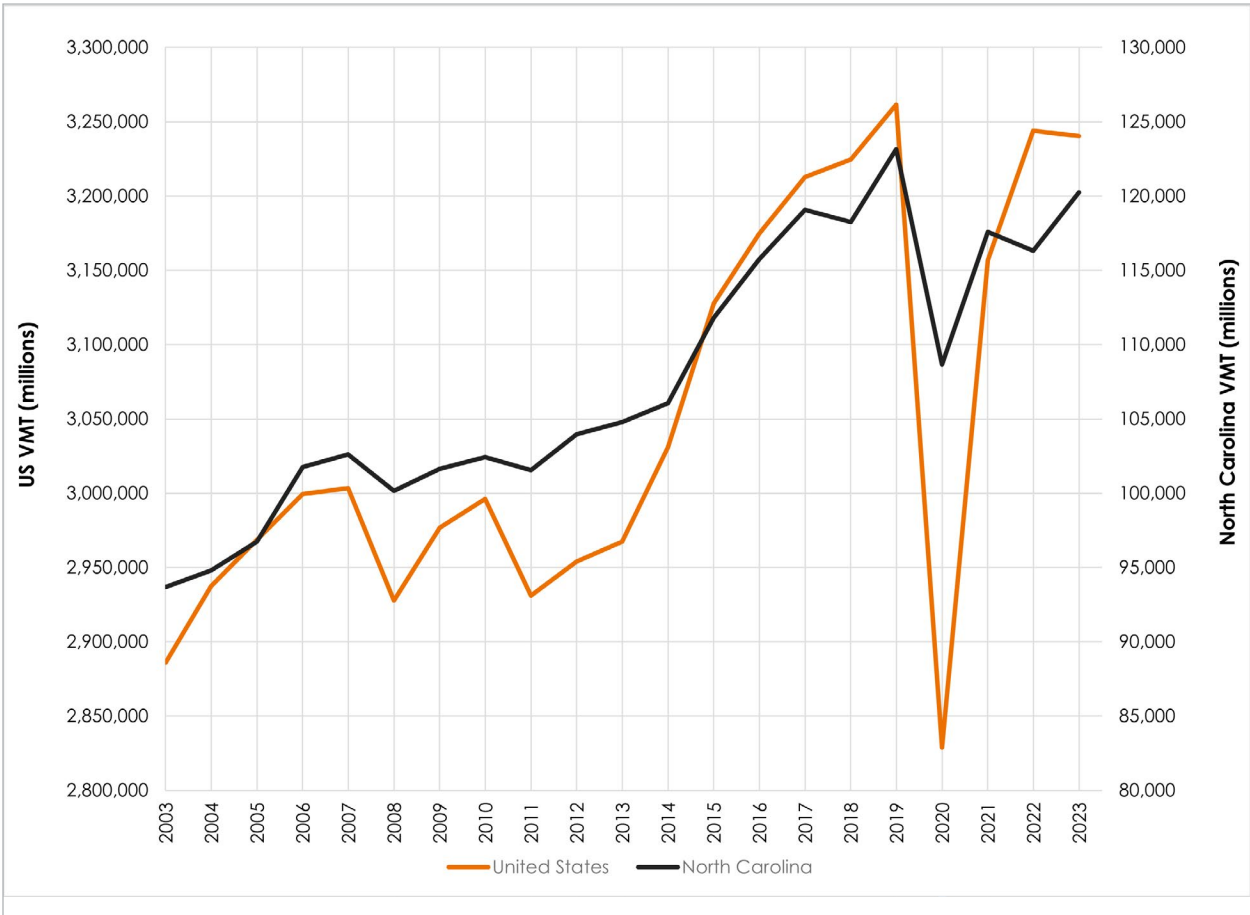


Figure 25: Total VMT in the United States and North Carolina 2003-2023

Source: FHWA, Office of Highway Policy Information, Travel Monitoring Trends Monthly Data

