2019

STATEWIDE TRANSPORTATION DEMAND MANAGEMENT PLAN

PHASE 1 REPORT: COLORADO TRANSPORTATION OPTIONS

COLORADO
Department of Transportation

Statewide Transportation Demand Management Plan

Phase 1 Report: Colorado Transportation Options

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CDOT's Mission: "To provide the best multi-modal transportation system for Colorado that most effectively moves people, goods, and information."

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$k	Thousands of dollars
$M	Millions of dollars
ACS	American Community Survey
ADVMT	Average Daily Vehicle Miles of Travel
AGS	Advanced Guideway System
BRT	Bus Rapid Transit
CDOT	Colorado Department of Transportation
CMAQ	Congestion Mitigation and Air Quality
DIA	Denver International Airport
DRCOG	Denver Regional Council of Governments
EPA	Environmental Protection Agency
ETC	Employer Transportation Coordinator
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
GPS	Global Positioning System
GRH	Guaranteed Ride Home
GVMPO	Grand Valley Metropolitan Planning Organization
HOT	High-Occupancy/Toll (lane)
HOV	High-Occupancy Vehicle
ITS	Intelligent Transportation Systems
MPO	Metropolitan Planning Organization
NFRMPO	North Front Range Metropolitan Planning Organization
PACOG	Pueblo Area Council of Governments
PPACG	Pikes Peak Area Council of Governments
RFTA	Roaring Fork Transit Authority
RTD	Regional Transportation District
SOV	Single-Occupant Vehicle

SRTS	Safe Routes to School
STIP	State Transportation Improvement Program
TDM	Transportation Demand Management
TIP	Transportation Improvement Program
TMA	Transportation Management Association
TMO	Transportation Management Organization
TNC	Transportation Network Company (e.g., Uber, Lyft)
TOD	Transit-Oriented Development
TPR	Transportation Planning Region
TSMO	Transportation Systems Management and Operations
USDOT	United States Department of Transportation
VHT	Vehicle Hours of Travel
VMT	Vehicle Miles of Travel

DISCLAIMERS

Product Endorsement: A number of private firms, products or services are mentioned in this report. For example, Uber is mentioned more than 70 times. Any such mention in this report is not intended as an endorsement by the Colorado Department of Transportation.

Omissions: This report mentions a number of programs undertaken by local governments, businesses and other organizations. This listing is not intended to be all inclusive. Undoubtedly there are many additional efforts underway.

Data Accuracy: Numbers are used in this report to show relative tendencies and trends. Many of the numbers presented in this report are estimates. Some are self-reported (e.g., Census or other survey) data on transportation mode use. Each number has a different margin of error, typically not identified in this report.

Data Currency: Most numbers used herein are derived from other reports and thus are possibly several years old. Some of them have been updated one or more times during the preparation of this report. Updated information may be available from the various sources identified in the List of References. The transportation marketplace is changing so rapidly that new programs are emerging on a constant basis.

COLORADO
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EXECUTIVE SUMMARY

ES.1 Overview

Transportation Demand Management (TDM) is the application of strategies and policies to reduce motor vehicle travel demand, or to redistribute this demand in space or in time. This has been a focus in the United States since the 1970s, in response to price hikes by the Oil Petroleum Exporting Countries (OPEC) and the urgent need to reduce motor vehicle emissions in polluted metropolitan areas. Today, with cleaner air and gasoline prices moderated, TDM remains a tool for addressing ever worsening traffic congestion.

Traffic congestion is estimated to cost Colorado motorists over 100 million hours of lost time each year and over $2 billion in excess travel costs. Much, but not all, of this congestion occurs in the Denver region and Colorado's Front Range communities, and on I-70 between Denver and the state's mountain recreation destinations. Much, but not all, of this congestion is related to daily weekday commuting, and some is recreation travel. The state's population is growing rapidly, expecting 50 percent growth in less than three decades. Clearly, traffic congestion can be expected to become much worse in the near future.

The Colorado Department of Transportation (CDOT) has stated for years that Colorado "cannot build its way out of congestion" and must look for cost-effective ways to get better use out of its existing infrastructure to address its growing mobility problems. While an important part of CDOT's responsibility is to maintain and operate the State Highway System, CDOT is not a highway agency but instead a multi-modal transportation agency which supports a wide variety of alternatives to single-occupant vehicle use. As of 2019, CDOT's stated Vision and Mission are as follows:

> ***Vision:*** To enhance the quality of life and the environment of the citizens of Colorado by creating an integrated transportation system that focuses on safely moving people and goods by offering convenient linkages among modal choices.
>
> ***Mission***: To provide the best multi-modal transportation system for Colorado that most effectively and safely moves people, goods, and information.

Much is known about TDM strategies and how they work. CDOT, the Federal Highway Administration (FHWA), the Denver Regional Council of Governments (DRCOG) and other agencies have prepared TDM "handbooks" or "toolkits" over the years. But there has not previously been a comprehensive statewide look at TDM in Colorado.

What TDM efforts are underway in Colorado now and what impact are they having? CDOT undertook this Statewide TDM Plan, Colorado Transportation Options, to answer these questions, and then to identify opportunities for productive future investment of limited available CDOT transportation funds. Phase 1 of this study was an inventory of existing Colorado TDM programs, and Phase 2 examines where and how CDOT can use TDM to address near-term mobility needs.

ES.2 TDM Core Strategies

Section II of this Phase 1 report inventories the strategies that the CDOT 2002 TDM Toolkit called Core Strategies. These focus largely on the travel modes available as alternatives to single-occupant motor vehicle use such as carpooling, transit, vanpooling, bicycling and walking. Also included are three other key TDM measures: telecommuting, variable work hours, and park-and-ride lots.

With regard to local and regional transit service, it was documented that the Denver region serves about ten times as many transit boardings as the rest of the state's metropolitan areas combined, largely because the area has a dedicated sales tax for its Regional Transportation District (RTD), unlike the other Colorado metropolitan areas. Various forms of transit are also available in non-metropolitan areas, and the leading non-metro transit provider by far is the Roaring Fork Transportation Authority (RFTA) which serves the heart of Colorado ski country. CDOT's intercity transit services called Bustang and outrider are increasingly providing long-distance mobility for commuting and non-commuting trip purposes.

Carpool and vanpool matching services are provided by several metropolitan planning organizations and by ski country local governments. Census data indicate a large amount of "organic" carpooling and vanpooling that occurs without the aid of these government programs. Certainly, there is an ever increasing number of national cellphone "apps" that can facilitate this type of travel.

Walking and bicycling comprise the "active transportation" modes that are inexpensive and promote fitness, although they are best suited for shorter trips. Colorado is among the national leaders in bike-friendly travel accommodations and is making concerted efforts to do even better.

Telecommuting is the travel alternative of completely eliminating a trip by working from home. Statistics show that Colorado is a national leader in telecommuting use. Use of variable work hours may reduce commuting trips once or twice weekly, but is also geared toward spreading out the concentrated travel demand of urban rush hours.

Park-and-ride lots do not by themselves offer a commuting alternative, but are keys hubs for intermodal connectivity. Travelers can use any of the modes listed above or drive to a park-and-ride lot to access modal connections. Every car parked in such a lot is a car that is not out on the road adding to the congestion. RTD owns about 30,000 parking spaces (many at light rail stations) and CDOT owns about 3,500 spaces.

ES.3 TDM Support Strategies

The CDOT 2002 TDM Toolkit identified a number of TDM support strategies that do not represent alternative travel modes but encourage or facilitate their use. These can include financial incentives, pricing mechanisms, education programs, preferential parking spots, and intelligent transportation system (ITS) technology. The impacts of some of these programs can be somewhat difficult to measure, but they end up included as part of the use of the core strategies. Support strategies can be especially helpful with regard to temporary situations such as during roadway construction activity or special events. TDM Support Strategies are addressed in **Section III** of this report.

ES.4 TDM Emerging Technologies

Section IV of this Phase I report discusses TDM emerging technologies. Even during the preparation of this report, new transportation technologies have been rapidly emerging. App-driven approaches to short-term rental of automobiles, bicycles and scooters have popped up in Denver and other Colorado cities. Pilot programs with transportation networking companies (TNCs) such as Uber or Lyft have been tried to address the "first-mile/last-mile" gaps between where fixed route transit services go and where they do not.

Meanwhile, the world's largest corporations are investing billions of dollars in a race to develop safe, automated and connected vehicles. At the same time, CDOT and other transportation agencies are developing "SMART" infrastructure so that real-time traffic operations data can be transmitted between vehicles and the roadway infrastructure. One of CDOT's organizational units, called RoadX, exists for the purpose of identifying and supporting new technological approaches to improving mobility and transportation safety. High-speed rail and technologies called HyperLoop and Arrivo also are actively being explored for possible future use in Colorado.

Some of these emerging efforts are hugely expensive, revolutionary technology that does not necessarily fit into the TDM paradigm of "low-cost ways to get more efficient use out of the existing transportation system". However, these technologies will not emerge everywhere all at once, and will be more effective if working cooperatively with ongoing traditional TDM measures to provide intermodal connectivity. Seamless intermodal connectivity emphasizing "Mobility as a Service" (or "Mobility on Demand") is a vision being actively pursued by the international transportation community. In the meantime, however, Colorado traffic congestion will get worse before it gets better (if ever).

ES.5 TDM for Specific Travel Markets

Travel to and from work is a major part of overall transportation demand, but other trip types also result in traffic congestion and can benefit from application of TDM measures. A 2004 FHWA report, Mitigating Traffic Congestion: Demand-Side Strategies, specifically identified the travel market segments that are listed below. These are addressed in **Section V** of this 2019 CDOT TDM report:

- Schools and Universities
- Special Events
- Recreation and Tourism Destinations
- Transportation Corridor Planning and Construction Mitigation
- Employer-Based Commute Programs
- Airports
- Incidents and Emergencies/Courtesy Patrol/Heavy Tow
- Freight Transportation

To emphasize the importance of these topics, it is noted that Colorado has: over 300,000 college or university students; recreation destinations that attract millions of annual visitors; and the fifth busiest passenger/freight airport in the United States.

ES.6 Participation in Colorado TDM Programs

Section VI of this report found the predictable result that existing TDM programs are provided where the congestion is. See **Table ES.1**.The area with the most types of TDM efforts was the Denver region. Interestingly, the Intermountain Transportation Planning Region (Colorado Ski Country) also has very active programs, as does the Fort Collins area which is the home of Colorado State University. TDM efforts largely do not occur in areas of less than 25,000 residents unless the community has a ski resort and its population dramatically swells during the recreation season(s).

Attempting to quantify participation in Colorado TDM programs is a challenge, requiring collection of program information from a wide variety of agencies based on many different types of data and surveys. A key data source for this report was commuting data from the American Community Survey (ACS), which is a Census Bureau product. The ACS data suggest that Colorado has 2.6 million workers and that 2 million of them drive alone to work, while about 600,000 workers do not drive alone. Carpooling is the most widely used commuting alternative, followed by telecommuting.

Transit is a significant commuter mode in the areas where good service is available, principally in the Denver region. Longer distance commuter modes (intercity transit and vanpooling) are used less because there is less demand for long-distance work trips.

Table ES.1: Summary of Existing Colorado TDM Efforts

Summary of Colorado TDM Efforts						
	DRCOG 9 Counties Denver Boulder	***Intermountain Aspen Glenwood***	***NFRMPO Fort Collins***	***PPACG Colorado Springs***	***Southwest Durango***	***Other***
1 Local Bus Transit	✓	✓	✓	✓	✓	✓
2 Light Rail Transit	✓					
3 Bus Rapid Transit	✓	✓	✓			
4 Bustang Intercity	✓	✓	✓	✓	✓	
5 TOD	✓		✓			
6 TMAs	✓					
7 HOV Lanes	✓	✓				
8 Bike Friendly (2015)	Platinum	Silver	Platinum	Silver	Gold	G/S/Bronze
9 Bike Corrals	✓		✓		✓	
10 Regional Vanpool Programs	✓		✓	✓		
11 Carpool Matching Service	✓	✓	✓	✓		
12 Employer Incentives	✓	✓	✓			
13 Marketing Campaigns	✓	✓	✓		✓	
14 Parking Management	✓	✓				
15 Carsharing (rentals)	✓	✓				
16 Bikesharing (rentals)	✓	✓	✓	✓		
17 Calhailing (Uber/Lyft)	✓		✓	✓		
18 Park and Ride Lots	✓	✓	✓	✓		✓

ES.7 Cost of Colorado TDM Programs

Section VII of this Phase 1 TDM report presents the costs of Colorado TDM programs as collected from a wide variety of information sources. The data are not all comparable and are somewhat outdated but do provide an impression of the magnitude of the costs of different program types. Due to differences in expenditure year, among other things, it is difficult to try to estimate an annual statewide total.

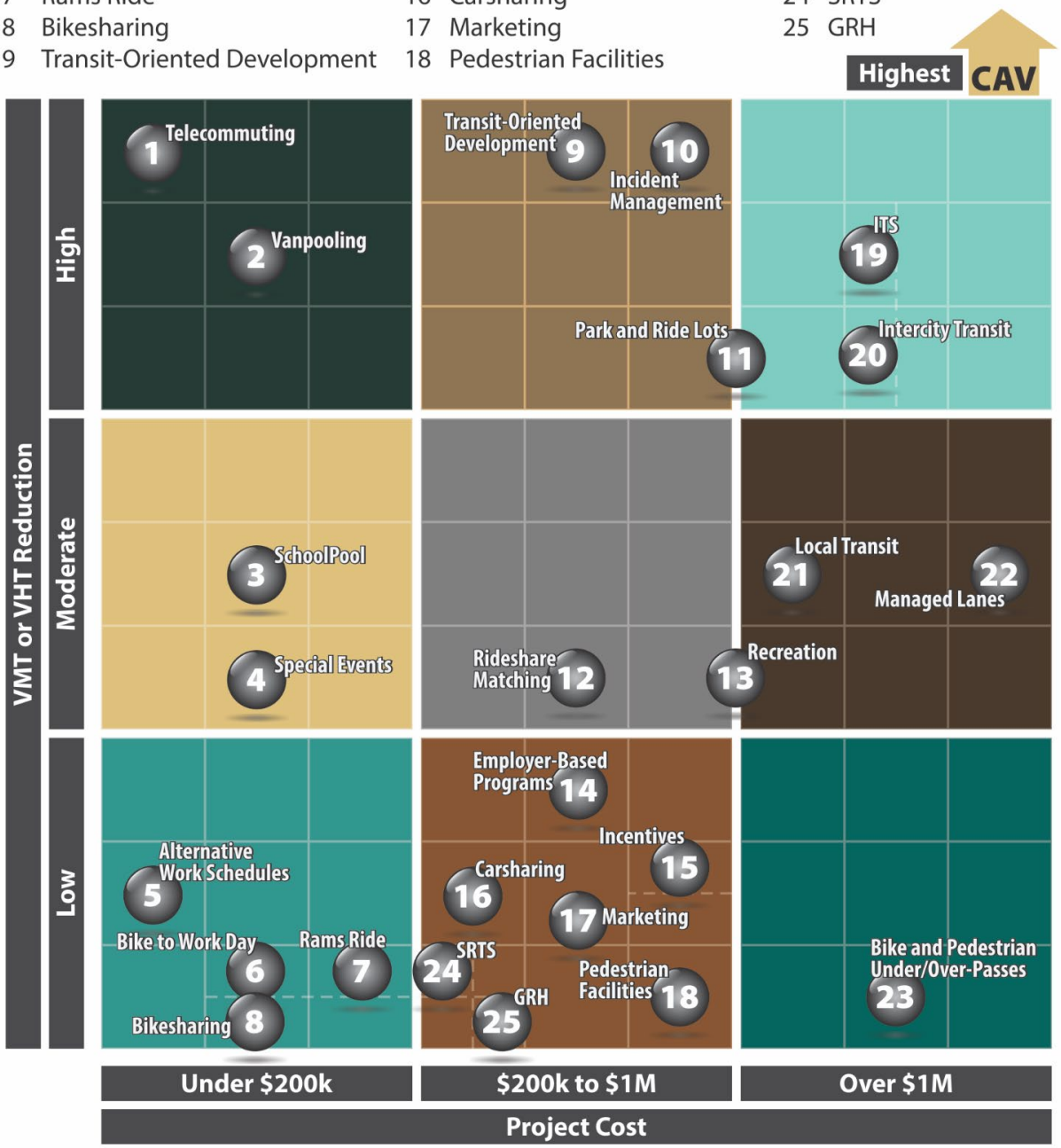
As examples, it was reported that statewide transit operating costs in 2016 were $654 million (this does not include capital costs and does not subtract fare revenue). Intercity buses for CDOT Bustang and Outrider services cost approximately a half million dollars apiece. Four planned CDOT park-and-ride lots were expected to cost a total of $11.5 million, or just under $3 million each. About 40 congestion mitigation bicycle and pedestrian grants made since 1992 have totaled $14 million and thus have averaged $350,000. Seven recent Safe Routes to Schools grants averaged $285,000 apiece.

ES.8 Cost Effectiveness of Current TDM Programs

Section VIII of this report compares reported program costs and participation results in order to assess comparative cost-effectiveness of various types of Colorado TDM efforts. This has been attempted in the past by FHWA in national studies examining TDM effectiveness for reducing motor vehicle emissions. The results of the Colorado effort are provided below, in Figure **ES-2**. This graph indicates for each program type whether its typical costs are low, moderate, or high, and whether its typical resulting travel reduction is low, moderate, or high.

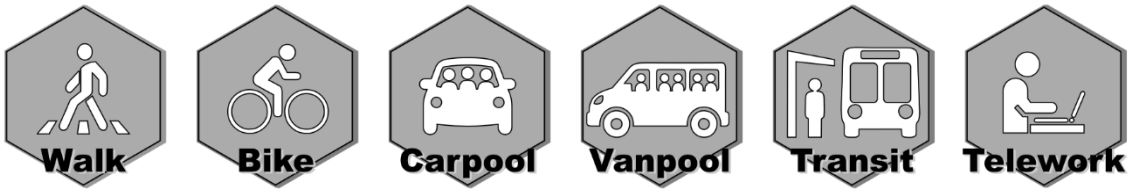
Figure ES.1: Summary of Colorado TDM Cost Effectiveness

1 Telecommuting
2 Vanpooling
3 SchoolPool
4 Special Events
5 Alternative Work Schedules
6 Bike to Work Day
7 Rams Ride
8 Bikesharing
9 Transit-Oriented Development
10 Incident Management
11 Park and Ride Lots
12 Rideshare Matching
13 Recreation
14 Employer-Based Programs
15 Incentives
16 Carsharing
17 Marketing
18 Pedestrian Facilities
19 ITS
20 Intercity Transit
21 Local Transit
22 Managed Lanes
23 Bike and Pedestrian Under/Over-Passes
24 SRTS
25 GRH



Low-cost, high-benefit programs may seem to be ideal, while high-cost, low-impact programs would seem to be less desirable. As an example of the latter, bicycle or pedestrian overpasses tend to be expensive and carry a limited number of fairly short trips; this may not be considered very cost-effective, but may have very important safety benefits. Indeed, these are results for projects which have already been constructed. Vanpooling is a low-cost, high-impact strategy, but there is limited demand for it as most workers choose to not commute 50 miles or more each way on a daily basis. Each of these TDM measures has its own merits and limitations, often dependent on local circumstances.

One caveat for **Figure ES.1** is that it looks at programs in isolation. As a multi-modal transportation agency, CDOT recognizes the value of providing a variety of transportation choices, and in facilitating intermodal connectivity.



COLORADO
Department of Transportation

I. INTRODUCTION

This plan is about transportation choices. If a person in Colorado wants to make a trip, what choices are available? What is the current Colorado Department of Transportation (CDOT) role in facilitating or promoting these choices, and what should CDOT's role be in the future? CDOT wants to encourage strategies to manage the demand placed upon the existing transportation network and to maximize the number of people moving and using the transportation network. Transportation demand management (TDM) strategies may be applied to commuter, recreational, freight, or special event trips.

In 2015, the CDOT 2040 Statewide Transportation Plan, Transportation Matters, set forth four broad goals for meeting transportation needs statewide over the next quarter century (CDOT, 2015). These goals are to:

- improve safety,
- enhance mobility,
- promote economic vitality, and
- preserve and maintain the existing transportation system.

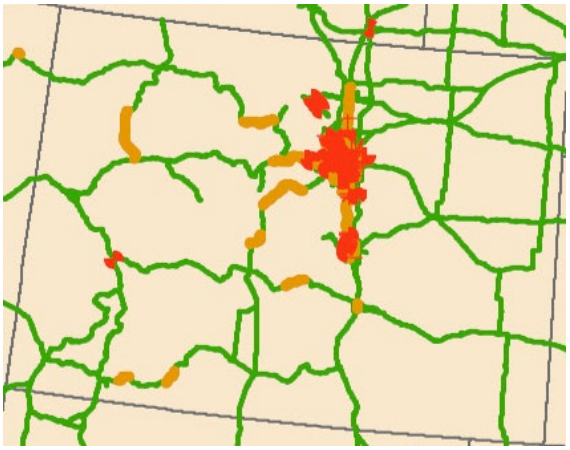
The mobility goal includes the need to improve operational efficiencies and the need to look for opportunities to provide more ***mobility choices*** and connections in future projects.

The need for transportation choices and the viability of certain choices depends on the number of people that could be served. Large concentrations of people and traffic are found along Colorado's Interstate 25 Front Range Corridor, from Colorado Springs through Denver and on to Fort Collins/Greeley/Loveland. Heavy traffic also occurs on I-70 between the Denver area and the mountain communities of Colorado Ski Country. These areas are evident on the accompanying Federal Highway Administration (FHWA) map (**Figure I.1**) of current congestion on the National Highway System.

What happens to the Colorado congestion map when the State's population and vehicle travel demand increase 50 percent by 2040, as projected in Transportation Matters? For every two people traveling in Colorado today, imagine a third in the future. **Figure I.2**, FHWA's peak congestion map for 2040, shows that congestion on NHS routes is expected congestion to worsen dramatically. A recent CDOT publication indicates that Colorado has a roadway "system that we do not have the funds to fully maintain. We have learned – we cannot just build our way out of congestion" (CDOT, 2015b). CDOT has reported projected revenues of $21.1 billion for 2016 to 2040, but identified needs of $46.0 billion, thus reflecting a shortfall of $24.9 billion (CDOT, 2015a). A January

Figure I.1: 2011 Recurring Peak Period Congestion in Colorado

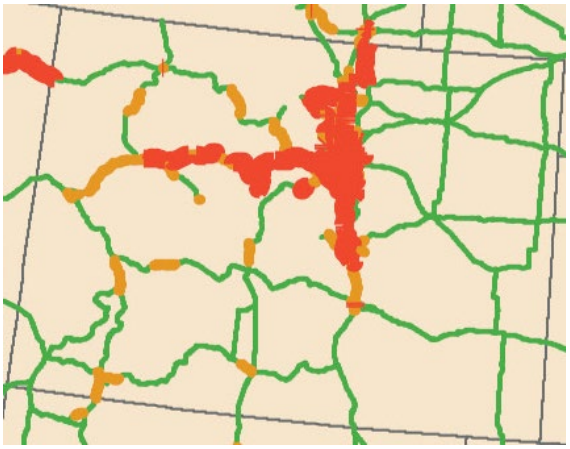
Congestion on National Highway System Routes



Green = uncongested; orange = congested; red = highly congested

Figure I.2: 2040 Recurring Peak Period Congestion in Colorado

Congestion on National Highway System Routes



Green = uncongested; orange = congested; red = highly congested

Source: FHWA, 2015.

2017 report by the U.S. Department of Transportation reported a $926 billion infrastructure investment need nationally (USDOT, 2017a).

I.1 What is TDM?

An important strategy for meeting Colorado's transportation needs is to get more efficient use out of existing transportation facilities. Decades ago, a somewhat cumbersome term was coined to describe this approach – Transportation Demand Management, or TDM. A TDM plan adopted in 2012 by the Denver Regional Council of Governments (DRCOG) explained TDM as follows:

> "Travel Demand Management…
> is a key tool to facilitate mobility options… while reducing single-occupant vehicle (SOV) travel by eliminating or shortening trips, changing the mode of travel, or changing the time of day a trip is made. It includes actions that increase transportation system efficiency through the promotion and facilitation of alternative modes of travel such as, but not limited to, carpooling, vanpooling, transit, bicycling and walking. TDM strategies also include employer-based programs such as alternative work schedules, which can shift demand away from peak travel times, and telework, which can reduce the necessity for trips and reduce demand on the region's transportation system." (DRCOG, 2012a)

TDM strategies are not new. During World War II gasoline rationing, the U.S. government encouraged citizens to save fuel by joining a "car club". During the 1970s, many regional carpool matching agencies began operations in response to the 1973 OPEC oil price shock and the nation's need to reduce urban air pollution as mandated by the 1970 Clean Air Act and 1977 Clean Air Act Amendments. Historically high nationwide carpooling rates of about 20 percent for commuting trips were recorded in 1980, after the second OPEC oil price shock. Carpool rates have been declining ever since. Today, only about 10 percent or less of U.S. commuters carpool.

CDOT developed a TDM Toolkit in 2002 (CDOT, 2002a), and a related report called Transportation Demand Management & Corridor Projects (CDOT, 2002b). The strategies identified in those reports remain valid today, but recent technological advances are rapidly changing the TDM landscape. FHWA noted in its own 2012 TDM Desk Reference that,

> "While traditional TDM strategies such as ridesharing, vanpool, and telecommuting programs are still vital and serve large sections of the population, new opportunities to manage travel demand have emerged in recent years with the advent of technology (and more importantly connectivity) to the transportation arena. Personal technology and communication advances show promise in making personal travel decisions more dynamic and fluid." (FHWA, 2012a)

Today's use of cell phones and computers to find transportation choices is exciting, and another revolutionary change looms large in the foreseeable future. Many motor vehicles today already have various technologies such as cruise control, crash avoidance or parking assistance. Vehicle makers around the world are racing to develop "driverless cars" for the future. Fully automated and connected vehicles could operate closer to one another with improved safety and thus a given amount of roadway space

could serve greater vehicle throughput. Such vehicles would also improve mobility for people who are unable to drive.

Automated and connected vehicle technology promises to reduce crashes, which are a major cause of congestion. It would also reduce driver stress and enable the user to tend to other tasks instead of driving. The change will not be instantaneous. There will be a transition phase of possibly decades when some vehicles are automated and some are not.

Demographic change also is influencing the need for future transportation choices. The Baby Boom generation (1946 to 1964) after World War II grew up with the opening of the Interstate Highway system and long enjoyed high levels of automobile availability. This age group is now beginning to enter into retirement years. Although their work commute trips will decline, this generation is likely to demand a high level of mobility in their older years.

Some recent transportation literature suggests that the Millennial generation (born between 1983 and 2000) drives less than the Baby Boomers (USPIRG, 2013, 2014). This is reflected in current regional transportation plans, such as the DRCOG *2040 Metro Vision Transportation Plan (*DRCOG, 2015a), which indicates that regional vehicle miles of travel (VMT) per capita historically grew between 1970 and 2000, but has recently slowed. DRCOG's *2015 Annual Report on Traffic Congestion in the Denver Region* (DRCOG, 2016a) indicates that VMT per capita peaked in 2006 at almost 27 miles per day, then declined and leveled off at 24 miles per day for 2011 to 2014. A major national recession that began in 2008 may have influenced these findings. Also, if Millennials are delaying their child-raising years, perhaps their VMT will increase in the near future. In any event, due to continued population growth, ***total travel demand will continue to increase*** in the coming decades, both in the Denver region and around the state, even if travel per capita does not increase.

FHWA Guidance:

FHWA's 2012 TDM Desk Reference defines Transportation Demand Management as "a set of strategies aimed at maximizing traveler choices." As an alternative to building more lane-miles, TDM strategies seek to get improved efficiency out of existing transportation infrastructure. (FHWA, 2012)

The agency's report called Mitigating Traffic Congestion (The Role of Demand-Side Strategies) indicates that, "[In] the 21st Century, strategies to manage demand will be more critical to better transportation operations and system performance than strategies to increase capacity (supply) of facilities." (FHWA, 2004)

The latter report adds that, "Managing demand in the 21st Century goes beyond just encouraging travelers to change their travel mode from driving alone to a carpool, vanpool, public transit vehicle, or other alternative. Managing travel demand today is about providing travelers, regardless of whether they drive alone or not, with informed choices of travel route, time, and location – not just travel mode."

I.2 Population by Region

Many of the TDM programs discussed in this report are found in Colorado's largest metropolitan areas, which are the Denver region (2010 population 2.8 million), Pikes Peak region (0.7 million) and North Front Range region (0.5 million). Each of these areas is served by a designated Metropolitan Planning Organization (MPO) as required under Federal transportation regulations. These are:

- Denver Regional Council of Governments (DRCOG)
- Front Range Metropolitan Planning Organization (FRMPO)
- Pikes Peak Area Council of Governments (PPACG)

Two other Colorado urban areas exceed 50,000 residents, so they also have an MPO, although they have less congestion and less TDM involvement:

- Pueblo Area Council of Governments (PACOG)

- Grand Valley MPO (serving the Grand Junction area)

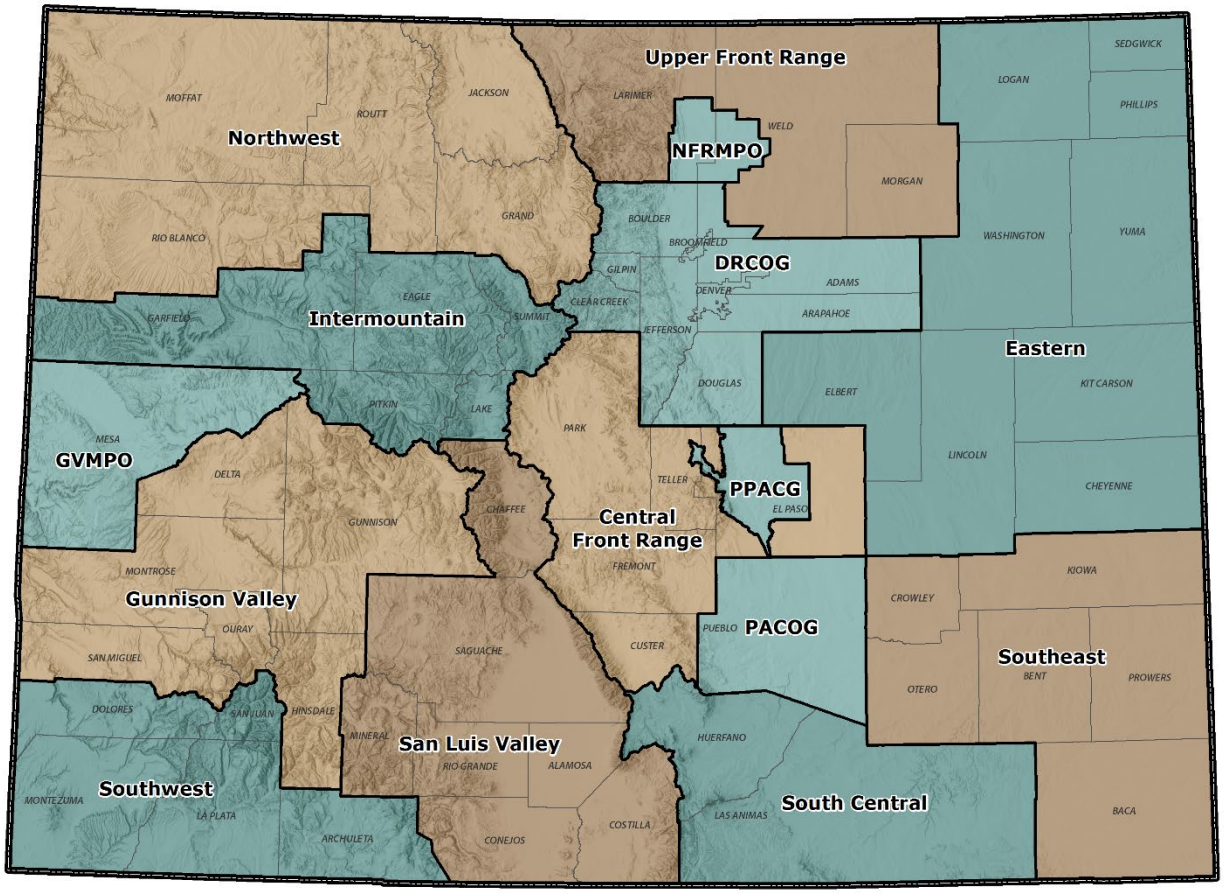
The rural counties of Colorado do not have MPOs but instead work cooperatively through ten Transportation Planning Regions (TPRs). These are generally named after the portion of the state where they are located (e.g., Southeast, Northwest).

Table I.1 presents population data for all 15 planning areas (five MPOs and ten TPRs) and **Figure I.3** shows the boundaries for these areas. Each of these 15 planning entities periodically updates its regional transportation plan, which identifies existing conditions, trends, and transportation needs (MPOs, 2015; TPRs, 2015). These plans describe the various TDM modes available in the respective regions.

Table I.1: Metropolitan Planning Organizations and Transportation Planning Regions

Metropolitan Planning Organizations and Transportation Planning Regions				
	Planning Organization	***2010 Population in 1000's***	***Largest City***	***Counties, Number and Names***
MPOs	Denver Regional Council of Governments (DRCOG)	2,799	Denver	9: Adams, Arapahoe, Boulder, Broomfield, Clear Creek, Denver, Douglas, Gilpin, Jefferson
	Pikes Peak Area Council of Governments (PPACG)	651	Colorado Springs	2: El Paso (part), Teller (part)
	North Front Range MPO	489	Fort Collins	2: Larimer (part), Weld (part)
	Pueblo Area Council of Governments (PACOG)	159	Pueblo	1: Pueblo
	Grand Valley MPO	147	Grand Junction	1: Mesa
TPRs	Intermountain TPR	161	Glenwood Springs	5: Eagle, Garfield, Lake, Pitkin, Summit
	Gunnison Valley TPR	100	Montrose	6: Delta, Gunnison, Hinsdale, Montrose, Ouray, San Miguel
	Central Front Range TPR	96	Cañon City	4: Custer, El Paso (part), Fremont, Park, Teller (part)
	Upper Front Range TPR	95	Fort Morgan	3: Larimer (part), Morgan, Weld (part)
	Southwest TPR	92	Durango	5: Archuleta, Dolores, La Plata, Montezuma, San Juan
	Eastern TPR	83	Sterling	9: Cheyenne, Elbert, Kit Carson, Lincoln, Logan, Phillips, Sedgwick, Washington, Yuma
	San Luis Valley TPR	64	Alamosa	7: Alamosa, Chafee, Conejos, Costilla, Mineral, Rio Grande, Saguache
	Northwest TPR	60	Steamboat Springs	4: Grand, Jackson, Moffatt, Rio Blanco, Routt
	Southeast TPR	48	Lamar	6: Baca, Bent, Crowley, Kiowa, Otero, Powers
	South Central TPR	22	Trinidad	2: Huerfano, Las Animas

Figure I.3: MPO and Transportation Planning Region Boundaries



I.3 Existing Congestion Levels

A study of congestion in many U.S. cities is conducted periodically by the Texas A&M Transportation Institute (TTI). The study estimates the number of hours of delay due to congestion and assigns a dollar cost value to that delay. The 2014 *Mobility Scorecard* (TTI, 2015) included cities in all five Colorado MPO regions, but none in any of the ten TPRs. The results are shown in **Figure I.4** and **Figure I.5**. (Note: The next TTI Mobility Scorecard is expected to be released in 2018.)