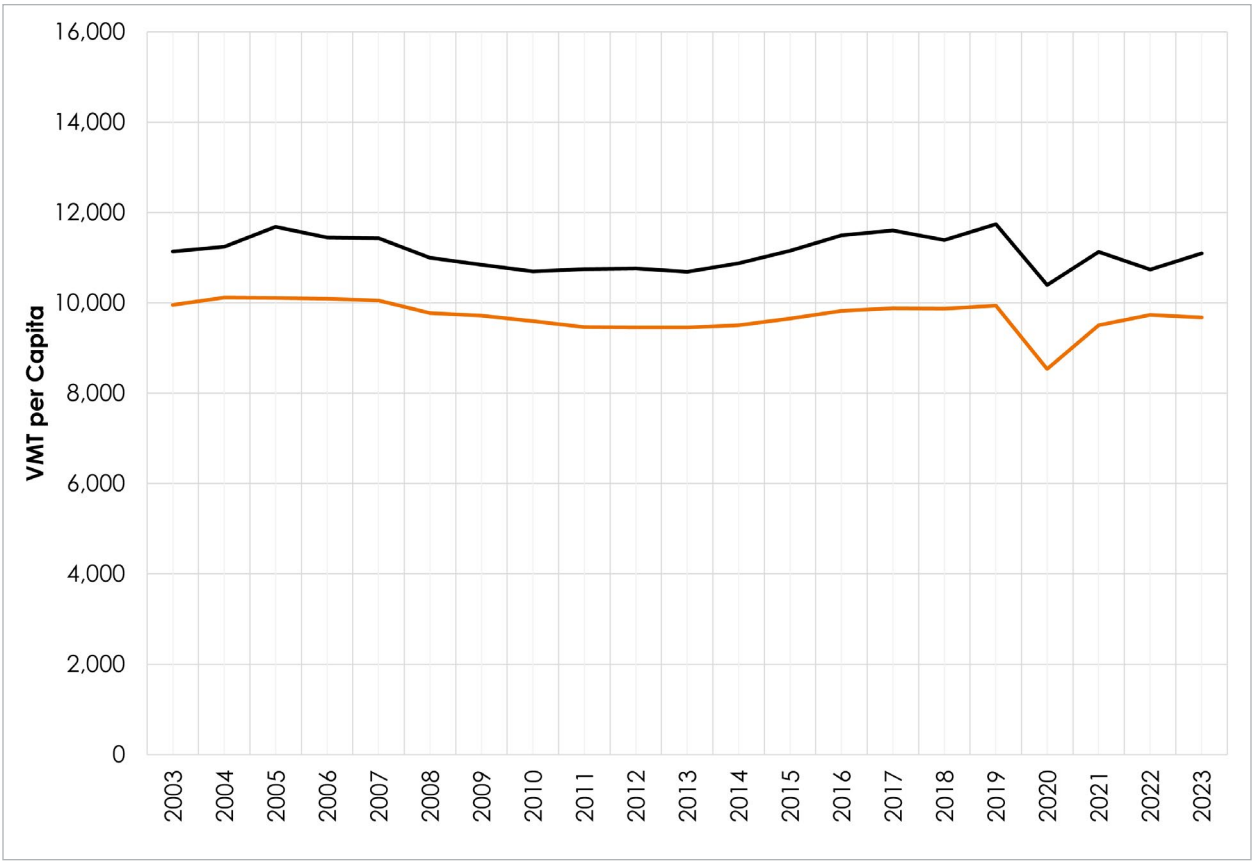


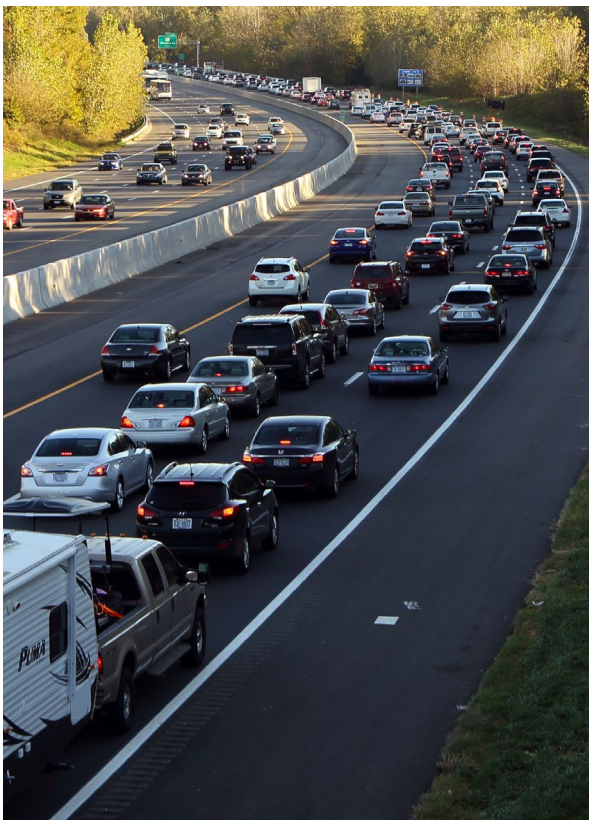
Figure 26: VMT Per Capita in United States and North Carolina 2003-2023

Source: FHWA Table VM-2 and July 1 Census Population Estimates

5.2 NEEDED VMT REDUCTION RESEARCH

Table 13 identifies ten other places that have a measurable target to reduce VMT. Of the ten noted, many have a clear baseline for comparison that uses a normalized measure of VMT in the form of VMT per capita. Note that some of the goals are aspirational when looking through a lens of historical knowledge and experience, particularly those in plans dated pre-2010.

Table 14 lists the strategies identified in each plan to reduce VMT as well as some of the primary strategies identified in the NCCTP. As expected, most every place identified "public transit expansion or improvements" as a primary strategy in their plans. Improvements that fall in the multi-modal category, including "complete streets", "active transportation networks" and "bicycle/ pedestrian safety improvements were common among the plans".