Figure I.4: Estimated Annual Delay Due to Congestion, by MPO (Million hours per year)

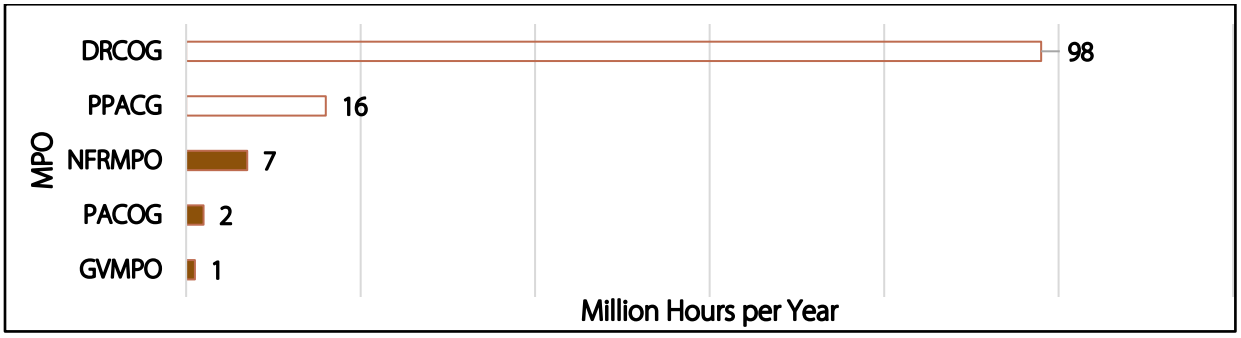
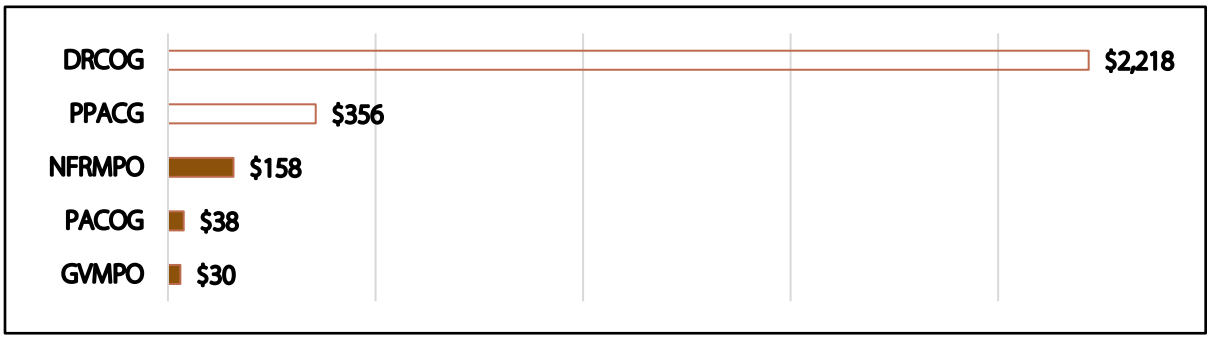


Figure I.5: Estimated Annual Cost of Delay Due to Congestion, by MPO (M $ per year)



The TTI results suggest that time and money lost to congestion are highest for the most populated metro area, the Denver region, at 98 million hours and $2.2 billion annually in 2014. Congestion costs in time and money are lower for the other MPOs, generally in relation to the regional population of each. Dividing the Denver numbers by population yields approximately 35 annual hours of delay and $800 annual delay cost per resident. The TTI report did not include data for smaller Colorado communities in the various TPRs.

A 2009 Census Bureau study estimated that the average American commuter spends 1.2 years commuting over his or her lifetime.

(Census Bureau, 2009)

All of these figures are estimates dependent on various assumptions, so the exact numbers are not important. The key message is that congestion is a costly problem and that the magnitude of the problem varies by metro area. Most of Colorado's congestion occurs in the Denver metro area.

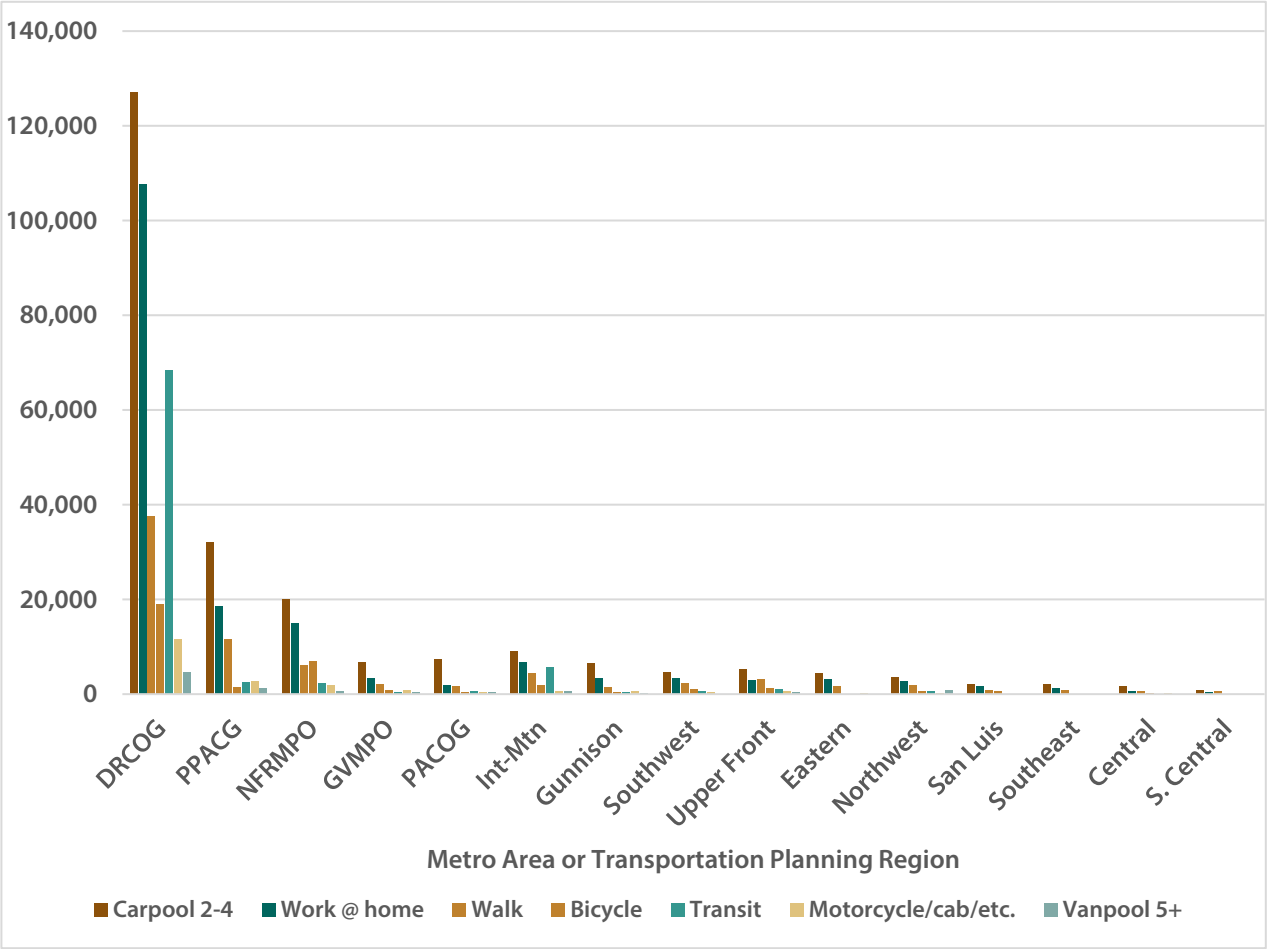
I.4 Transportation Mode Use by Region

Year 2015 Census Bureau estimates of transportation mode from the American Community Survey (ACS) are also shown in **Figure I.6**. Colorado has an estimated 2.6 million workers, of whom about 1.5 million are in the Denver metro area. The Denver metro area accounts for more than half the statewide workers, and also more than half the use for every transportation mode. Figure I.6 omits the 75 percent of state residents who commute by driving alone, and focuses on showing use of all other transportation modes. In every region of the state, carpooling is the most-used alternative to driving alone, and working at home is the second most-used alternative.

In **Figure I.6**, the regions are ordered not by residential population by instead by the number of estimated commuters in the region.

These ACS estimates from the Census Bureau differ from other reported results in Colorado regional transportation plans and from a Front Range Travel Survey done in 2010. However, the ACS data cover all geographic areas of interest and were prepared in a uniform manner, thus offering comparability. Unfortunately, the ACS estimates are far from perfect. For example, ACS data indicate that 274 persons in Colorado commuted by ferryboat, including 106 persons in the Denver metro area. The correct numbers for ferryboat use throughout Colorado should probably be zero. The exact numbers for alternative mode use are not as important as the relative mode use within a region and the differences between regions.

Figure I.6: Commuter Transportation Use Other than Driving Alone by Region



Source: ACS, 2015.

Table I.2 and **Table I.3** present the numbers that are charted in **Figure I.6**. **Table I.2** also contains ACS data for the ***cities*** of Denver and Boulder. Added at the end of **Table I.2** are results for downtown Denver only, taken from a 2015 survey (Downtown Denver Partnership, 2015). This is not ACS data. These results show extremely different commuter choices for dense downtown Denver than are characteristic of the rest of the city.

For example, solo driving in downtown Denver is roughly half the rate found citywide, and the 40.6 percent rate of transit usage in downtown is totally unlike the rates of one to six percent found elsewhere. High parking costs in downtown Denver contribute to this outcome.

These data show extremely different commuter choices for dense downtown Denver than are characteristic of the rest of the city. For example, solo driving in downtown Denver is roughly half the rate found citywide, and the 40.6 percent rate of transit usage in downtown is totally unlike the rates of one to six percent found elsewhere. High parking costs in downtown Denver contribute to this outcome.

Table I.2: Metro Area Estimated Transportation Mode of Commuter Trips

2015 Transportation Mode of Commuter Trips in Percent								
Place	***Drive Alone***	***Carpool 2 to 4 Persons***	***Work at Home***	***Transit***	***Walk***	***Bike***	***Other: Taxi, Motorcycle***	***Vanpool 5+ Persons***
National Total *	76.4	9.0	4.4	5.1	2.8	0.6	1.3	0.4
Colorado Total *	75.3	9.1	6.7	3.2	3.0	1.3	1.1	0.4
Denver Metro	75.1	8.3	7.0	4.5	2.5	1.2	1.0	0.3
Colorado Springs Metro	78.0	9.9	5.8	0.8	3.6	0.5	1.2	0.4
Fort Collins Metro	76.3	8.9	6.6	1.0	2.5	3.0	1.2	0.3
Pueblo Metro	79.9	11.5	3.0	0.7	2.7	0.5	0.7	0.7
Grand Junction	78.1	10.0	5.1	0.5	2.9	1.2	1.7	0.4
Selected Locales within Denver Region								
City of Denver	70.3	8.2	6.5	6.8	4.5	2.3	1.0	0.3
City of Boulder	52.5	5.0	11.7	8.4	10.6	10.4	1.3	0.2
Source: US Census Bureau, 2016.								
Downtown Denver	38.5	5.2	2.2	40.6	5.6	6.5	1.2	0.2
Source: Downtown Denver Partnership, 2016. Note: * National and State totals include both urban and rural areas, and thus are not comparable to the rest of the percentages in this table of metropolitan areas.								

Table I.3: TPR Estimated Transportation Mode of Commuter Trips

2015 Transportation Mode of Commuter Trips in Percent								
Place	***Drive Alone***	***Carpool 2 to 4 Persons***	***Work at Home***	***Transit***	***Walk***	***Bike***	***Other: Taxi, Motorcycle***	***Vanpool 5+ Persons***
Intermountain	68.3	9.9	7.3	6.2	4.7	2.0	0.7	0.7
Gunnison Valley	66.5	12.0	6.8	2.3	7.2	2.8	1.4	0.9
Southwest	71.7	10.4	7.3	1.3	5.3	2.3	1.4	0.3
Upper Front Range	79.2	10.5	5.2	0.6	2.3	0.6	1.2	0.4
Eastern	74.6	11.5	8.2	0.4	4.2	0.1	0.8	0.4
Northwest	68.1	11.0	8.1	1.8	5.8	1.9	0.7	2.6
San Luis Valley	73.5	10.5	8.1	0.4	4.0	2.7	0.4	0.2
Southeast	75.2	11.1	6.7	0.5	4.8	0.4	1.2	0.0
Central Front Range	76.9	10.8	4.9	0.4	3.3	1.1	1.2	0.4
South Central	72.8	11.2	5.0	1.2	7.9	0.2	1.0	0.6
Source: US Census Bureau, 2016.								

Driving alone is the most-chosen means of transportation to work in every metro area and every planning region of Colorado. In the figures, the highest drive-alone percentage is found in Pueblo (79.9%).

Carpooling is the most-used commuting alternative to driving alone in all regions of the state. An estimated 233,000 workers carpool, out of 2.5 million workers. Among the urban areas, carpooling is highest in Pueblo (11.5%). Carpool rates of 10 to 12 percent are typical in the non-metro transportation planning regions. Carpooling is lowest in the cities of Denver (5.2%) and Boulder (5.0%), where the transit use is highest. This suggests that people will use transit where good service is available, but otherwise must settle for carpooling.

Working at home is the second-most used commuting alternative in every region of the state. An estimated 172,000 workers statewide work at home on a regular basis, according to the 2015 ACS data. The City of Boulder had the highest rate (11.7%) of teleworkers. Rates of 5 to 8 percent were typical in non-metro TPRs.

In most parts of Colorado, **walking** to work is the third most-used alternative to driving alone, but not in the Denver metro area and the Intermountain TPR, where extensive transit options are available. Walking to work accounts for 2.5 to 3 percent of work trips in metro areas, and higher percentages in the non-metro regions. Highest rates were noted in Boulder and downtown Denver.

Bicycle commuting is most prevalent in the City of Boulder (10.4%) and downtown Denver (6.5%). Boulder is home to the University of Colorado (32,000 students) and is a very bicycle-oriented community, as discussed later in this report. Bicycling commuter rates of 1 to 2 percent are typical in metro areas while rates of 2 to 3 percent are typical in non-metro TPRs.

Transit includes bus, light rail, commuter rail, and other services. Transit accounts for about 40 percent of commuting to downtown Denver, 8.4% of commuting in the City of Boulder and 6.2 percent of commuting in the Intermountain TPR. Commuting rates of less than one percent are typical in most other urban and non-urban areas where transit service is less robust.

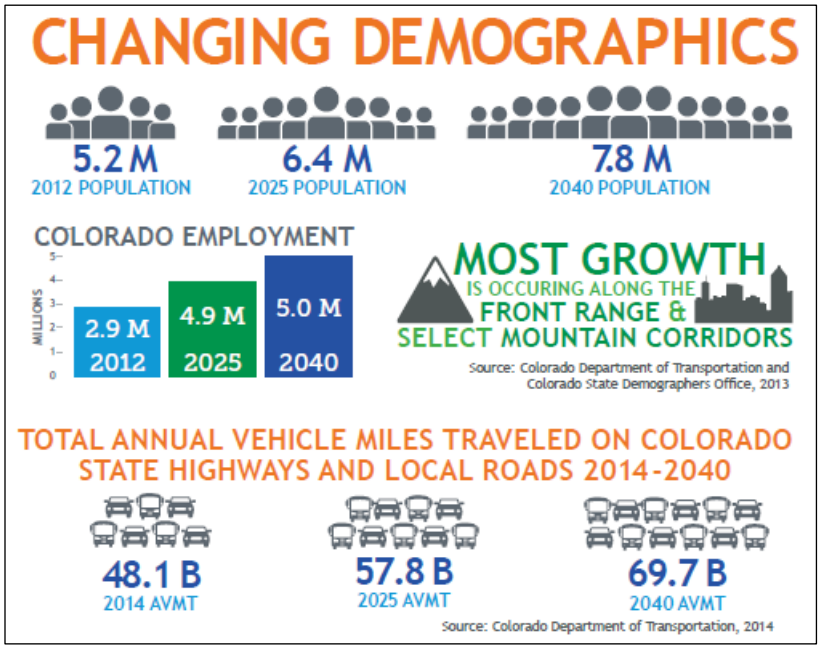
Vanpooling is the least used transportation alternative, accounting for less than half of one percent in most Colorado regions. ACS data categorize carpools by number of occupants. Persons in a non-transit vehicle with five or more occupants are shown as vanpools in **Table I.2**. Formal public vanpool programs are available in the Denver, North Front Range and Pikes Peak regions.

I.5 Planning for the Future

Referring back to the congestion maps in **Table I.1** and **Table I.2,** congestion can be expected to increase throughout the state in the future, and particularly in the fastest growing areas.

Figure I.7, from Colorado's Statewide Transportation Plan, indicates a 50 percent expected increase in the state's population between 2012 and 2040, and nearly 50 percent increase in vehicle miles traveled between 2014 and 2040.

Figure I.7: Colorado Population and Traffic Growth Outlook



For each two people in Colorado today, expect a third person in 2040.

For each two vehicles on the road in Colorado today, expect a third vehicle in 2040.

Source: CDOT, 2017a.

Some Colorado communities have established specific quantitative goals for managing their future vehicle use. Examples discussed here are the Denver region, the City of Boulder, and the City of Aspen.

The DRCOG 2035 *Metro Vision Plan* sets the following inter-related goals pertaining to transportation, greenhouse gas emissions and land use:

- Reduce the percent of trips to work by single occupancy vehicles (SOV) to 65 percent by 2035
- Reduce the regional per capita VMT by 10 percent by 2035
- Reduce the annual per capita greenhouse gas emissions from the transportation sector by 60 percent by 2035
- Urban centers will accommodate 50 percent of new housing and 75 percent of new employment between 2005 and 2035

Recall from **Table I.2** that the percent of SOV (Drive Alone) trips in the Denver Region for 2015 was estimated as 77.2 percent, so the 65 percent goal would represent a major reduction. The greenhouse gas emission goal will not require a 60 percent reduction in driving because tighter Federal motor vehicle standards mandated in 2011 call for increasingly cleaner vehicles in the years ahead. Concentration of new housing and new jobs in specified urban centers means increased development and redevelopment densities, particularly in the vicinity of light rail stations.

The City of Boulder, already shown to be the state's leader in alternate mode use (see **Table I.2**, presented earlier), desires to take that effort to the next level. The city's 2014 Transportation Master Plan calls for major reductions in SOV use by 2035, coupled with increases in the use of all alternative modes. These goals are presented in **Table I.4**. In this table, multiple-occupant vehicles means carpools and vanpools. Note that Boulder desires a reduction in the multi-occupant travel percentage by its residents, converting some of this to non-motorized modes.

Table I.4: City of Boulder Transportation Mode Targets for 2035

City of Boulder 2035 Transportation Mode Choice Targets for 2035				
Travel Mode	***Resident Travel***		***Non-Resident Travel***	
	Current	***2035 Target***	***Current***	***2035 Target***
Pedestrian	20%	25%	0%	0%
Bicycle	19%	30%	1%	2%
Transit	5%	10%	9%	12%
Drive Alone	36%	20%	80%	60%
Multi-Occupant	20%	15%	10%	26%
Source: City of Boulder, 2014.				

Aspen is a premier Colorado skiing destination located approximately 220 miles west of Denver. The 1993 *Aspen Area Community Plan* adopted policies and strategies seeking to limit traffic at 1993 baseline levels through the year 2015 (which has now passed). Its 2012 Plan update calls for continued efforts to reduce peak-hour vehicle trips to below 1993 levels (City of Aspen, 2012).

Aspen today is served by the state's second largest transit system (after Denver's Regional Transportation District), the Roaring Fork Transportation Authority, which is discussed later in this report. Aspen also has a free carpool matching service ("Commuter Connect") and provides free parking permits for carpools.