Municipality [Plan Date]	Targets by Year							Reduction applied to	Reduction compared to baseline year of:
	2025	2027	2030	2035	2040	2045	2050		
Boulder Valley, CO			20%						1990
British Columbia			25%					light duty	2020
California [2022]			25%			30%			1990
Connecticut [2021]			5%					*per capita*	2019
Maine [2021]	10%		20%					light-duty	
Minnesota [2023]					14%		20%		No action scenario
New Mexico [2019]		15%						*per capita*	2015
Oregon					20%			light-duty *per capita*	
San Antonio, TX			47%		75%				2016
Washington State [2008]				30%			50%	light-duty *per capita*	1990

Table 13: VMT Targets around the United States and Canada

Table 14: Strategies Identified by Municipality to Reduce VMT

VMT Reduction Strategy or Focus	North Carolina	Boulder Valley, CO	British Columbia	California	Connecticut	Maine	Minnesota	New Mexico	Oregon	San Antonio, TX	Washington State
Complete Streets	xx		o		xx	xx	o	xx	xx	xx	xx
Active Transportation Networks		xx	xx	xx	xx		o			xx	xx
Bicycle/Pedestrian Safety Improvements	xx	xx				xx		xx		o	o
E-Bike Incentives			xx	o	o	o	xx	o	o		o
Shared Micromobility	xx	o			o						
Transit-Oriented Development/Land Use Efficiency	xx	o	o		xx		o		xx	o	xx
Equitable Access for Priority Populations	o	xx		xx			o	o		o	xx
Public Transit Expansion or Improvements	xx	xx	xx	xx	xx		xx	xx	o	xx	xx
Fare-Free Transit	o	xx									
Commute Trip Reduction Programs			o		xx	xx					xx
Rideshare Apps						xx					
Telework	o		o		o		o				o
Evaluation/Mitigation of VMT from Future Road Projects				xx			xx				xx
Road User Charging				o				o	xx		
Parking Cash-Out/ Parking Reform			o	o					o		o

xx - Priority
o - Secondary

5.3 NORTH CAROLINA MODE CHOICE ENABLEMENT SCENARIOS

Mode choice enablement resulting in VMT reduction is a key strategy to improve safety, reduce transportation-related expenses, reduce energy use and its associated emissions, and promote healthier transportation options. This is why it is a key component of North Carolina's Clean Transportation Plan. Mode choice enablement and resulting reductions in VMT will require investment and commitment from a broad array of funding sources and local communities.

NCDOT utilized the VMT reduction strategies outlined in the VMT Reduction Toolkit to develop mode choice enablement scenarios ranging from 5-20% statewide VMT reduction from 2018 levels by 2050. These scenarios reflect an assumption of greater mode choice enablement and VMT reductions in urban areas. Urban areas are generally better positioned than rural areas to implement VMT reduction strategies due, in part, to having higher population densities, more transit-friendly and progressive land use practices, greater need to relieve recurring roadway congestion, and greater public desire to have viable transportation alternatives to driving. These scenarios also reflect an assumption that most individuals will only shift modes from driving if the alternative mode is equivalent to driving in terms of travel time, convenience and cost. Furthermore, scenarios of significant widespread VMT reduction will require development of a highly efficient, robust and safe multi-modal network that rivals driving and is available to a large portion of the population.

Some mode choice enablement strategies work at the *micro level*, where direct actions, often locally implemented by a municipality or a business, can lead to mode shift for a targeted area. Examples of direct local actions include establishing new transit routes or vanpools, improving the travel time of existing transit services, building complete streets on local facilities to safely accommodate all users, and promoting active transportation options (walking, biking). Other strategies are applied at the *macro level*, systematically impacting how transportation infrastructure and services are planned, prioritized and designed to accommodate and enable mode choice. This may include regional or statewide policies or practices that impact how state and federal transportation funding is prioritized or which impact the role local agencies have in decisions about transportation infrastructure in their community. Macro changes may also include national, state, or regional paradigm shifts in how the future of transportation is envisioned, cascading down to smaller decisions and policies that impact how quickly or broadly mode choice enablement strategies are deployed.

Ultimately, VMT reduction depends on the degree to which mode choice enablement strategies are adopted in terms of both the number of communities adopting strategies as well as the intensity of adoption in each community. Statewide and regional policy changes that facilitate greater local implementation of mode choice enablement strategies will lead to more mode shift and result in greater VMT reduction. The information below summarizes key strategies and hypothetical statewide VMT reduction scenarios based on varying degrees of mode choice enablement strategy adoption.

Table 15: Mode Choice Enablement Strategy Categories and Examples

Population Based Strategies These strategies build upon existing foundations of public transit networks and relatively compact development. By expanding transit routes and increasing frequencies, while instituting connected and complete streets policies, North Carolina's urban areas can see sizable reductions in VMT and increase safe, active transportation trips in local communities.	**Employment Based Strategies** The state, regional, and local agencies work with employers to incentivize both a reduction in the number of commutes and a switch to alternative modes. Condensed work weeks and hybrid working can benefit employees at often no cost to the employer, while facilitating transit and vanpools can provide employees with efficient and convenient mobility options.
Greater Metropolitan Area Intensification Helping suburban commuters utilize carpools, vanpools, and public transit will reduce the most-common long trip. More infill development can lead to a better jobs/housing balance, while the suburbs can benefit from greater mixed-use development and non-motorized mode support.	**Rural and Tourist Area Strategies** Expanding broadband into new areas will help reduce the need for vehicle trips, while the growth of transit, including microtransit and other demand-response forms, will allow people to shift more of their trips into alternative modes. Forward-thinking land use policies will allow development that encourages trip-chaining and active transportation.
Statewide Strategies Various strategies can be implemented on a statewide level, such as those involving flexible work schedules, transit/vanpool subsidies and incentives, and greater utilization of internet resources, such as tele-working and tele-commerce. Additionally, actionable land use policies can be enacted to encourage all types of communities to become more amenable to alternative modes.	**Advanced Strategies** The key for sustainable VMT per capita reductions is to use pricing and subsidies to develop a robust system of mode alternatives that are as attractive to the general public as driving is. Removing regulations that encourage driving, such as many parking mandates, can help make healthier and more vibrant communities, where biking, carpooling, and transit are as attractive as driving a personal vehicle.

5.3.1 Hypothetical VMT Reduction Scenarios

There are many routes to reaching North Carolina's VMT reductions goals. The following shows one path to reaching successive milestones.

No Reduction:

Mode choice is enabled in a scattershot manner across North Carolina, primarily in the most densely populated communities. Transportation funding continues prioritizing highway expansion which induces demand for driving by increasing trip distances. Urban roadway expansion consumes the majority of transportation funding due to the high costs of land acquisition, utility work, and construction in dense environments, and ultimately suffers from diminishing marginal utility.

Five Percent Reduction:

In the three largest metropolitan areas, transit frequency has increased and routes are extended, while active transportation is supported and complete streets redesigns are accelerated. Lower density urban areas enable mode choice in select communities.

Ten Percent Reduction:

The large metropolitan areas have enabled mode choice to incentivize a shift to non-driving modes. State and local governments work with the business community to institute commute reduction strategies, including parking cash-out, vanpools, and telecommuting. Investment supports microtransit programs in additional areas, including rural areas and tourist destinations. Land use policies encourage infill development, affordable housing, and reduced or eliminated parking requirements in urban centers.

Fifteen Percent Reduction:

In all urban areas – including low and medium density urban communities – alternative, high-quality modes are as fast, convenient, and economical as driving for most trips. Conventional and flexible public transportation is expanded in smaller towns and rural areas, as well as tourist destinations. Transit and vanpool fare subsidies are offered across the state.

Twenty Percent Reduction:

In addition to a widespread increase in the quality of alternative modes in all urban areas leading to high rates of mode shift, rural communities develop dense community centers more easily accessible to all modes. There is an expansion of intercity rail and buses across the state to reduce long-distance VMT trips and connect towns and cities of all sizes across North Carolina.