Colorado Springs and Pueblo do not have aggressive mode share targets such as those discussed above, but do call for expansion of transportation alternatives. The 2012 Pikes Peak Area Council of Governments Sustainability Plan called for doubling transit use in the Colorado Springs Area from 1.2 percent to more than 3 percent by the year 2030, noting that a new, dedicated funding source would be needed to make this happen (PPACG, 2012). The 2040 Long Range Transportation Plan adopted by the Pueblo Area Council of Governments calls for more than doubling its facilities available for bicycling from 531 existing miles to 1,243 miles in the future (PACOG, 2016).

COLORADO
Department of Transportation

II. TDM CORE STRATEGIES

TDM strategies are often associated with commuter trips to work. This is logical because work trips are frequent (e.g., five days per week) so they have a large contribution to congestion. Since work trips also have a predictable, repetitive trip origin and destination (home and work), targeted efforts can be used to provide effective alternatives to driving alone. Accordingly, much of this report focuses on TDM measures that address work trips. Other trip types will be addressed in **Section V** of this report.

CDOT's 2002 TDM Toolkit identified a list of TDM core strategies, which are mostly the actual transportation modes used to reduce vehicle use, and a list of TDM support strategies, which are ways to increase the use of those modes. These are listed in **Table II.1** below.

Table II.1: CDOT TDM Toolkit Strategies

TDM Strategies	
Core TDM Strategies	***TDM Support Strategies***
Transit – Local/Regional	Rideshare Matching
Intercity Transit	Guaranteed Ride Home
Vanpools	Parking Management
Carpools	Incentives
Walking	Marketing and Education
Bicycling	Market-Based Strategies
Variable Work Hours	Intelligent Transportation Systems
Telecommuting	TDM-Friendly Design Considerations
Source: CDOT TDM Toolkit, 2002.	

The core strategies listed above are discussed in this chapter, followed by a discussion of Park-and-Ride Lots. The TDM support strategies are discussed in **Section III**.

II.1 Transit (Local/Regional)

CDOT's Division of Transit and Rail prepared the 2015 Statewide Transit Plan "to establish a framework for creating an integrated statewide transit system that meet the mobility needs of Coloradans, while minimizing duplication of efforts and leveraging limited funds." The plan notes that "Transit comes in many forms and is not limited to urban areas – some form of transit is available in many parts of the state."

The Statewide Transit Plan identifies a total of eight urban transit systems in Colorado, as listed in **Table II.2**. The largest of these is the Regional Transportation District (RTD) serving the metro Denver area, which is funded by a regional one percent sales tax. Sales and use tax provided 54.8% of RTD's total revenues in 2014, while fares provided an additional 12.8% (RTD, 2015).

Most ***urban transit systems*** in Colorado do not have a dedicated tax revenue like RTD does. Urban transit systems in Colorado Springs and Fort Collins serve about one-thirtieth as many passengers as RTD, and the other urban bus systems in Colorado carry fewer passengers, as detailed in **Table II.2**. These are transit agency profile data reported for 2016 (FTA, 2017).

Table II.2: Colorado Urban Transit System Data for 2016

Colorado Urban Transit Systems		
Urban Transit System	***Annual Boardings (in Millions)***	***Annual Operating Costs (Millions $)***
Regional Transportation District – Denver	103	521
Mountain Metro – Colorado Springs	4.1	15
TransFort – Fort Collins	3.4	20
Pueblo Transit System	0.9	4.7
Grand Valley Transit – Grand Junction	0.8	3.5
Greeley-Evans Transit (GET)	0.7	3.8
City of Loveland Transit (COLT)	0.2	1.1
Berthoud Area Transit	0.1	1.4
FTA, 2017.		

In 2014, about 61 percent of RTD's boardings were made on regular bus routes, 25 percent on light rail, and 14 percent on Free MallRide, Free MetroRide, Call-n-Ride, Access-a-Ride, and special event service (RTD, 2015). On U.S. Highway 36 between Denver and Boulder, RTD also operates bus rapid transit (BRT) service called the "Flatiron Flyer." BRT service is also provided in Fort Collins ("MAX") and offered between Aspen and Glenwood Springs ("VelociRFTA"). See **Figure II.1**.

Figure II.1: TransFort MAX Bus Rapid Transit Vehicle

Usage and cost statistics for Colorado's ***rural transit systems*** are presented below in **Table II.3**. The boarding data listed below for rural transit generally are totals for a number of small transit systems across a multi-county area. Many of these do not offer fixed route service but are demand-responsive. In some cases, users have to call one or more days ahead of time to request a ride.

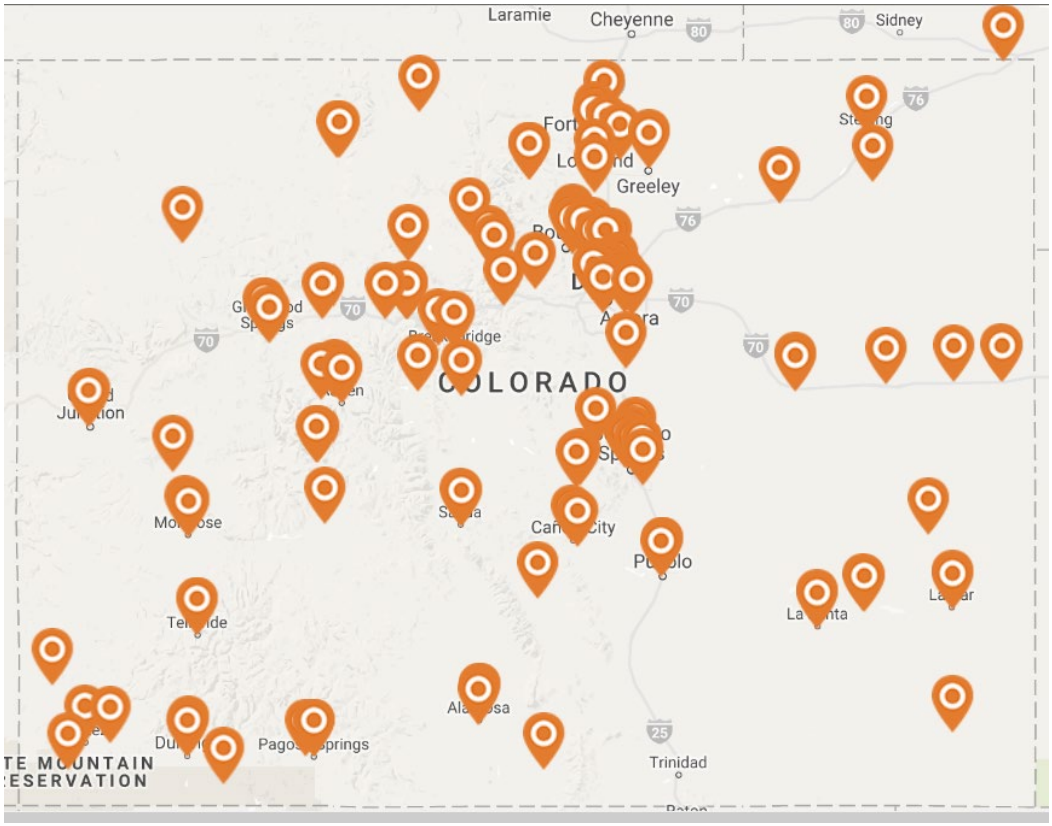
Table II.3: Colorado Rural Transit System Data for 2016

TDM Strategies		
Transportation Planning Region *Regions listed in order of total ridership; Providers in each region listed in order of ridership*	***Annual Boardings (in Millions)***	***Annual Operating Costs (Million $)***
Intermountain (8): Roaring Fork Transportation Authority; Summit County; Eagle County RTA; Town of Breckenridge; Town of Snowmass Village; City of Glenwood Springs; Crested Butte; Garfield County	9.2	$57
Southwest (7): Town of Mountain Village*; City of Durango; Town of Telluride; San Miguel County; Southern Ute Community; Montezuma Senior Service; Dolores County Senior Services	3.7	8.6
Northwest (2): City of Steamboat Springs; City of Winter Park	1.7	5.6
Gunnison Valley (2): GV Transportation Authority; Montrose County Seniors	0.2	2.3
Eastern (2): NE Colorado ALG; East Central Council of Local Governments	0.2	1.5
Central Front Range (3): City of Cripple Creek; Cañon City Golden Age Council; Wet Mountain Valley	0.07	0.7
Southeast (2): Prowers County; City of La Junta	0.04	0.5
South Central (1): Huerfano/Las Animas COG	0.03	0.6
San Luis Valley (1): Neighbor to Neighbor	0.01	0.2
NON-TRR, Non-"Urban" (4): Via Mobility Services (Boulder); NFRMPO; Senior Resource Development Agency (Pueblo); Seniors' Resource Center (Boulder)	0.3	6.0
Source: FTA, 2017; Note: * Town of Mountain Village has free gondola transit, 2.8 million annual boardings.		

The boundaries of the areas served by the respective regional planning entities referenced in **Table II.3** were previously presented in **Table I.3.** The locations of Colorado transit operators, both urban and rural, are mapped in **Figure II.2**.

A highly unusual rural transit system is the Roaring Fork Transit Authority (RFTA), which operates in the Intermountain Transportation Planning Region (TPR). RFTA is ***the largest rural transit system in the U.S.***, the second largest transit system in Colorado (after RTD), and the first rural transit agency to construct and operate a Bus Rapid Transit (BRT) system. In operation since 1983, RFTA serves the communities of Aspen, Snowmass Village, Pitkin County, Basalt, and a portion of Eagle County, Carbondale, Glenwood Springs and New Castle. The name of the BRT service is VelociRFTA and the logo is a speedy velociraptor dinosaur. RFTA routes within Aspen (Pitkin County) are fare-free.

Figure II.2: Map of Colorado Transit Agencies



Colorado Association of Transit Agencies (CASTA), 2017.

Summit Stage, another transit system in the Intermountain TPR, provides fare-free service in Breckenridge (Summit County). Local service in Steamboat Springs is also free. Free transit service avoids boarding delays and reduces administrative hassle (but also revenue) for the operator.

Free transit service in mountain ski areas helps to reduce congestion as well as air pollution, which could easily be trapped by thermal inversions in mountain valleys. It also responds to the reality that housing prices in ski resort areas may be unaffordable for ski resort workers who necessarily must live somewhere cheaper and commute to the resorts. For example, Census data suggest that 87 percent of those who work in the Town of Breckenridge live outside the town (Town of Breckenridge, 2016). Free transit service decreases parking demand in mountain communities where meeting visitor parking needs is often a challenge. Additionally, free fare transit is a way that resort areas cater to tourists.

Figure II.3: Aspen's Free "Downtowner" Micro-Transit

Aspen's free Downtowner "microtransit" service began in June, 2016. In partnership with the city, a private company provides door-to-door rides in compact, five-passenger electric vehicles resembling elaborate golf carts. See **Figure II.3**. Two or three Downtowner vehicles are in operation at any given time, until 11:00 PM daily. Ridership for the first year

(mid 2016 to mid-2017) was 45,732 passengers. This is an average of more than 100 passengers per day. Since ridership on City services generally increased in 2016, it appears that the Downtowner ridership did not diminish fixed-route transit ridership, and may have helped to increase it. While rides can be hailed from the street or ordered through a mobile app, 97 percent are generated through the app. The service provider, Downtowner Inc., also operates in three other U.S. cities (Aspen Times, 2016).

Steamboat Springs Transit offers two trips of regional service in the morning from Craig into Steamboat Springs and two trips in the evening back to Craig, at the cost of $6 for the 42-mile, one-way trip, with intermediate stops in the communities of Milner and Hayden. The RouteShout app (www.RouteShout.com) is used to enable riders to find out when the next bus is coming (Steamboat Springs, 2018).

The City of Lone Tree identified a transit gap not served by the RTD and in 2014 partnered with private sector employers to provide weekday circulator service called the Lone Tree Link. This free shuttle, with service every ten minutes, connects major employers on Park Meadows Drive with the Lone Tree RTD light rail station. The Link consists of four 14-passenger, gasoline- powered buses. It is estimated that the service served 60,000 boardings in its first year (or roughly 250 per day) at a cost of $775,000. Of this, $250,000 was paid by the city, and the remainder by the private employers (Denver Post, 2016a; Castle Pines Connection, 2015). In 2017, the City announced it was teaming with Uber to provide free service anywhere inside City limits (KDVR, 2017).

In addition to the transit systems discussed above, human service organizations often provide specialized transportation for clients of their programs. There are about 45 such providers in the Denver area and a total of 82 in the five urban areas served by MPOs. Examples include Via Mobility (Boulder), Seniors' Resource Center (Denver), Silver Key Senior Services (Colorado Springs), Senior Resource Development Agency (Pueblo), and Colorado West Mental Health (Grand Junction).

II.2 Intercity Transit

Intercity transit serves passengers traveling between cities or metro areas, rather than local trips within those areas. The Statewide Transit Plan notes that some intercity transit services are not well suited for commuting purposes, due to their infrequent service. These include both Amtrak routes (the California Zephyr and the Southwest Chief) in Colorado, along with existing intercity bus services such as Greyhound, Trailways, and Los Paisanos. These services serve important trips, but typically not commuting trips.

Intercity Rail Service

A number of studies have been completed over the years to examine the feasibility of passenger rail service along the Colorado Front Range (generally following north-south Interstate 25), or between Denver and the mountain ski areas (following I-70 on the map). There is considerable public interest and support in these ideas, but lack of funding has typically been the obstacle to pursuing these.

I-70 West Mountain Corridor: CDOT's Advanced Guideway System (AGS) Feasibility Study was completed in August 2014 and evaluated technology, alignment and funding/financing options to determine the technical and financial feasibility of a high-speed transit system for the 120- mile segment of the I-70 Mountain Corridor from C-470 in Jefferson County to Eagle County Regional Airport. It concluded that, "As of 2014, the AGS is not financially feasible. There are no current local/state/federal funding sources identified to cover the AGS capital costs." Those capital costs were estimated at $13.3 to $16.5 billion (CDOT, 2014b).

I-25 Corridor, Denver to Fort Collins: The Preferred Alternative in CDOT's 2001 *North I-25 Final Environmental Impact Statement* (FEIS) included commuter rail service with nine stations connecting Fort Collins to downtown Denver. The Record of Decision for this FEIS identifies the need for $26.2 million to

preserve right-of-way for future commuter rail (CDOT, 2011).The 2014 CDOT *Interregional Connectivity Study* estimated the cost of high-speed rail connecting these communities to be $2.5 billion (CDOT, 2014c).

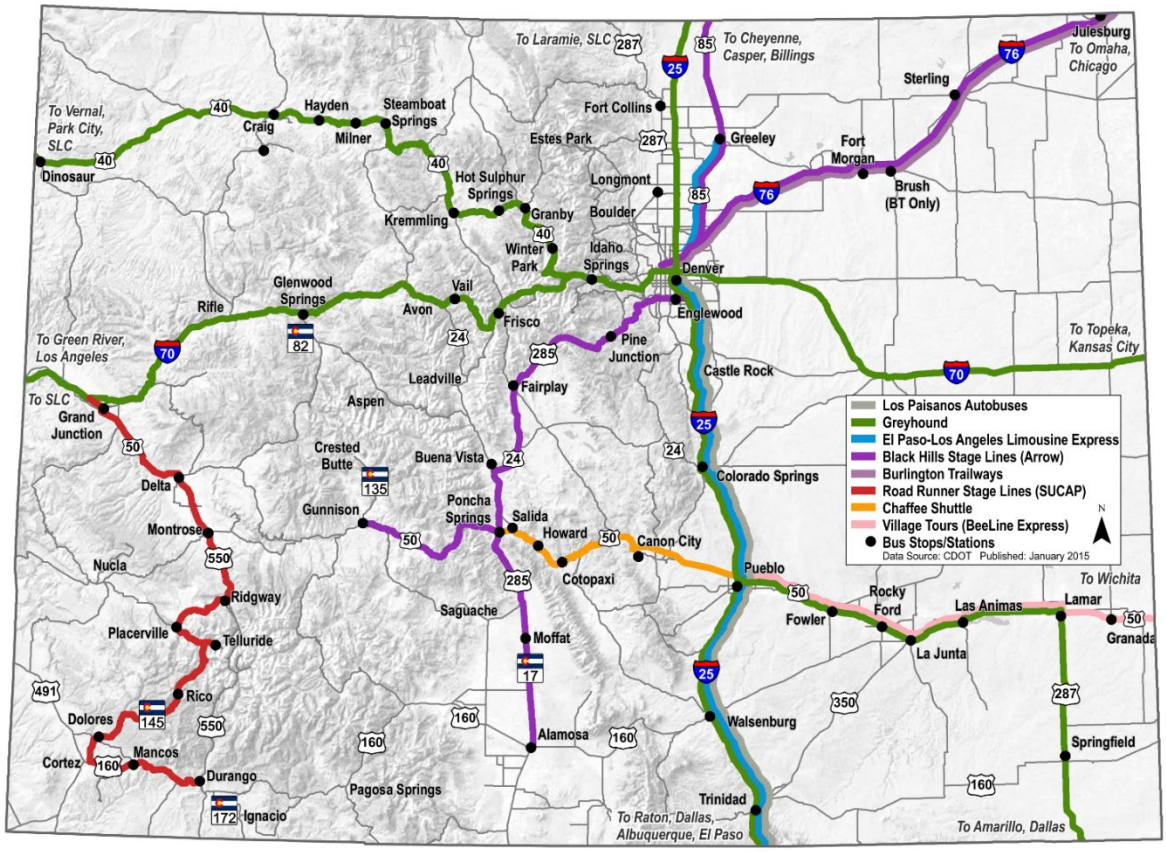
I-25 Corridor, Fort Collins to Pueblo: The 2014 CDOT *Interregional Connectivity Study* (ICS) evaluated alignment alternatives for implementing high-speed passenger rail service between Fort Collins and Pueblo, connecting major cities along the I-25 corridor. The study recommended an Initial Operating Segment (IOS) from Fort Collins to Briargate. This alignment bypassed downtown Denver but provided service to Denver International Airport. A subsequent analysis, the ICS Interoperability Report (2017) documented preferred alternatives, explored interoperability issues, and identified rail technologies to provide better access to downtown Denver. This report resulted in three final alternatives, with capital costs ranging from $9.7 to $11.5 billion.