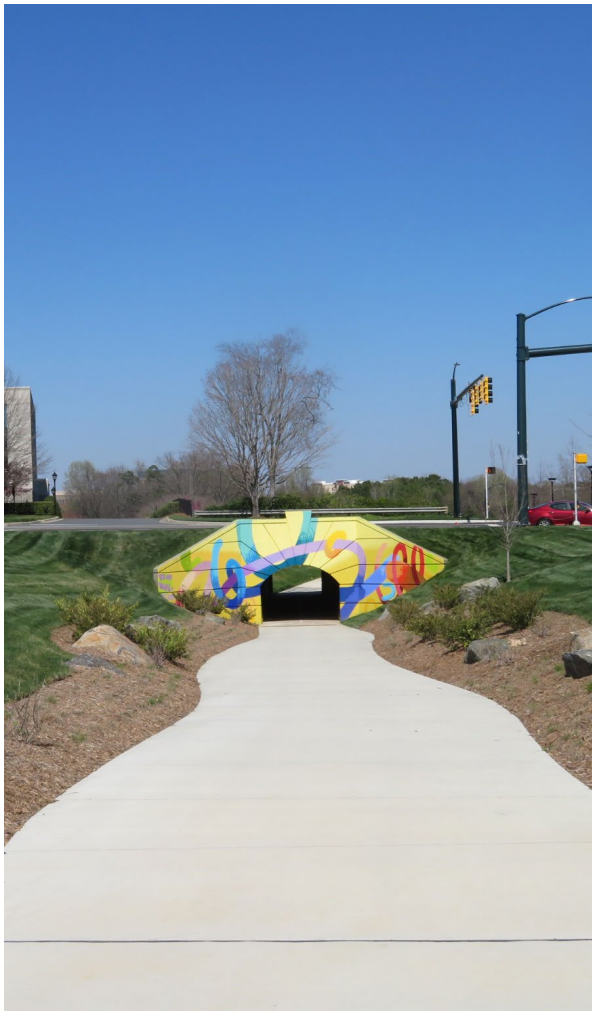


Figure 27: Five Percent Reduction Scenario

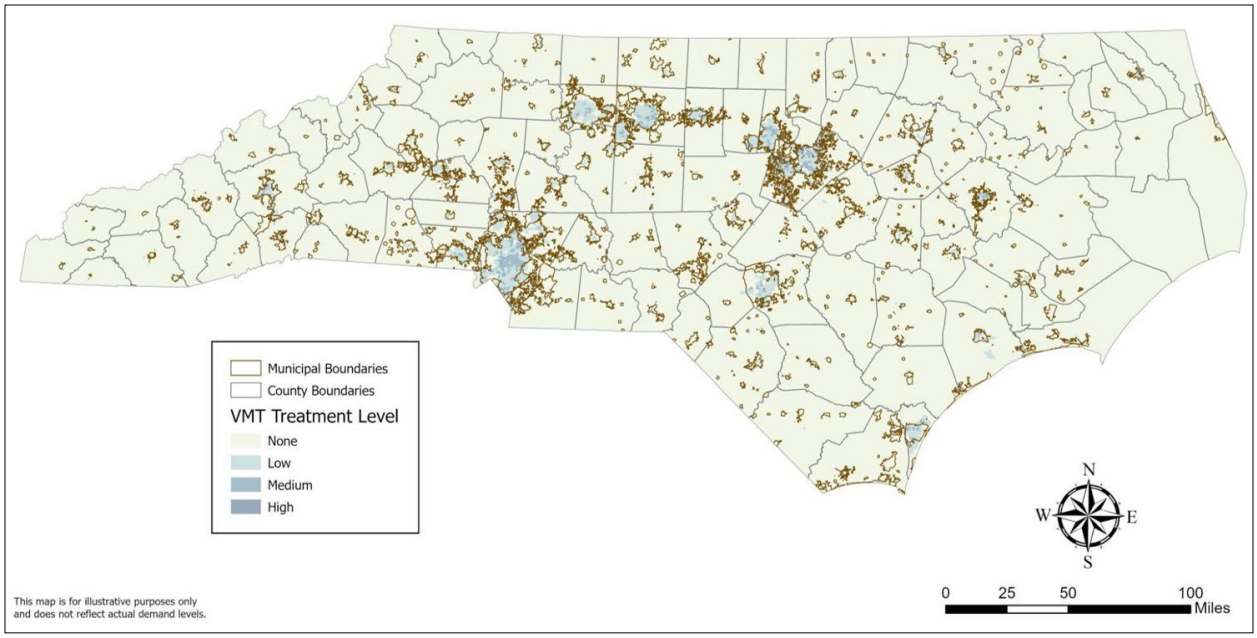


Figure 28: Ten Percent Reduction Scenario

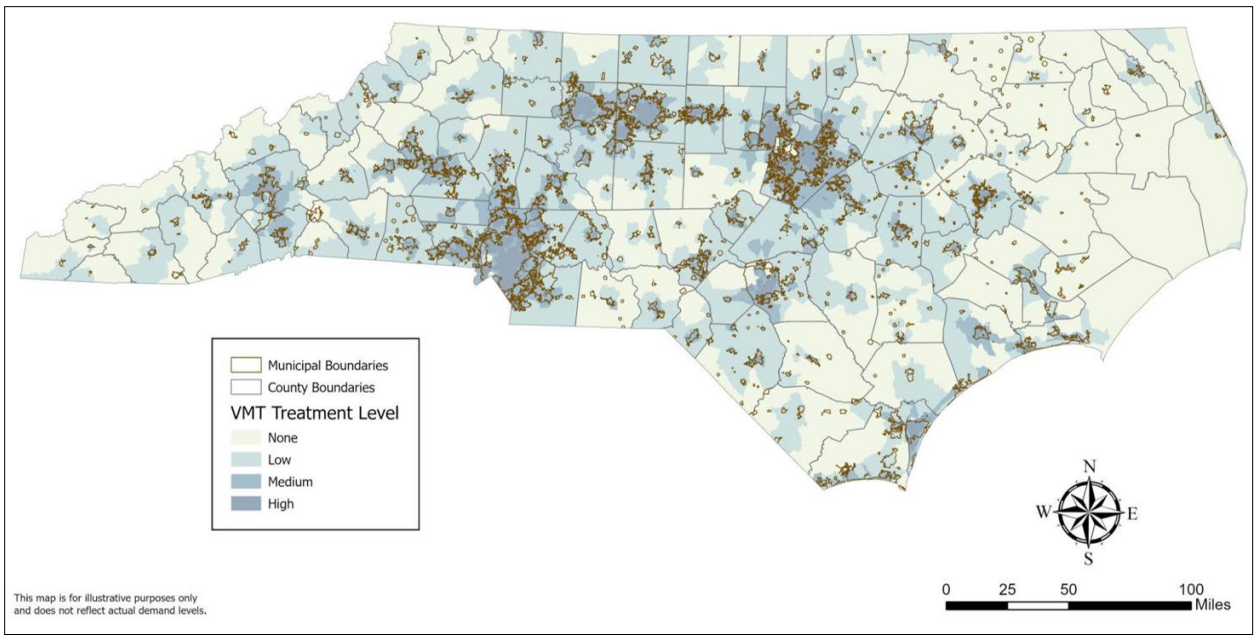


Figure 29: Fifteen Percent Reduction Scenario

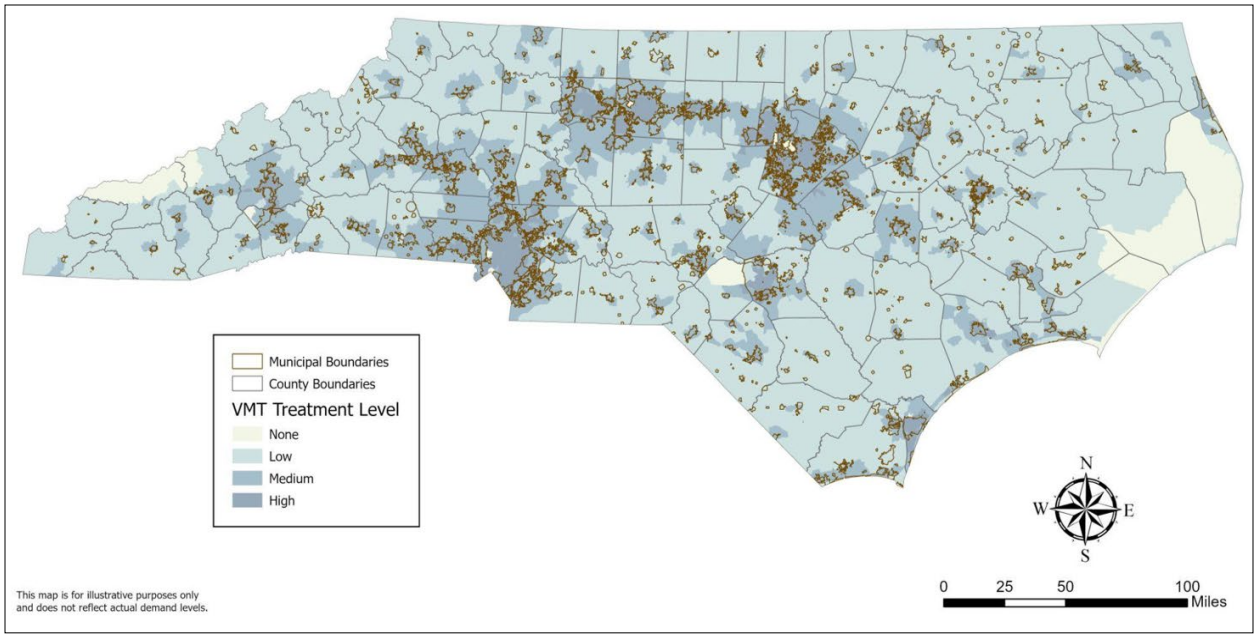
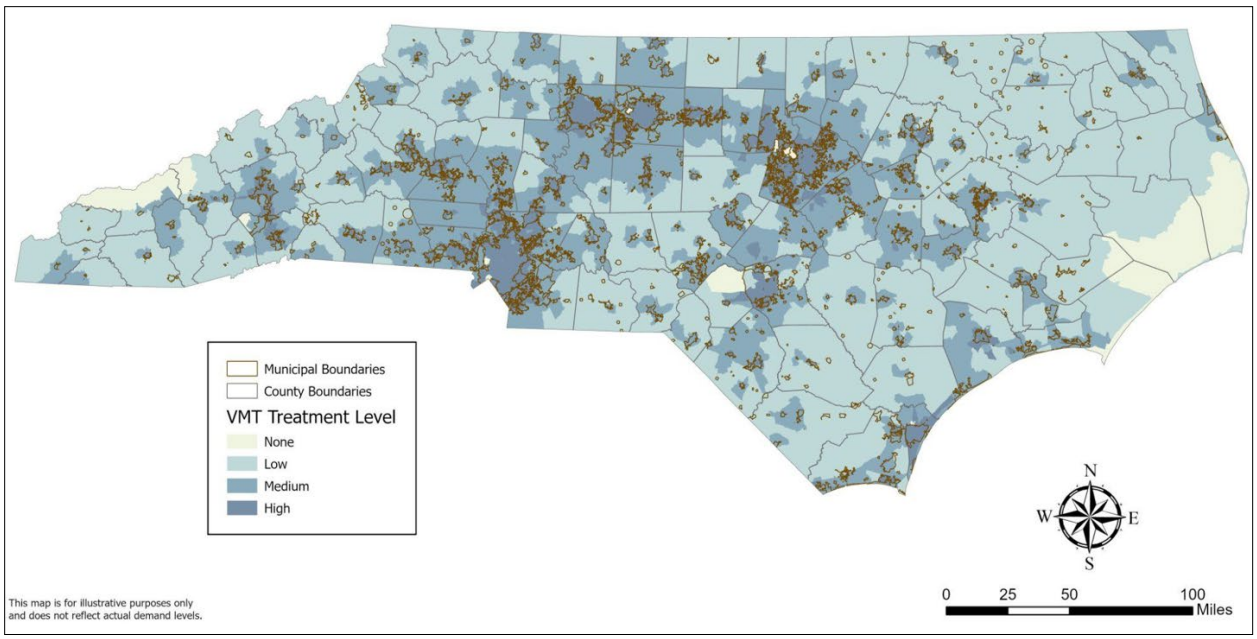