Current Efforts - Front Range Passenger Rail: In 2017, the Colorado General Assembly established the Southwest Chief and Front Range Passenger Rail Commission. One of the key directives is to facilitate the development and operation of a Front Range passenger rail system that provides passenger rail service in and along the I-25 corridor. The Commission submitted a phased plan which includes: 1) definition of a service vision; 2) formation of a governing authority; 3) a federal project development process; and 4) final design and construction. The anticipated timeframe for project completion is 15 years.

Intercity Bus Service

Existing intercity bus services in Colorado are shown in **Figure II.4**, taken from the *2040 Statewide Transit Plan*.

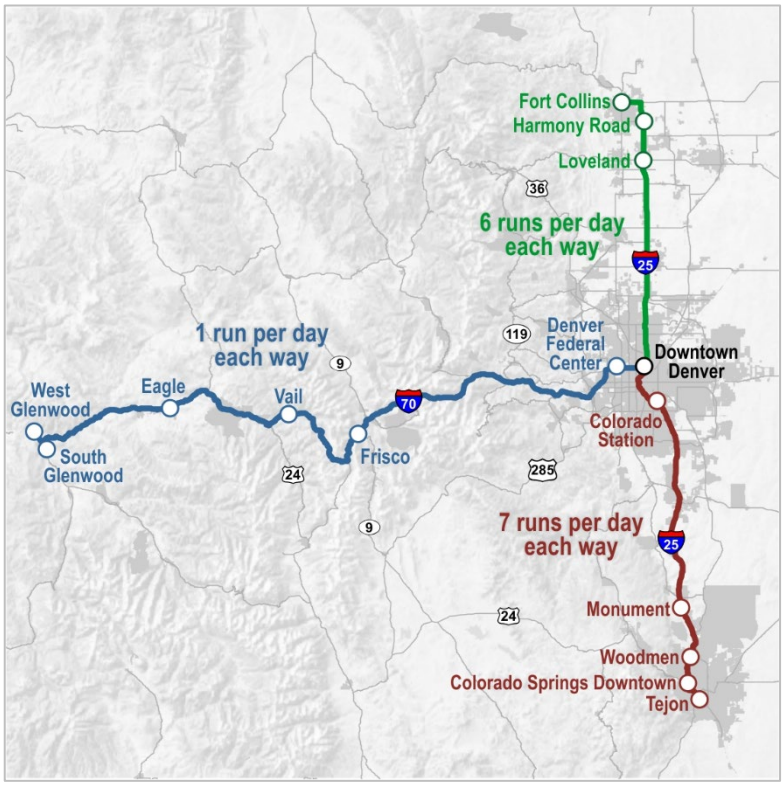
Figure II.4: Existing Intercity Bus Services in Colorado



The one intercity transit service that is designed to accommodate daily commuting is the Bustang service that was begun by CDOT in March 2015. As shown in **Figure II.5**, the 2016 Bustang routes take passengers along I-25 between Colorado Springs and Denver, along I-25 between Fort Collins and Denver, and along I-70 between Glenwood Springs and Denver. Prior to initiation of Bustang, the publicly funded Front Range Express (FREX) provided similar service between Colorado Springs and Denver from 2004 to 2012.

The 2015 CDOT *Statewide Transit Plan* recommended the addition of similar Interregional Express Routes to connect Denver and Greeley, as well as Colorado Springs and Pueblo, indicating that these are anticipated "over the next 7 to 12 years" (CDOT, 2015c).

Figure II.5: 2016 Intercity CDOT Bustang Service Routes



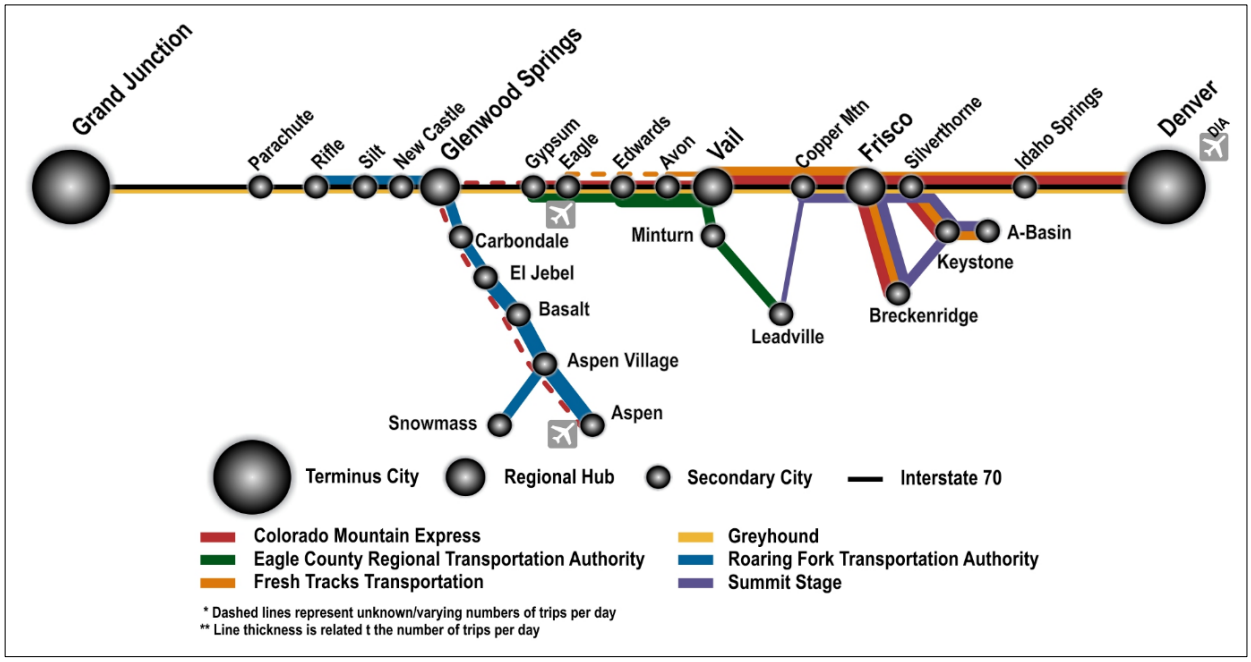
The same plan recommended new or modified regional bus service on 26 routes around the state, as well as 17 proposed "essential service" routes. CDOT in 2017 is beginning to acquire buses for new rural regional service currently branded as "Outrider" routes (CDOT, 2017b). Planned expansion to Alamosa and Durango was announced in late 2017 (KRDO, 2017). New service being added in 2018, in cooperation with Pueblo's Senior Resource Development Agency (SRDA), includes the following:

- January 2018 Lamar to Pueblo, Pueblo to Lamar (2 times daily)
- May 2018 Alamosa to Pueblo, Pueblo to Alamosa (2 times daily)
- Late 2018 Pueblo to Denver (via Colorado Springs), Denver to Pueblo

In 2017, CDOT announced a ticketing partnership between Bustang's interregional routes and Greyhound's national routes that allows travelers to book both services with a combined ticket This is a major step forward into providing seamless intermodal service (CDOT, 2017d).

A key area of congestion concern in Colorado, especially with regard to winter ski traffic, is the I-70 Mountain Corridor. Portions of this route are served by CDOT's Bustang route and various transit providers, as shown in **Figure II.6**. Bustang provides a way for riders to access these other systems. The Bustang trip from Frisco to downtown Denver takes about two hours and the trip from Glenwood Springs is four hours. These trip times are too long for reasonable commute trips, so the Bustang West Line is less commuter-oriented than the North and South Bustang lines to Fort Collins and Colorado Springs. CDOT added a West Line stop at Idaho Springs in January 2017.

Figure II.6: Existing Bus Service in the I-70 Mountain Corridor



II.3 Vanpools

Regional vanpool services are offered by DRCOG's Way to Go program in the Denver region, the North Front Range Metropolitan Planning Organization's (NFRMPO) Van Go program in Fort Collins (North Front Range region), and Mountain Metro Rides in Colorado Springs. Their typical vehicles are depicted in **Figure II.7**. No other regional vanpool programs exist in Colorado.

Figure II.7: Vanpool Vehicles in Three Metro Areas

Shown: DRCOG Way to Go, NFRMPO VanGo, and PPACG Mountain Metro Rides

These vanpool agencies not only match riders with common trip origins and destinations, but also pay up front capital costs for the vehicle, plus insurance, maintenance and fuel. Participants in the vanpool pay monthly fees into the program. Organizing a vanpool is something that individual commuters would not be able to do on their own, but instead is done by a public agency, an employer, or a third- party vanpool administration company, such as vRide (now Rideshare by Enterprise). See **Figure II.8.**

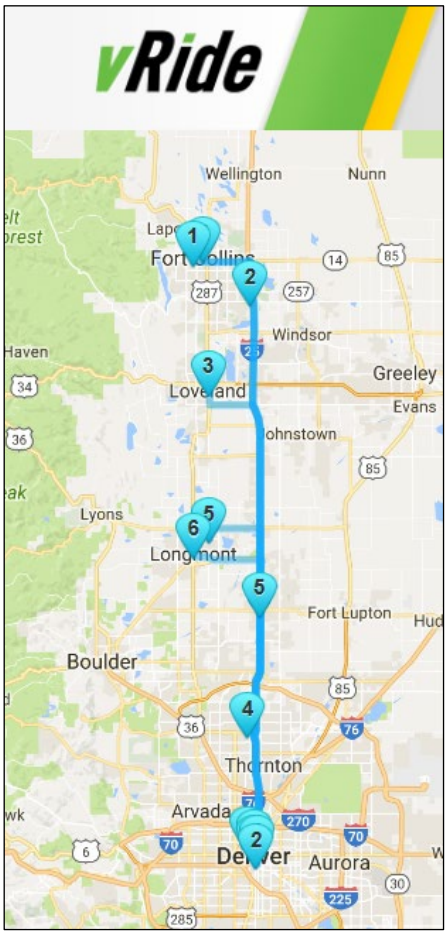
Information on employer-sponsored vanpools is not readily available. There is a report of one vanpool created by a bank to bring employees from Rifle to work in Aspen, due to high housing costs in Aspen.

Vanpools can carry five to 15 passengers, with five and six being typical in Colorado. Vanpools are appropriate for commuter trip distances of 15 or more miles (origin to destination), as they are not as economical for shorter trips. Vanpool trips from Colorado Springs to Denver are easily 60 miles long. Typically the volunteer driver of the van (not a paid employee) receives compensation such as waived vanpool fees or free use of the van during evenings and weekends.

The number of vanpools in operation at any given time fluctuates in response to consumer demand. DRCOG's Way to Go Vanpool program operated an average of 114 vans in 2015, the NFRMPO VanGo program operated 64 vans as of February 2016, and Colorado Springs Mountain Metro reported 24 vans in operation as of August 2017. Each of the three public programs also has several spare vehicles as replacements for times when a vehicle is out of commission for repairs. This is critical because lack of an available van for even one workday would greatly inconvenience the vanpool participants.

Park-and-ride lots are convenient places for vanpool participants to gather for their rides. As an example, eleven vanpool vehicles were observed in the Woodmen Road (Colorado Springs) Park-and- Ride lot on the January 2017 Martin Luther King, Jr. Federal holiday. These were five DRCOG Way to Go vans, five Mountain Metro Rides vans, and on V-Ride vehicle.

Figure II.8: Available Vanpool Seats



Note: Offered by VRide.com, now Rideshare by Enterprise.

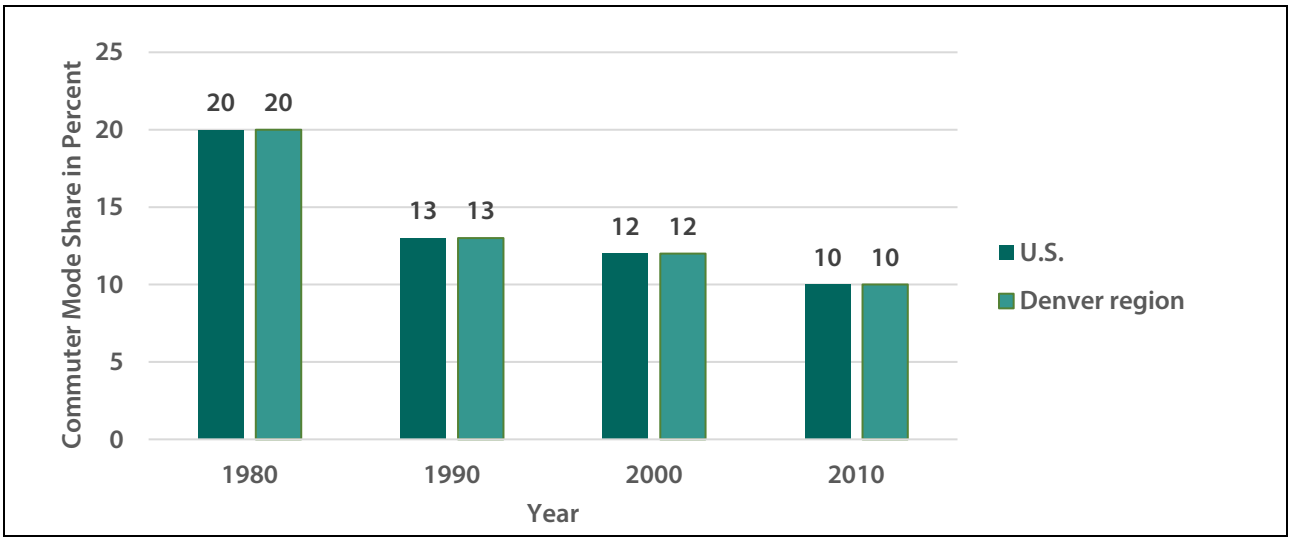
II.4 Carpools

Carpooling consists of two or more people sharing a ride to their place of employment or other destination. Using their own vehicles, carpoolers often share the responsibility of driving, or one drives and the passengers share the cost of gas and/or parking expenses. Carpooling is most appealing for people who commute at least 10 miles and whose trip to work takes at least 30 minutes. Carpoolers can take advantage of numerous "Carpool/High Occupancy Vehicle" lanes on I-25, U.S. 36 and other HOV facilities, located primarily in the Denver metro area. In most communities, carpooling is the most-used commuting alternative to driving alone, at about 10% of commuter trips. Carpooling was widely used following the international oil price hikes in the 1970s, but has been declining since then. **Figure II.9** shows a ten percent carpool rate for Denver in 2010. The rates for U.S. and the Denver region were the same in each of the four years shown, according to the U.S. Department of Commerce (Census Bureau, 2013).

Table I.2 presented in **Section I** showed an ACS-estimated 8.3 percent carpool rate in metro Denver as of 2015. This represents further decline from 2010.

DRCOG, NFRMPO and Mountain Metro (the same three agencies involved in vanpooling) and the City of Aspen offer free carpool matching services. These agencies provide a list of potential carpool matches, screened primarily on origin, destination and schedule. They do not get involved with any administration of carpool trip expenses, as they do for vanpools. Please see more detailed discussion of this topic in **Section III**, under "Rideshare Matching."

Figure II.9: Commuter Carpool Rates, U.S. and Denver Region 1980-2010



Note: Rates for the U.S. and Denver have been the same over the analysis period.

II.5 Walking

Walking is well suited for relatively short commuter trips, but not for longer trips, due to the amount of time it takes to travel a given distance. A 1996 study of over 7,000 pedestrians determined that average walking speeds range from 2.8 miles per hour for older pedestrians to 3.4 miles per hour for younger pedestrians (Knoblauch, 1996). Census data from 2009 indicated that the median work trip time for 133 million U.S. commuters was between 20 and 24 minutes. A person willing to spend 20 minutes walking to work would thus be able to travel about one mile. A Front Range Travel Counts survey of over 12,000 households in 2010 found that the average walk trip distance (all trips, not just work trips) was between 0.3 and 0.4 mile (DRCOG, 2012b).

The feasibility of walking to work also depends on the availability of safe routes, typically sidewalks. Having to wait to cross streets adds travel time, and the actual crossing involves danger from inattentive motorists. Exposure to the weather and other hazards are additional considerations in this mode choice decision.

Another impediment to walking is outdated infrastructure. Nearly a quarter century after passage of the Americans with Disabilities Act of 1990, many existing sidewalks remain ADA non-compliant. There are ongoing efforts in many Colorado communities to replace non-compliant sidewalks. An inventory prepared in conjunction with CDOT's 2013 *ADA Transition Plan* identified 18,376 intersections with existing ADA-compliant curb ramps, 25,356 intersections without curb ramps, and 2,801 intersections needing further evaluation but possibly requiring ramps (CDOT, 2013).

EVERYONE IS A PEDESTRIAN

"Everyone has different preferences when it comes to transportation, but there's one that all road users share— everyone is a pedestrian."

- National Highway Safety Administration, 2017.

[Note that NHSA includes wheelchair users in its definition of pedestrian.]

ACTIVE TRANSPORTATION

Walking and bicycling are together referred to as "active transportation" because human muscles rather than fuel-burning engines provide the means of propulsion. Walking burns calories, which is beneficial for America's increasingly overweight population, and does not burn fossil fuel, thereby reducing emissions compared to motor vehicle use. Also, walking and bicycling have no out-of-pocket costs for automobile ownership, fuel and maintenance.

(Partnership for Active Transportation, 2016)

Land use patterns are extremely important in fostering pedestrian travel. Mixed land use where residences are close to employment destinations and shopping opportunities is more conducive than stereotypical suburban sprawl where employment and shopping destinations are far from home. Transit-oriented land use development generally encourages walking because a transit user walks to or from a bus stop or rail station to get to the trip origin and/or destination.

CDOT in 2015 updated its Statewide Bicycle and Pedestrian Plan. The plan's vision statement indicates that, "The Colorado Department of Transportation intends to increase bicycling and walking activity levels, for both transportation and recreational purposes, through both infrastructure projects and promotional programs, to help achieve the broadly established and supported economic, public health, environmental, and quality of life benefits" (CDOT, 2015d).

> *"The Colorado Department of Transportation intends to increase bicycling and walking…"*
>
> *2015 Statewide Bicycle and Pedestrian Plan*

CDOT has the opportunity to provide sidewalks or trails along some State Highways. Prominent examples include the U.S. 36 Bikeway and the Centennial (C-470) Trail and the U.S. 36 Bikeway, both in the Denver region.

The U.S. 36 Bikeway opened in 2016, in conjunction with the U.S. 36 Express Lanes project. It offers a concrete surface 12 feet wide with two-foot shoulders, enabling commuters to bicycle the entire 18-mile distance between Boulder and Denver. **Figure II.10** shows the Centennial Trail crossing over a cross-street called Erickson Boulevard. The trail has its own exit/entrance ramps taking bicyclists and pedestrians between the cross-street and the trail. Two new grade/separations along this trail are being constructed in 2018 as part of the C-470 Express Lanes project.