Figure 30: Twenty Percent Reduction Scenario



5.4 VMT REDUCTION SCENARIO ESTIMATED POTENTIAL BENEFITS

Table 16 uses the Rocky Mountain Institute's (RMI) Smarter MODES Calculator [Ver.1.3 (NC)], to estimate the per capita savings that can be achieved for each of the four scenarios based on several key assumptions:

- A 50% statewide EV adoption rate by 2050,
- 10% of the VMT reductions are due to a Cycling mode shift,
- 10% of the VMT reductions are due to a Pedestrian mode shift,
- The estimated future VMTs before reductions are first calculated by an extrapolated linear regression line of the 2007-2019 VMT data to future years,
- Crash fatality rates are assumed to be $1.3x10^{-8}$ Life/VMT
- Crash injury rates are assumed to be $1.95x10^{-7}$ Life/VMT

Furthermore, the estimated cumulative avoided costs over this period (2024 through 2050) are presented in Table 17 for each of the four scenarios. Several key assumptions are:

- The costs associated with injuries and fatalities are determined by the USDOTs Value of a Statistical Human Life document
- While the operating expenses for fuel, charging, and maintenance costs are estimated to be $0.10/VMT for gas vehicles, and $0.08/VMT for EV vehicles
- Lastly, the congestion savings assume that each VMT reduced saves 0.015 hours of time, and that each hour saved is worth $16.50, which equates to approximately $0.25 saved per VMT reduced.

Table 16: Per Capita Savings For Each Scenario

Estimated Avoided Values (Cumulative 2024-2050)				
Category	**20% Scenario**	**15% Scenario**	**10% Scenario**	**5% Scenario**
VMT (Miles)	806.9 billion	701.2 billion	595.5 billion	489.8 billion
Crash Fatalities	10,490	9,116	7,742	6,368
Crash Injuries	157,357	136,746	116,135	95,524
Air Quality Fatalities	1,158	1,006	855	703
Traffic Congestion (Hours)	12.1 billion	10.5 billion	8.9 billion	7.3 billion
Fuel Usage (Gallons)	16.4 billion	14.3 billion	12.1 billion	9.9 billion
Air Emissions (Tonne CO_2-E)	113.0 million	98.2 million	83.4 million	68.6 million

Table 17: Estimated Cumulative Avoided Costs Over This Period (2024 through 2050)

Estimated Cumulative Avoided Costs (2024-2050)				
Category	**20% Scenario**	**15% Scenario**	**10% Scenario**	**5% Scenario**
Crash Fatalities	$123.8 billion	$107.6 billion	$91.4 billion	$75.2 billion
Crash Injuries	$77.1 billion	$67.0 billion	$56.9 billion	$48.8 billion
Operating*	$160.6 billion	$139.6 billion	$118.5 billion	$97.5 billion
Traffic/Congestion	$245.3 billion	$213.1 billion	$181.0 billion	$148.9 billion
Total Savings	**$606.8 billion**	**$527.3 billion**	**$447.8 billion**	**$370.4 billion**

* Does not include depreciation costs

Considering North Carolina's diverse geographical landscape, the strategies for reducing VMT in the context of clean transportation need to be adaptable and scalable. They should encompass suitable solutions for rural, suburban, and urban areas, which the VMT Reduction Toolkit addresses in its strategy descriptions. Most importantly, the toolkit provides an interactive document for users that pairs mode choice enablement strategies with funding opportunities. These competitive funding sources and other funding strategies will be critical to implement mode choice enablement strategies at the scale and intensity needed to achieve VMT reduction targets.

List of Appendices

A-1.EXTERNAL QUESTIONNAIRE..... **88**

A-2. INTERNAL QUESTIONNAIRE..... **92**

A-3.LIST OF VMT SOURCES..... **95**

APPENDIX A-1

EXTERNAL QUESTIONNAIRE

The North Carolina Department of Transportation has contracted Stantec to review Travel Demand Measures (TDM) that are currently used to reduce Vehicle Miles Traveled (VMT) throughout the state. These measures, combined with successful measures utilized globally, will provide a long list of options to reduce VMT. From that database, Stantec will assess the effectiveness of these programs. The results will provide a tool kit that can be used to optimize VMT-reduction policies for RPOs, MPOs and TPDs throughout the state. Please note: this research is for policies undertaken prior to the COVID-19 pandemic.

1. What type of area does your planning organization cover (more than one answer is OK)?

- [ ] Rural
- [ ] Suburban
- [ ] Urban

* 2. Who can we reach out to if we have any follow-up questions? (Name and Contact info)

Name	
Planning Organization	
E-mail address	
Phone Number	

3. What types of TDM strategies to reduce VMT are active in your area? Which measures were implemented by your Planning Organization? Which Measures were implemented by other agencies or the private sector?