Figure II.10: Centennial Trail Bridge and Access Ramps at Erickson Boulevard in Littleton

Eastbound Mainline

Eastbound On-Ramp

Grade-Separated Trail

Trail Access to Arterial

CDOT also recognizes that state highways can be a barrier to crossing by non-motorized traffic. Pedestrian overpasses or underpasses are provided in cases where warranted by local demand. **Figure II.11** shows a pedestrian bridge crossing an Interstate highway to connect a neighborhood with a regional park and

downtown area. In the Denver region, there are numerous bridges that connect a light rail station on one side of a freeway with neighborhoods and/or parking facilities on the other side.

Figure II.11: CDOT-Built Pedestrian Bridge across Interstate 25 in Colorado Springs

Multimodal transportation is a key element of CDOT's mission in providing improvements for the statewide transportation system. CDOT's 2009 Bicycle and Pedestrian Policy Directive states:

> "It is the policy of the Colorado Transportation Commission to provide transportation infrastructure that accommodates bicycle and pedestrian use of the highways in a manner that is safe and reliable for all highway users. The needs of bicyclists and pedestrians shall be included in the planning, design, and operation of transportation facilities, as a matter of routine."

The Colorado Office of Economic Development and International Trade in 2016 issued a report called Economic and Health Benefits of Bicycling and Walking (COEDIT, 2016). This report concluded that walking in Colorado improves the health of many thousands of residents and currently helps prevent about 285 deaths per year, thus yielding about $2.7 billion in annual health benefits. Recreational hiking and walking for exercise by residents and tourists accounted for much of the benefit. Walking to work would be a small fraction of the total benefit. Offsetting part of these major exercise benefits are the small risks of a pedestrian being struck by a motor vehicle. According to preliminary CDOT fatalities data, 67 pedestrians were killed in Colorado by motorists in 2016.

There are also other economic benefits of bicycling and walking that are more difficult to measure, such as the increased economic vitality of communities that have emphasized bicycle and pedestrian mobility. Finally, walkable communities create a more equitable society that provides transportation choice for all citizens, including those who cannot afford an automobile.

II.6 Bicycling

CDOT's Statewide Bicycle and Pedestrian Plan (amended 2015) reports that bicycle commuting is more common in Colorado than in other states. It cites 2009 National Household Travel Survey data indicating that nearly two percent of commute trips in Colorado are made by bicycle, which is more than twice the national average. Colorado ranked second in the nation in this bicycle use by commuters. For more information, please see the entire plan online at: https://www.codot.gov/programs/bikeped/building-a-bike-ped-friendly- community/Bike_Ped_Plan/BikePedStatePlan/view.

Colorado's Governor, John Hickenlooper, in September 2015 announced a plan to make Colorado "the best state for biking" (BicycleColorado.org, 2016). This public-private Colorado Pedals Project calls for developing more bike and pedestrian infrastructure, using CDOT and federal Transportation Alternatives Program and Congestion Mitigation and Air Quality Improvement Program funds. Additional funds will come from Great Outdoors Colorado. The initiative includes continued support for the state's Safe Routes to School program. This program is discussed later in this report, in the discussion of school trips.

CDOT, counties, cities and towns all provide bicycle facilities as part of their transportation systems. A DRCOG Bicycle Plan (DRCOG, 2009a) inventory summarized the available facilities into three overall types:

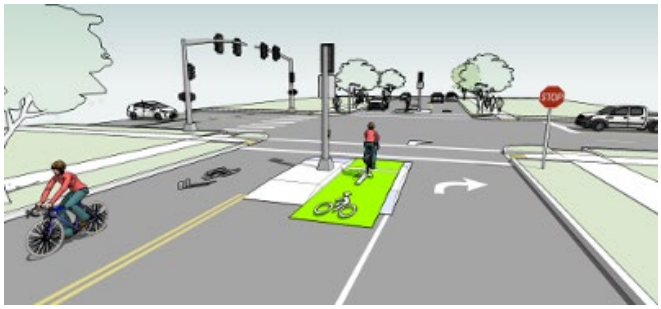
- Sidewalks along the non-freeway regional roadway system;
- Signed or marked bicycle facilities on roadways; and
- Off-street multi-use trails.

On-street bike facilities have traditionally included signed bike routes, on roads selected as being suitable for bikes based on safety considerations (e.g., vehicle traffic volumes and speeds), and bike lanes, where a portion of the pavement is striped for use by bicycles only. Relatively newer concepts are "sharrows", where striped bike lanes do not exist but painted markings on the pavement alert motorists to share the road with bicyclists, and "bike boulevards", which are quieter local streets optimized for bicycle use. The Denver MOVES Bike Plan identifies additional variations including climbing lanes, bicycle tracks and buffered bike lanes (City and County of Denver, 2011). Denver also has protected bike lanes and parking- protected bike lanes (see **Figure II.12**). Generally, the purpose of these variations is to improve safety by reducing the potential for conflicts with moving vehicles, parked vehicles, and pedestrians. Parking-protected bike lanes have been added on several downtown streets in Colorado Springs.

Figure II.12: ParkIng-Protected Bicycle Lane

Note: Parking-Protected Bicycle Lane in Denver.

Figure II.13: Toucan Crossing



Source: City of Fort Collins, 2017.

Figure II.14: Protected Bike Crossing

Source: Tom Humphrey, CDOT Region 5.

Fort Collins in 2017 opened a new $900,000 Pitkin Street bike corridor that features something called a "toucan" crossing, shown in **Figure II.13**. Here the side street is striped to allow vehicles to turn right only. The bicyclist can push a button to activate a signal to cross the busier arterial street, with no interference from vehicles going straight or turning left. Fort Collins reports that this approach costs between $100,000 and $150,000 per intersection (ITE, 2017).

In the City of Durango, bicycle-activated crossing signals have been added to improve safety at CDOT's major intersection of US Highways 550 and 160 (see **Figure II.14**).

To recap, a variety of innovative roadways treatments have been installed recently in Colorado communities to improve bicycle safety, and thus encourage bicycle use.

More can be done, but Colorado is already considered a national leader in terms of providing bicycle-friendly infrastructure. An organization called the League of American Bicyclists (LAB) annually ranks states and classifies communities, businesses and universities as to how bicycle-friendly they are, based on a set of criteria established by that organization. In 2015, Colorado ranked as the seventh most Bicycle-Friendly state in the U.S., with 21 communities, 5 universities and 86 businesses that were called Bicycle-Friendly by LAB. **Table II.4** lists the communities and the universities. For the list of businesses, see the organization's website.

Nationally, there are only five Platinum communities and only five Platinum universities. Colorado has two of these Platinum communities and one of the Platinum universities. Colorado also has one Platinum-level bike-friendly business, which is the New Belgium Brewing Company in Fort Collins. Additional Colorado entities would likely qualify for some of these designations but have not yet undertaken and/or completed the application process.

Table II.4: 2015 Bicycle-Friendly Communities and Universities in Colorado

Bicycle Friendly Communities and Universities in Colorado by Classification			
Platinum	***Gold***	***Silver***	***Bronze***
Boulder Fort Collins	Breckenridge Carbondale Crested Butte Durango Steamboat Springs	Arvada Aspen Colorado Springs Denver Golden Gunnison Longmont Salida Vail	Castle Rock Grand Junction Greeley Lakewood Summit County
Colorado State University			Colorado College CU Colorado Springs University of Denver University of Northern Colorado
Source: League of American Bicyclist, 2016.			

Figure II.15: Secure Bicycle Storage

Note: Secure Bicycle Storage at a Boulder County Transit Stop.

Bicycling to work can involve a transit component. If secure bicycle storage is available at a transit stop, the commuter can bicycle to the transit stop and then take transit to work. Boulder County provides secure bicycle storage as pictured in **Figure II.14**.

Alternatively, in many communities, public transit buses are equipped with a bike rack on the front of the bus, usually with the capacity to hold two bicycles. See **Figure II.16**. Additionally, it is permissible to take bicycles aboard RTD light rail, loaded only at the front and the back of the train. RTD reported nearly 4,000 bike-on-bus loadings for an average summer day in 2013 (RTD, 2017a).

The City of Fort Collins has 15 portable A-frame bike racks available for temporary use at special events, upon request.

The City of Durango has seven on-street "bike corrals" which take the place of a vehicle parking space. These are installed in commercial areas if requested by the affected businesses owners. Fort Collins has six bike corrals. Boulder has two bike corrals on Pearl Street (see **Figure II.17**).

The City of Durango in September 2017 began a one-year pilot program to allow electric bicycles ("e-bikes") on some of its hard-surface trails, for the benefits of physically impaired bicyclists (Durango, 2017). The report cited earlier called *Economic and Health Benefits of Bicycling and Walking* concluded that bicycling in Colorado improves the health of many thousands of residents and currently helps prevent about 50 deaths per year, thus yielding about $511 million in annual health benefits (COEDIT, 2016). Recreational bicycling for exercise by residents and tourists accounted for much of the benefit. Bicycling to work would be a small fraction of the total benefit. Offsetting part of these benefits are the risks of a bicyclist being struck by a motor vehicle. According to preliminary CDOT fatalities data, 13 bicyclists were killed in Colorado by motorists in 2016.

For decades, a nationwide promotional event called Bike to Work Day has encouraged Americans to take to the streets and try commuting to work by bicycle. Most of the country celebrates Bike to Work Day in May, but due to Colorado's mountain communities and unpredictable weather, the state legislature declared June as Colorado Bike Month, with the fourth Wednesday of the month being Bike to Work Day. It is hoped that participants on Bike to Work Day will find that bicycle commuting is a reasonable option for them so that they will be willing to consider it on a regular basis. CDOT participates with a large number of regional and local entities to promote Bike-to- Work events (see **Figure II.18**).

The City of Boulder promotes a Winter Walk and Bike Week in January (began in 2016) to emphasize that with a reputation for 300 days of sunshine annually, Colorado does offer feasible conditions for walking and biking even in the winter.

Here is a list of 2017 winter bike to work events (9news.com, 2017):

- January 25 is Winter Bike to Work Day in Denver, Boulder, and Longmont.
- Fort Collins has an ongoing Bike Winter Photo Contest which closes on January 31.
- Durango has its Bike to Work Day on February 24.
- February 10 is International Bike to Work Day.

Regardless of these relatively new winter promotions, Colorado's longstanding June event is the primary focus of most Bike to Work Day efforts.

Figure II.16: Bike on Bus

RFTA in Aspen Bike n Bus.

Figure II.17: Bike Corrals

Bike Corral on Pearl Street in Boulder.

Figure II.18: Bike Events

Poster for Colorado Bike Week, 2018.

In addition to establishing public bicycle facilities and encouraging bicycle use, there is a wide range of supportive efforts that can be and are undertaken. Many of these are smaller in scale and cost than the efforts described above, so they are more difficult to track or quantify. Such efforts might include provision of bike lockers, bike racks, covered racks, bike repair kits and clinics, wider shoulders on highways and shower facilities at places of employment. Some community organizations give free bicycles to low-income youths (Groundwork Denver, Inc., 2016).

II.7 Variable Work Hours

Variable work hour programs can allow workers to shift their commute outside of peak traffic periods or to compress the work week to fewer than five days per week, thus eliminating some work trips. Generally, flex-time allows employees to choose when their work day starts and ends, as long as they are on the job during specified core hours.

Staggered work hours are most effective in the case of many employees working for the same employer or in a dense employment area. In modern times, employment centers are more dispersed than they used to be, resulting in less concentrated radial flows into and out of downtown, for example. Also, in the congested Denver metro area, peak period traffic can easily last for two full hours, making it more difficult to avoid the congestion by minor work schedule changes.

Another popular arrangement is the compressed work week, where employees work four 10-hour days, three 12-hour days, or complete 80 hours of work in nine days. Staggered work hours have potential to reduce congestion without reducing vehicle miles of travel, while compressed work weeks can reduce commuter VMT by one trip every one or two weeks, thus yielding a reduction of 10 percent or 20 percent.

A major national study of TDM effectiveness cites "A comprehensive 1980s experiment in Denver involving 9,000 federal employees [which] found the longer work day flattened the peak, reducing the peak half hour from 56 to 42 percent of all arrivals; had no adverse effect on ridesharing or transit use; and reduced vehicle miles of travel (VMT) by a net 15 percent among participating employees. Employee participation in the program was 65 percent" (Transportation Research Board, 2010).

II.8 Telecommuting

Teleworking allows employees to work from home or another off-site location either part-time or on a full-time basis. Employees are connected to the office usually by computer, fax and telephone. Benefits of teleworking include: increased employee productivity by eliminating the hassles of driving to and from the office; savings for employers on office space and parking costs; reduced absenteeism; recruitment and retention of skilled employees; improved customer service; reduced traffic congestion and improved air quality.

With continued technological advancements, working at home has become an increasingly common commuting alternative. It is appropriate for information-based jobs that can be conducted by telephone and computer. As noted earlier in **Table II.2**, working at home was the reported practice of five to seven percent of Coloradans in most urban areas, and for almost 12 percent of workers in Boulder. Some people work at home for most of the week and travel to the office on a small number of days.

Critical to working at home is the availability of adequate internet service. Residents in Colorado's most populated metro areas may take such service for granted, but it is sorely lacking in many rural parts of the state. Efforts are ongoing to bring adequate internet service to areas that do not have it. In August 2015, an organization called Region 10 received a $5.2 million grant from the Colorado Department of Local Affairs to develop high-speed broadband service to the cities of Delta and Montrose in western Colorado. The grant request was submitted in partnership with Montrose, Delta County, the Delta Montrose Electric Association and Delta County Economic Development (Daily Sentinel, 2016). CDOT also participates in

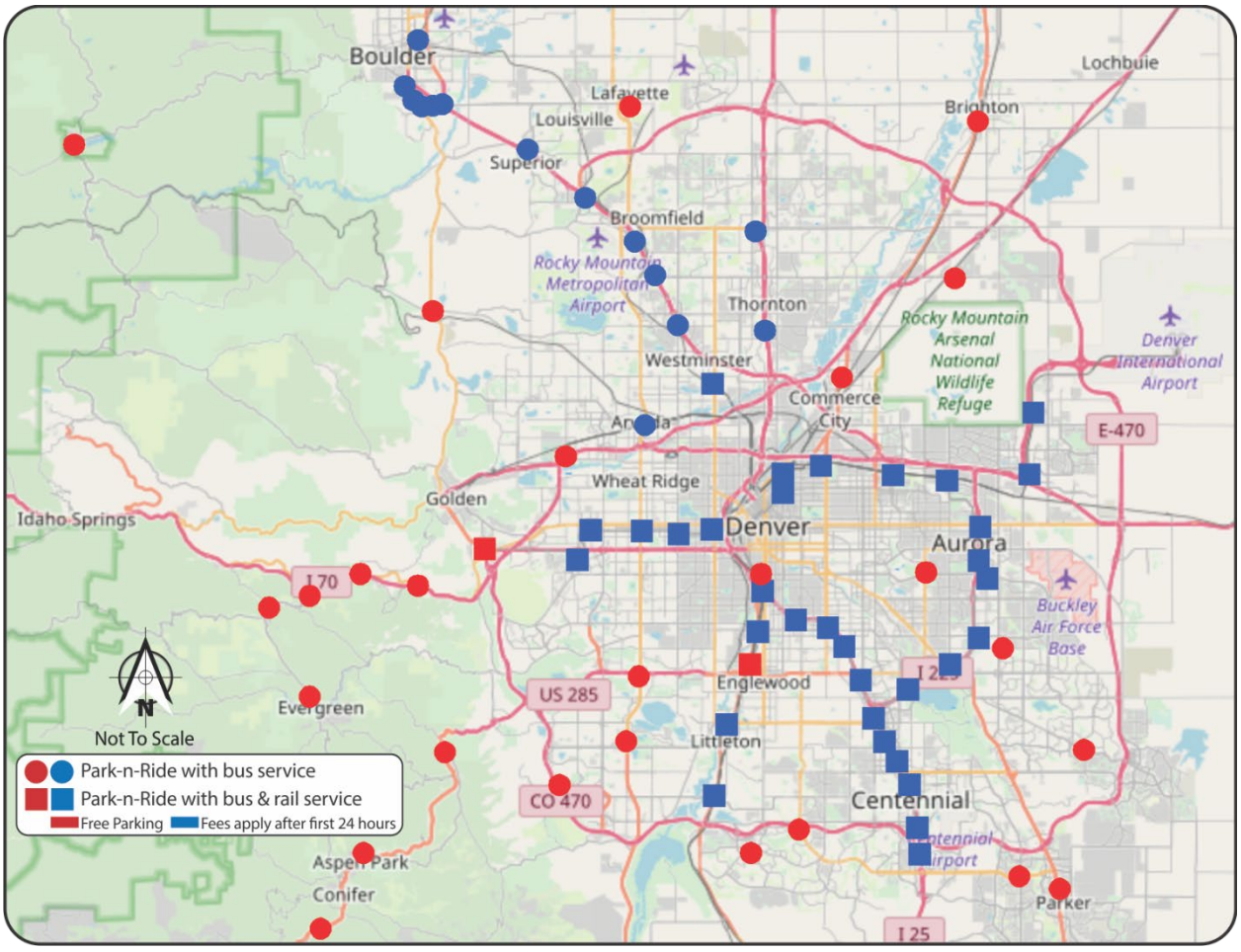
public-private partnerships for fiber optic cable. In many locations, fiber optic cable lines are put underground in CDOT right-of-way.

II.9 Park-and-Ride Lots

Public park-and-ride lots are provided for the purpose of accommodating and encouraging the use of transit and carpooling. The largest owner and operator of these facilities in Colorado is the Regional Transportation District (RTD), serving the Denver metro area. As of December 2016, RTD has 77 "Park-n-Rides," as they are called by that agency, totaling more than 30,000 parking spaces (RTD, 2016a; see **Figure II.19**). Some lots are located adjacent to light rail stations, and all of them are served by one or more RTD bus routes.

Many of the RTD lots also have bike racks and/or bike lockers for intermodal connectivity. RTD reports it provided 750 bike lockers regionally as of 2015. The user's cost is $30 for a six-month lease, plus a one-time pad-lock fee of $20 (RTD, 2017a).

Figure II.19: Map of RTD Park-n-Ride Lots



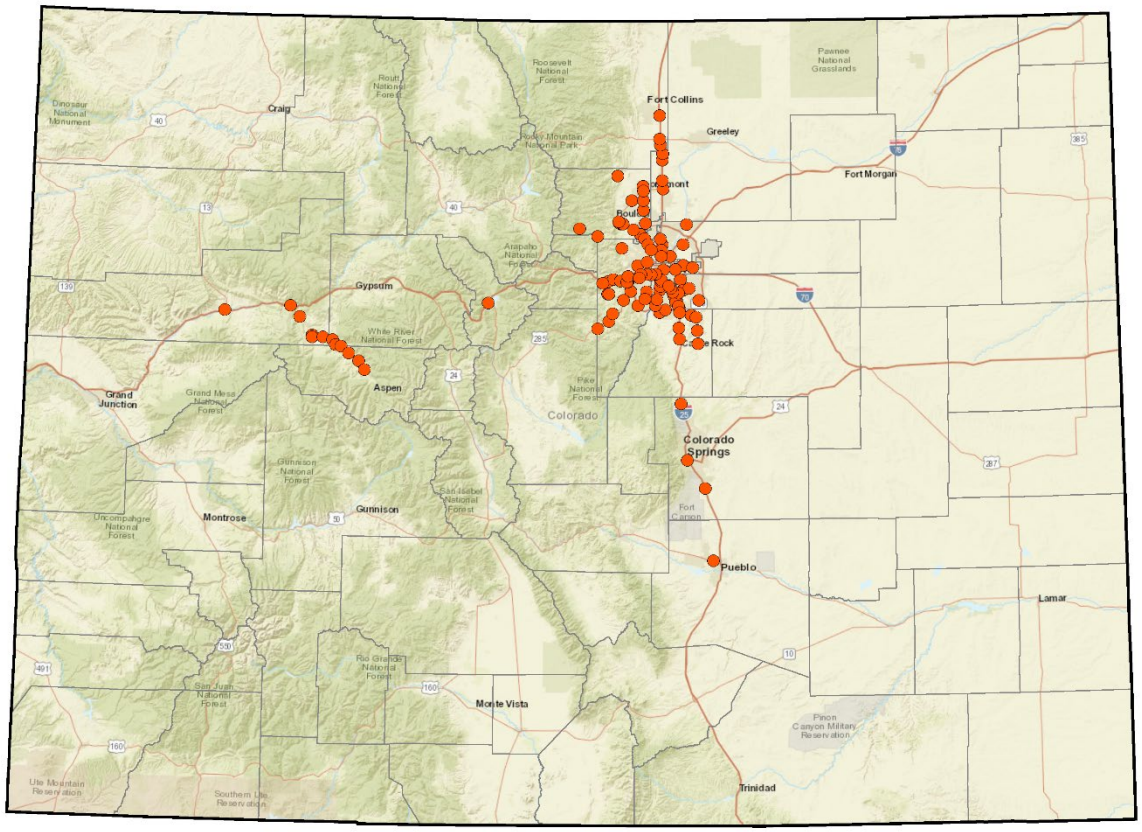
Source: RTD; December, 2016.

CDOT has approximately 3,500 parking spaces at 27 park-and-ride lots at strategic locations along Interstate 25, Interstate 70, U.S Highway 50, and the State Highway 82 (SH 82) corridor between Glenwood Springs and Aspen. The SH 82 corridor has ten lots, supporting the RFTA transit system discussed earlier. CDOT's intercity Bustang express bus service makes stops at selected CDOT park-and-ride lots.

CDOT's largest park-and-ride complex has 1,375 spaces, at I-70 "Hogback" exit 259. This complex at the western edge of the Denver area is used extensively for winter ski trips into the mountains. Unlike most CDOT lots that are heavily used on weekdays and mostly empty on weekends, the I-70 lots are mostly full on weekends and mostly empty on weekdays. While CDOT's park-and-ride lots do have some connectivity with transit, they primarily serve to accommodate carpools.

The City of Colorado Springs has two park-and-ride lots totaling 374 spaces. One of these is next to I-25 at Woodmen Road, a Bustang stop owned by CDOT but not on the online list of CDOT- maintained park-and-ride lots. The other is located many miles east of I-25.

Figure II.20: Map of CDOT Park-and-Ride Lots



Source: CDOT 2017; Map Created April 16, 2018.

COLORADO
Department of Transportation

III. TDM SUPPORT STRATEGIES

III.1 Rideshare Matching

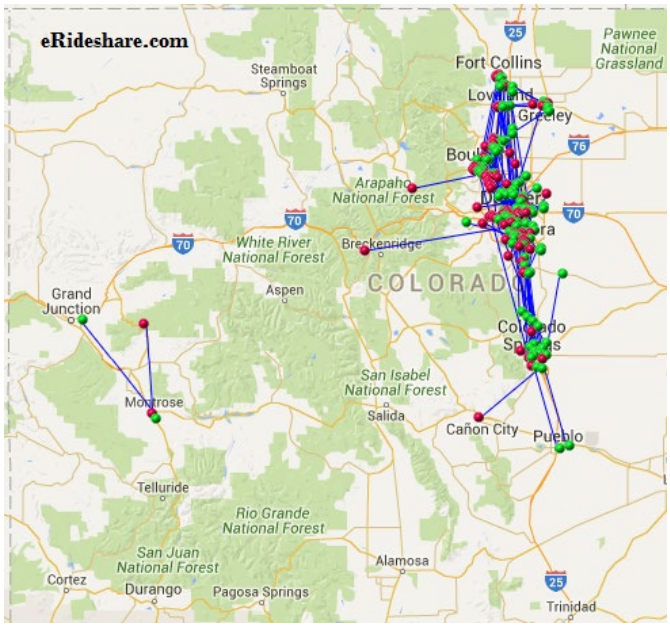
Most carpools form without the need for regional carpool matching assistance. For example, data from the American Community Survey (a Census Bureau product) suggest that there are slightly over 130,000 carpoolers in the Denver region. DRCOG reports that it has a total 13,000 carpool applicants in its database (DRCOG, 2016b), and successfully matches about one sixth of its applicants. These roughly 2,000 matched applicants account for about 1.5 percent of reported carpoolers in the region.

In bigger cities, people move or change jobs relatively frequently. For this reason, it has been reported that the typical carpool lasts for just two to two and a half years. In response to this situation, rideshare matching agencies must continually purge their databases to eliminate outdated information. This may be done by sending the registered carpooler a postcard, e-mail or text message requesting verification of continued interest.

Some large employers run their own internal carpool matching programs. Since all of their workers have a common trip destination, it would be of no benefit to put these names in a regional database with people who do not share the same destination. Also, the employees' information is kept more private on an internal database. An example is the Sustainable Fort Carson Rideshare program discussed later under "Employer-Based Programs."

With rapid advances in computer and cell phone technology, there is an increasing number of online carpool matching services that are not community based. For example, it is possible to arrange a carpool online – usually for single trips, rather than long-term commuting – via the iCarpool app or websites such as carpoolworld.com, erideshare.com and even craigslist.com (see **Figure III.1**).

Figure III.1: Carpool Availability Report



Example of Carpool Availability Reported by eRideshare.com.

An online article entitled "*15 Best Apps for Carpool and Rideshare in 2015*" listed additional possibilities (GreenLivingIdeas, 2015). That article included Uber and Lyft, which are not traditional carpools, but more like informal taxicabs, because the passenger pays the driver to drive, although the payment goes through a third party. As with the websites listed above, Uber and Lyft are more geared toward matching a single trip need rather than a long-term commuter arrangement. These are discussed further in **Section IV**.

In addition to providing carpool matching services for the general public, DRCOG's Way to Go Program works with employers on a subregional basis to promote alternative mode use in particular areas or corridors. This is also done through entities called Transportation Management Associations (TMAs) and Transportation Management Organizations (TMOs). These are discussed in **Section V**, under "Employer-Sponsored Programs."

III.2 Guaranteed Ride Home

Employees who leave their cars at home also want to leave their worries at home — worries about not having transportation if they become ill, have a family emergency or need to work late. Guaranteed ride home programs typically offer a free taxicab ride in case of emergency.

DRCOG's Way to Go program offers this benefit to participants of its programs:

- Vanpool
- RTD's EcoPass
- Carpool
- Bike to Work Day

In the Denver metro area, all holders of an RTD EcoPass (i.e., well over 100,000 people) have this benefit. This includes many thousands of college students who have CollegePasses.

A guaranteed ride home is also available under the NFRMPO vanpool program, VanGo.

III.3 Parking Management

According to CDOT's 2002 TDM Toolkit, parking management consists of three strategies: preferential parking, parking pricing, and the transportation allowance.

Preferential parking reserves prime parking spaces for employees who share a ride to work instead of driving alone. This might be covered parking that protects the vehicle from inclement weather, a spot close to the building entrance, or perhaps first-level parking in a multistory parking garage. Preferential parking is highly cost-effective because it only requires signage. It shows the employer's commitment to TDM and it can save the cost of providing additional parking spaces. The cost of providing a parking space varies by location due to land costs (e.g., very high in downtown Denver, and lower elsewhere). A surface level space might cost $2,500 to $4,000. A space in a multiple level parking garage in Denver might cost in the range of $17,000 to $18,000 (CarlWalker.com, 2017). Preferential parking is flexible because reserved spots can be increased or decreased in response to demand by adding or removing signs.

The University of Colorado at Boulder has some reserved parking spaces for carpools, as does the City of Colorado Springs downtown parking garage. These are not free parking spaces, but preferred spaces.

At the Keystone ski resort, visitors arriving with four or more people in a car can use a premier parking section in Keystone's River Run Free Lot, which is a short walk to the River Run Gondola. Carpool parking is limited and first come, first serve.

Parking pricing is a strategy intended to eliminate free parking in certain areas of the community. It is common in downtown areas to limit on-street parking to one or two hours, which is sufficient to serve customers but does not accommodate employees. In dense downtown areas, especially Denver, the high cost of parking (e.g., $15 or more per day, which is $300 for a 20-workday month) is a powerful incentive for workers to use alternative modes of travel, especially bus or light rail. Property leases negotiated by an employer may or may not include parking spaces, and parking spaces can be costly. Charging employees for parking spaces can generate income available for subsidizing bus passes.

Under a ***transportation allowance*** approach, the employer offers a monthly benefit to each employee equal to or less than the employer's cost of a parking space. The employee may choose to rent a parking space, purchase a bus pass, or take some other transportation mode, and is allowed to keep any savings.

Parking management is not only about preferences and pricing. A newly emerging parking management strategy is about ***improving efficiency in finding a parking space***. DRCOG's 2008 Congestion Management Toolkit (DRCOG, 2008) includes a strategy called "parking facility management information

signs." A lot of time, travel and fuel is wasted each year by motorists driving around looking for an available parking space. Some major parking facilities such as at Denver International Airport have signs indicating whether each parking level is full or open.

At Colorado State University in Fort Collins, the parking guidance system features parking sensors in each of the university's two parking structures. The Lake Street Parking Garage has a combination of single space and multi-space sensors monitoring all 870 spaces, and the South College Avenue Garage uses sensors to manage all 663 of that facility's spaces. The sensor network records parking space occupancy, advises parkers of real time parking availability as they approach the garage, and guides them to open spaces. The sensors also collect data about length of stay, occupancy, and usage for each of the different user groups at the garage, which the university uses to enhance its parking policies and procedures (Business Wire, 2016). The parking garage at CDOT's new headquarters in Denver has technology indicating unoccupied parking spaces.

In 2016, a firm called Parkify is installing sensors at downtown Denver on-street parking spaces so that motorists can use the firm's cell phone application to find and pay for on-street parking spaces. One analysis suggests that 30 percent of downtown congestion may be attributed to motorists looking for a parking spot (Denver Post, 2016b).

Another Denver Post article indicated that in 2015 there were already nine mobile phone applications up and running to assist motorists to find parking in Denver (Denver Post, 2015a).

Every community "manages" its parking supply to some degree, through land use ordinances and street development policies. Metered on-street parking is typically used to limit the amount of time a vehicle is allowed to be parked at a city-owned space, so that others can use the space to access local businesses or other downtown destinations.

The amount of the fine for a parking meter violation varies from community to community. One of the more extreme fines is found in the City of Manitou Springs, the base for hikers wishing to climb Pikes Peak. As the City puts it, "Manitou Springs is a small mountain town with narrow streets and limited parking. Tourists from all over the country visit Manitou every year. Add those visitors to the approximately 6,000 year-round residents and parking is hard to find. In addition, fines for parking on residential streets without a permit are steep, ***$70 for your first violation***" (City of Manitou Springs, 2017).

Three Colorado communities that manage their parking with the specific intention of encouraging alternate mode use in their downtown are the cities of Denver, Boulder, and Aspen, discussed below.

The City of Denver maintains a very active parking management program, as detailed in its Denver Strategic Parking Plan (City and County of Denver, 2010). The plan indicates that public parking is managed as an asset. In 2008, the city spent a total of $18 million on parking administration and collected $26 million in parking revenues and fines, for a net income of $8 million. The plan indicates that different management strategies are appropriate for different types of neighborhoods. The plan specifies a number of short-term and long-term strategies to assure that parking facilities are optimized for the overall public good.

A 2005 study had reported a total of 64,500 parking spaces in the downtown Denver area, of which six percent (roughly 3,900) were on-street parking (City and County of Denver, 2005). A subsequent parking inventory indicated that downtown Denver had 46,623 off-street parking spaces, consisting of 32,998 garage space and 10,639 surface lots spaces. [The city likely did not lose a quarter of its parking spaces in the intervening six years. Different methodologies and different study areas likely explain the discrepancy.] Median parking rates were reported as $15 daily for garages and $7.50 daily for surface lots (Downtown Denver Partnership, 2011).

Denver has made arrangements with carsharing companies that allow those rental units to be parked in on-street spaces, not subject to ordinary time restrictions or towing that would apply to vehicles owned by a private individual.

The ***City of Boulder*** Parking Services manages the parking garages, on-street parking systems and enforcement for Boulder's three major commercial districts: Downtown Boulder (4,000 parking spaces), University Hill and Boulder Junction. The city has 2,200 spaces in parking garages and 165 on-street meter pay stations. The Parking Services department also manages ten Neighborhood Parking Permit programs throughout Boulder (City of Boulder, 2017a).

In the ***City of Aspen***, paid parking is available throughout the downtown with 700 parking spaces on street and 330 garage parking spaces, at a cost of $15 per day. Short-term parking in downtown is available for up to four hours. The City of Aspen implemented a PAY-and-DISPLAY parking system in January 1995, reportedly the first of its kind in North America. Parking revenues support the city's free public transportation system. Carpools of two or more adults are eligible for free carpool permits for parking in residential or carpool zones (City of Aspen, 2017).

Aspen offers free parking at a remote Brush Creek "intercept" lot, with free shuttle service, as a way to keep vehicles from entering their city in the first place. This eliminates excess traffic caused by people driving around to look for a parking space. Similar facilities are available at Telluride (another ski area) and Manitou Springs (busy tourist locale near Pikes Peak).

III.4 Incentives

The CDOT 2002 TDM Tool Kit identified incentives as another TDM strategy. Generally this involves TDM agencies or employers rewarding people for their use of transportation modes other than solo driving. This could be in the form of cash, prizes, redeemable program points, time off or recognition. Some incentives are time-limited (e.g., for up to six months) as a way to get a motorist to try using a bus, carpool or vanpool. At the end of that time, it is hoped that the commuter will recognize the inherent cost savings and other benefits of the alternative mode so that a continued incentive payment would not be necessary.

There are a number of incentive programs currently in Colorado. As of December 2016, there are a number of Regional Incentives listed on the website of the DRCOG Way to Go program. These include, in extremely limited detail (because they have near-term expiration dates):

- US 36 Corridor - free RTD ten-ticket ride book
- US 36 corridor - 70% discount for employer-purchased EcoPasses
- US 36 corridor - $75 cash award for solo driver logging 8 round-trips by carpool
- US 36 corridor - $75 cash award for solo driver logging 8 round-trips by vanpool
- City of Boulder - registered vanpoolers can receive $20 monthly payment
- City of Boulder - employers of 11 or more get 50% off EcoPass contract for one year
- City of Boulder - various discounts available for Boulder B-Cycle and eGo Car Share
- RTD District - Up to 60 percent subsidy of van cost for vanpoolers from Way to Go
- Fort Collins to Denver - free roundtrip on Bustang
- I-25 North - expand carpool from 2 to 3 and all get $40 gift card
- I-25 North - form a new 3-person carpool and all receive $75
- Longmont to Denver - free RTD ten-ticket ride book
- I-25 North - join an existing carpool and receive $40 gift card

The City of Durango operates a Way to Go! Club wherein registered participants track and report the number of (non-recreational) miles they travel by alternate modes in the Durango vicinity only. These miles are program points which can be redeemed for awards with local merchants. As of late 2016,

approximately 800 registered participants had recorded over 1.1 million miles traveled without driving (City of Durango, 2016). The City of Durango has a Free Transit Day scheduled in 2017, sponsored by a local business.

The City of Aspen began a "Drive Less Aspen" program in January 2017, offering participants weekly prize drawings and an end-of-the-season grand prize drawing.

CDOT offers a $20 incentive to its employees who bicycle to work ten or more times per month. A subsidy of $35 per month is provided for those who carpool or vanpool from the NFRMPO region to CDOT offices in Denver.

Transit agencies occasionally offer a free day of transit service to get citizens to try out their bus service. This has been done in the Denver area by RTD when new light rail lines have been opened. There is also the example of Boulder's 2016 Bus-to-Work Day. Through a partnership with RTD, Via Mobility, Transfort, Google, Inc. and the City of Boulder, the RTD local bus routes, the HOP, and the FLEX (from Boulder to Fort Collins) offered free rides all day in the City of Boulder on October 5, 2016. This was advertised as an inaugural event, suggesting that it may be repeated annually in the future. A second annual Boulder Bus to Work Day was held in 2017.

At the ***Breckenridge*** Ski Resort, visitors arriving with four or more people in a vehicle receive a $5 discount at any of their pay lots.

III.5 Marketing and Education

CDOT's TDM Tool Kit stressed the importance of marketing and education as the foundation of any successful TDM effort. It is not enough to provide a new transit service, managed lane or bike route, but instead some effort must be made to let potential users know that it is being made available and how to use it. The Toolkit suggested that, as a rule of thumb, up to 15 percent of a TDM project budget should go to marketing it. According to the Toolkit, the three key goals of a marketing effort should be:

- Awareness – let the consumer know that the new service is available
- Try It – convince the consumer to actually try out the new service at least once
- Maintain – after the consumer is aware and has tried the service, remind them to use it regularly

Numerous marketing techniques are available for getting out TDM messages. These include radio and television advertisements (free public service announcements, if possible), billboards, utility bill flyers, ads on buses or bus stops, and agency involvement at community events, among many others. Press releases and advertisement on agency websites are additional, lower cost options.