	Available, administered by Planning Organization	Available, administered by Local Transit Agency	Available, administered by Other Local Public Agency	Available, administered by Private Company	Not Available
HOV Facilities	☐	☐	☐	☐	☐
Park & Ride Lots	☐	☐	☐	☐	☐
Vanpool Services	☐	☐	☐	☐	☐
Transit Services	☐	☐	☐	☐	☐
Ridematching Services	☐	☐	☐	☐	☐
Guaranteed Ride Home	☐	☐	☐	☐	☐
Bicycle infrastructure	☐	☐	☐	☐	☐
Transit and Vanpool Fare Subsidies	☐	☐	☐	☐	☐
Alternative Mode Rebates/Incentives	☐	☐	☐	☐	☐

	Available, administered by Planning Organization	Available, administered by Local Transit Agency	Available, administered by Other Local Public Agency	Available, administered by Private Company	Not Available
Transit-Oriented Development	☐	☐	☐	☐	☐
Compact Employment and Activity Centers	☐	☐	☐	☐	☐
Compact Residential Development	☐	☐	☐	☐	☐
Mixed Land Use Zoning	☐	☐	☐	☐	☐
Complete Streets	☐	☐	☐	☐	☐
Downtown Revitalization	☐	☐	☐	☐	☐
VMT Tax	☐	☐	☐	☐	☐
Road/Congestion Pricing	☐	☐	☐	☐	☐
Gas Tax Increase	☐	☐	☐	☐	☐
Parking Pricing	☐	☐	☐	☐	☐
Broadband Infrastructure Improvements	☐	☐	☐	☐	☐
Telecommuting	☐	☐	☐	☐	☐
Compressed work week	☐	☐	☐	☐	☐
Car-Free Zones	☐	☐	☐	☐	☐
Trip Reduction Ordinances	☐	☐	☐	☐	☐

4. Please list the five **most effective** TDM strategies for reducing VMT in your area .

	TDM Strategies
Most Effective	
2nd most effective	
3rd most effective	
4th most effective	
5th most effective	

5. Please list the five **most easily implemented** VMT-reducing TDM strategies in your area.

	TDM Strategies
Easiest	
2nd most easiest	
3rd most easiest	
4th most easiest	
5th most easiest	

6. Are there any other VMT-reducing TDM strategies not listed that have been implemented or are planned for implementation in your jurisdiction?

7. Has your agency completed any studies that evaluated the effectiveness of VMT-reducing policies enacted in your jurisdiction?

- ◯ Yes
- ◯ No

8. Do you have any comments that you'd like to provide regarding TDM strategies to reduce VMT?

APPENDIX A-2

INTERNAL QUESTIONNAIRE

Stantec

VMT-REDUCTION STRATEGY EXPERT QUESTIONNAIRE

Please provide your input as to the most effective and easiest-to-implement strategies in the table below for different area types. For reference, we already know that planning organizations in North Carolina have implemented, considered, or know about the strategies listed on the next page to reduce VMT. We would especially like to know if you are aware of any strategies that are NOT on this list. Please check off any of the strategies in that list with which you have experience.

Thank you!

	Urban	Suburban	Rural
Most effective strategies			
How did you measure the effectiveness?			
Easiest strategies to implement			

NORTH CAROLINA VMT REDUCTION STRATEGIES

Please check off any of the strategies in this list with which you have experience.

Pricing Strategies
☐Transit and Vanpool Fare Subsidies
☐VMT Tax
☐Road/Congestion Pricing
☐Gas Tax Increase
☐ Parking Pricing

Public Policy & Regulatory Strategies
☐ Support of New Institutional Relationships
☐ Access Priority/Restriction
☐ Trip Reduction Ordinances

Telecommunication Strategies
☐ Telecommuting
☐ Internet-Based Strategies (teleshopping)
☐ Information Services

Worksite-Based Strategies
☐ Transportation Management Associations
☐ Facility Amenities
☐ Parking Management
☐ Guaranteed Ride Home
☐ Alternative Work Schedules
☐ Monetary Incentives

Land Use Strategies
☐ Development Impact Mitigation
☐ Providing Affordable Housing
☐ Jobs/Housing Balance
☐ Parking Management
☐ Transit/Pedestrian Friendly Urban Design
☐ Connectivity
☐ Mixed Land Uses
☐ Compact Employment and Activity Centers
☐ Compact Residential Development

Other Strategies
☐ Carsharing
☐ Park & Ride Lots
☐ HOV Facilities
☐ Non-Motorized Mode Support
☐ Custom Transit Services
☐ Vanpool Services
☐ Transit Services
☐ Ride-matching Services
☐ Public Education and Promotion

APPENDIX A-3

LIST OF VMT SOURCES

- Expanding Traveler Choices through the use of Incentives: A Compendium of Examples
  https://ops.fhwa.dot.gov/publications/fhwahop18071/index.htm

- Connecting North Carolinians to Opportunities (NCDOT
  https://www.ncdot.gov/divisions/public-transit/statewide-strategic-plan/Pages/statewide-strategic-plan-documents.aspx

- Short-and Long-Term Effects of Land Use on Reducing Personal Vehicle Miles of Travel
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