In the Denver area, the DRCOG Way to Go program has its own strong marketing efforts, and also includes marketing in the TDM outreach efforts of the Transportation Management Organization grants it awards. RTD also conducts extensive marketing efforts to promote transit use.

The Regional Air Quality Council (RAQC) in Denver is working to improve the region's summertime ozone air pollution problem with various marketing efforts including its "Every Trip Counts" program. This program provides incentives to people who choose to leave their car at home and bike, walk or use the bus a minimum of two trips per week during the summer. By leaving their car at home, participants are eligible for drawings for RTD ride tickets, and can also track their trips using the OzoMeter to see the immediate air quality impact of their trip reduction. The program is the result of a partnership between the RAQC and the Smart Commute Metro North TMO.

RAQC also conducted a regionwide OzoneAware campaign. RAQC reports that in 2015, 585 persons logged their travel reduction with the OzoMeter (RAQC, 2016).

A Boulder County Clean Air Challenge targeting the ozone-sensitive months of July and August attracted 200 registrants including 100 active participants who logged 60,000 vehicle miles of travel reduction, for an average of 300 miles per person per month, or ten miles per day per person. The 2016 campaign reportedly reduced 66,000 VMT, a ten percent improvement. Ten gift cards and an iPad Air tablet computer were awarded as prizes to program participants (Boulder County, 2017).

Groundwork Denver, Inc., a recipient of a DRCOG federal Congestion Mitigation and Air Quality (CMAQ) grant, reports that it conducted outreach ("Over 19,000 doors were knocked on…") in Denver neighborhoods to promote their "Strive Not to Drive" campaign to promote alternative transportation modes (Groundwork Denver, Inc., 2016).

The Downtown Denver Partnership, a TMA, has conducted alternative marketing campaigns such as Drive Less Denver 2006, Drive Less Denver 2007, and Get Downtown Unconventionally in 2008 during August, the month of the Democratic National Convention in Denver (Downtown Denver Partnership, 2009).

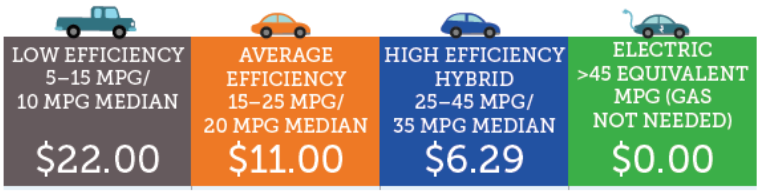
III.6 Market-Based Strategies

CDOT's TDM Toolkit discusses the topic of market-based strategies which are geared toward helping consumers understand the costs of their commuting behaviors. One example is ***variable pricing on CDOT's Express Lanes***, where tolls are highest during the busiest peak periods and lower during the off-peak, thus encouraging motorists to shift their trip-making to off-peak hours if possible.

The ***parking cashout or employee transportation allowance*** approach discussed earlier is another example. Rather than provide free parking, the employer makes its workers aware of the actual cost of a parking space and gives them the option to pay it or find more economical transportation options.

A ***road usage charge*** is receiving increased interest nationwide as both the U.S. Department of Transportation and state departments of transportation (including CDOT) face rising infrastructure and maintenance costs with dwindling revenues derived from traditional gasoline taxes. The Federal gasoline tax and Colorado's gasoline tax have not increased in more than 20 years, even while costs have escalated dramatically. Meanwhile, vehicles have become more fuel-efficient. The result is that for the same amount of travel now versus in the past, motorists now pay less gasoline tax. Electric vehicles and other alternative fueled vehicles pay less gas tax or even none at all, as indicated in **Figure III.2**.

Figure III.2: Average Monthly Gas Tax Paid



CDOT, Average Monthly Gas Tax Pid by by Vehicle Type, 2017.

In 2014, CDOT joined 13 other member states in the Western Road Usage Charge Consortium (RUCWest.org, 2017). RUC West gathers state DOTs to collaboratively research RUC systems, feasibility, and policy development. While sharing information on this topic, each state is proceeding at its own pace, dependent on its local needs and political philosophy, with regard to potential implementation. For example, Oregon and California seem to be pursuing the concept most aggressively.

In addition to participating with the consortium, Colorado is conducting its own research. During 2016-2017, CDOT conducted a Roadway User Charge pilot program using 100 recruited volunteers. The results of this study will help CDOT to identify advantages and disadvantages of this approach. The issue is very complicated and will require more research. On August 30, 2017, the Federal Highway Administration announced $14.2 million in grants for states under a new program called Surface Transportation System

Funding Alternatives (STSFA). Colorado has received a grant of $1 million under this program to do additional research.

Note that although improved fuel efficiency has been very beneficial for the environment, it has not reduced travel demand and roadway congestion. Additionally, it has reduced transportation revenues while the cost of maintaining and operating transportation facilities continues to increase. In the above graphic, four vehicles traveling the same number of miles in a month pay widely different gas taxes, ranging as low as zero. A Road User Charge might charge all four vehicles the same amount, hypothetically $12 per month. The motorists would still pay different amounts for their actual fuel, which is much more costly than the tax or charge, so they would still have an economic incentive to use fuel-efficient vehicles. Additionally, a road user charge would make motorists more directly aware that each mile they drive has a financial cost. Most people are not aware of what cost per mile they pay in gas taxes.

III.7 Intelligent Transportation Systems and Traveler Information Systems

The CDOT TDM Toolkit discussed intelligent transportation systems (ITS) as a TDM support strategy, i.e., something that helps people to decide to travel by modes other than solo driving. CDOT has developed an extensive statewide network of ITS equipment since the Toolkit was published in 2002. Technology has advanced considerably over the last 15 years, increasingly making it possible for government and even private entities to collect real-time transportation data, apply it for system management purposes, and communicate useful information back to the travelling public.

CDOT operates and maintains the Colorado Transportation Management Center in Golden and statewide ITS communications, network systems and equipment. ITS infrastructure includes elements such as fiber optic cable along highways, closed circuit television cameras, variable message signs, ramp meters, high occupancy vehicle/high-occupancy toll lane systems, road and weather information service, travel time indicators, and highway advisory radio.

The CDOT TDM Toolkit gave as ITS examples Smart Cards for payment of transit fares, and Traveler Information Systems. These and other strategies are also discussed below.

Smart cards in many varieties are available and used for RTD transit. These include the EcoPass, CollegePass, and Neighborhood EcoPass (all homes in a neighborhood signed up for the discount, sponsored by their local government). Use of these cards adds convenience for the card holders and speeds up the boarding process for the benefit of all transit users. Efficient boarding is needed to allow buses and trains to remain on their schedules.

Many buses now have transponders to communicate their position to transit operators, who in turn have some ability to pass this information along to customers. Real-time bus locations can be tracked online by customers of Greeley-Evans Transit with the GETrax application (Greeley-Evans Transit, 2017). Transit users in Grand Junction can get real-time status information on where their bus is by going online to gvteta.com (stands for Grand Valley Transit estimated time of arrival).

Mountain Metro Transit in Colorado Springs has signs at bus stops enabling the customer to learn via cell phone what times the next several buses are scheduled to arrive (see **Figure III.3**.) Similar systems are available elsewhere in the state.

Figure III.3: Sign Offering Schedule Information by Cell Phone

Mountain Metro Transit in Colorado Springs.

In Denver, RTD's Next Ride system lets customers search for scheduled departures through phone, web, and texting. They can use their stop, station, or Park-n-Ride five-digit stop number for quick access to route and schedule information 24-hours a day, seven days a week. Additionally, electronic signs at RTD FasTracks light rail stations also indicate upcoming train arrival times.

As of March 2001, at least 300 telephone numbers existed for travel information systems in the United States. To overcome the confusion caused by this array of numbers, the United States Department of Transportation and the Federal Communications Commission created a national three-digit phone number 5-1-1 for ITS traveler information. Colorado participates in this voluntary program.

The volume of 5-1-1 calls received differs dramatically between the non-snowy half of the year (i.e., May through October), compared to the snowy (ski season) half (i.e., November through April). For the two full years between November 1, 2015 through October 31, 2017, the average number of 5-1-1 calls ***per day*** was about 1,100 during non-snowy months and 4,800 per day during the snowy months. The all-time record was 81,000 calls in a single day, during northern Colorado's catastrophic flooding in the year 2013. In total, the 5-1-1 number receives about 1.1 million calls annually.

CDOT also maintains up-to-date traffic information on its website, accessible via computers, cell phones, tablets and other mobile devices, to alert motorists about congestion, construction and road weather conditions. CDOT also makes traveler information available via Facebook and Twitter.

Additionally, numerous modern applications such as Waze can give motorists real time travel speed information, and various Global Positioning System (GPS) apps provide maps and directions to help motorists chart a course to their destination.

Logo of the Go Denver app

The City and County of Denver uses a radio channel, AM 1260, as its Highway Advisory Radio. The city broadcasts information about road closures and special travel conditions on this station. In February 2016, Denver launched a new cell phone app called Go Denver, designed to help commuters find the fastest, cheapest and greenest routes to their destinations. A local newspaper described it as "basically Google Maps with added traveling options, including Lyft rides, Car2Go rentals and taxi services" (Westword, 2016).

Technology that helps motorists find parking spaces was discussed earlier in this report.

CDOT is strongly committed to developing and implementing new technology to improve safety and mobility on the state transportation system. See the discussion of automated and connected vehicles and the CDOT RoadX program in **Section IV**. One of the current projects being implemented under RoadX is a significant software and traffic-sensor upgrade to the aging traffic management and ramp-metering systems on I-25 between RidgeGate Parkway and University Drive, in the southern portion of the Denver metro area. This hyper-smart system called SMART 25 will help to better manage the flow of vehicles, which could increase the road's capacity by 5 to 20 percent, but at a fraction of the cost of widening.

III.8 TDM-Friendly Design Considerations

CDOT's TDM Toolkit discusses a variety of ways to design new buildings and other development in a manner that would accommodate alternative mode use. These include provision of:

- sidewalks
- bike paths

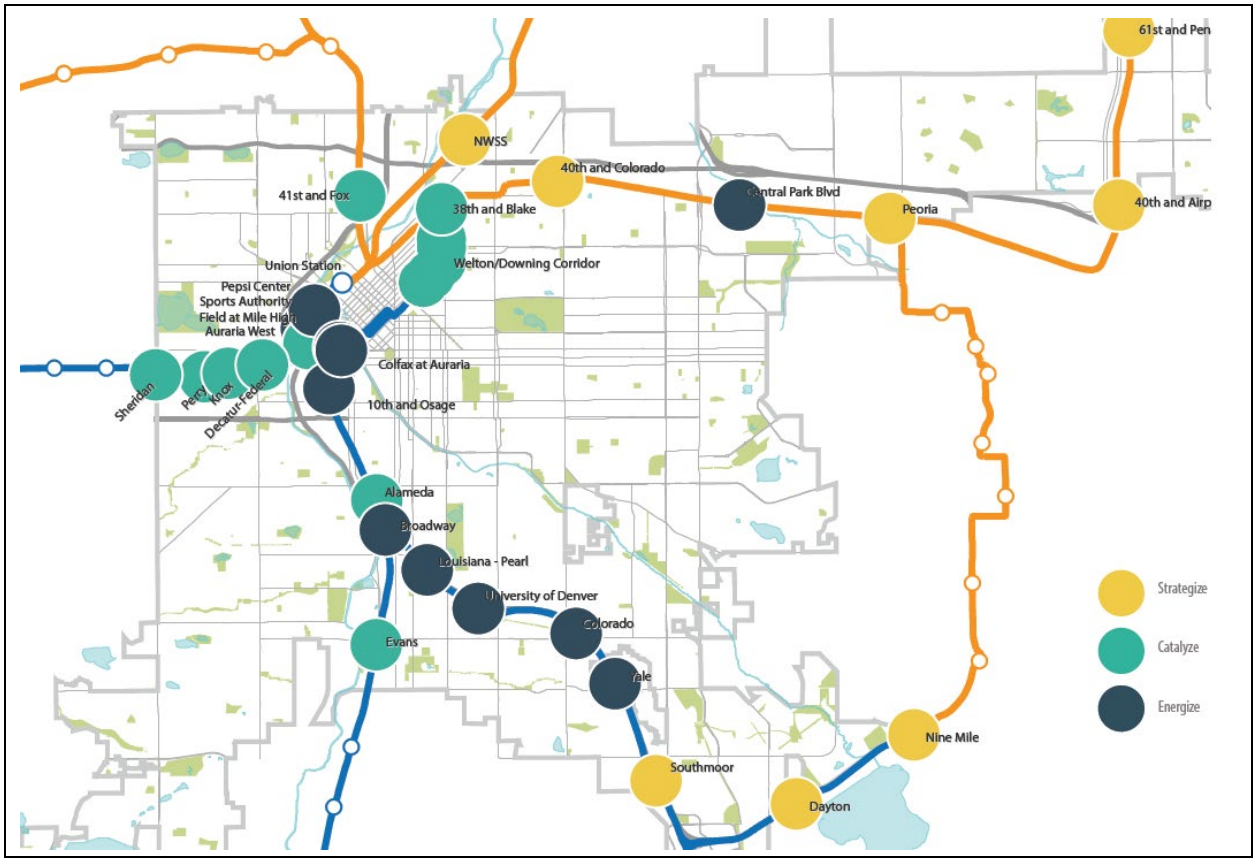
- nighttime lighting
- bicycle parking
- design that minimizes conflicts between vehicles and pedestrians

The City of Boulder has a similar approach. "TDM-friendly site design includes an aesthetically pleasing environment for pedestrians; adequate and convenient bicycle facilities; protected pedestrian corridors through parking facilities; preferential parking for carpools and vanpools; passenger drop-off locations near building entrances; and buildings sited to the street" (City of Boulder, 2017b).

Local governments have control over land use decision-making, while RTD operates regional transit service, including both light rail and buses. RTD has worked closely with the City and County of Denver and other communities to encourage transit-oriented development (TOD) in the vicinity of light rail stations. Transit-oriented development includes high development densities and mixed land uses, such that local residents have walkable access to shopping and employment. Creating high-density development contributes to the success of the light rail lines by ensuring a large number of potential customers.

Denver adopted a TOD Strategic Plan in 2006 and updated it in 2014 based on lessons learned from experience as RTD light rail lines were built and stations opened (City and County of Denver, 2014a). **Figure III.4** depicts station locations where the city hopes to "strategize, catalyze, or energize" TOD. The city has also decided to examine potential for TOD in transit intensive corridors that are not planned to have light rail lines.

Figure III.4: Denver-Identified Sites for Transit-Oriented Development



Source: City and County of Denver, 2014a.

Supporting these efforts is the identification of dense "Urban Centers" throughout the region in the *DRCOG Metro Vision 2035 Plan*, an outline for regional land use and development. All local governments in the Denver metro region are members of DRCOG and have worked cooperatively to create this vision to focus infrastructure investments in a way that will maximize efficiency and avoid urban sprawl. Many of the urban centers are located at RTD light rail stations, but some are in areas where no light rail is planned.

In 2011, the City and County of Denver, along with its partners, received a joint U.S. Department of Housing and Urban Development Community Challenge Grant ($1.8 million) and U.S. Department of Transportation TIGER Grant ($1.2 million). Together, this grant was the foundation for the Denver Livability Partnership (DLP). The DLP worked to expand permanent affordable housing, improve access to jobs and create better multi-modal connectivity along Denver's transit corridors. The federal funding allowed Denver to leverage partnerships and opportunities along the west light rail corridor to transform Denver's west side into livable, transit-oriented neighborhoods. Through capacity-building and knowledge sharing, best practices will now be applied to other corridors in Denver, in the region and nationwide (City and County of Denver, 2016).

The City of Boulder has a transit-oriented development called Boulder Junction (previously known as the Transit Village). This 160-acre redevelopment area is located in the geographic center of the community, connecting west and east Boulder. It features a bus rapid transit (BRT) station and residential, commercial, and retail space. The centerpiece of this area is an RTD underground bus facility adjacent to the new Hyatt Place Hotel. Robust transit service is critical to supporting a transit-centered lifestyle in the Boulder Junction area. According to the development's master plan, it is intended to create a mix of ownership and rental housing at a range of 220 to 300 units (City of Boulder, 2017c).

The Panasonic Corporation is developing a "Smart City" connected neighborhood called Peña Station NEXT, to the south of Denver International Airport. The futuristic neighborhood will feature smart LED street lights, a blanket of Wi-Fi coverage, smart parking and smart bus stops (Denver Post, 2017a). The 400-acre development will have an 800-space light rail station Park-n-Ride and is projected to generate 2,760 light rail boardings per day at buildout (City and County of Denver, 2017a). EasyMile—a French-based developer of electric, self-driving buses—has established its North American headquarters at Peña Station NEXT. An autonomous shuttle will offer a first- and last-mile solution for getting to and from the train station and throughout the development.

As part of its multi-year partnership with the Colorado Department of Transportation, Panasonic has transformed some of the streets at Peña Station NEXT into a live "test track" for connected vehicles and connected roadways (also known as V2X). It's a first for the state and positions Colorado at the forefront of transportation innovation nationally, too. Why is that a big deal? Because as V2X takes off on Colorado's roads and highways, it promises to make driving much safer while helping traffic flow smoother (penastationnext.com, 2017).

Denver, Lone Tree and Centennial are three of the 16 cities participating in "smart cities collaborative" begun in 2016 by an entity called Transportation for America (T4A). This process was to begin with information-sharing meetings, both with other member cities and with industry-leading transportation experts. From there, city representatives are to receive direct technical assistance, create pilot programs and share results with the rest of the collaborative to drive best practices across the country (Lone Tree, 2016).

In October 2016, Denver received the $6 million grant under FHWA's Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD) program and will use the funds to implement three intelligent vehicle projects: a Connected Traffic Management Center (TMC) and Connected Fleets; Travel Time Reliability as a City Service for Connected Freight; and Safer Pedestrian Crossings for Connected Citizens. The technologies include dedicated short-range communications in 1,500 city fleet vehicles to enable signal priority for truck platooning and for a freight efficiency corridor.

The trucks also will be equipped with a system that automatically detects when a pedestrian is in close range (City and County of Denver, 2017b).

The ATCMTD program funds technologies that address the concerns outlined in *Beyond Traffic 2045* (USDOT, 2015), the recent U.S. Department of Transportation report that examines the challenges facing America's transportation infrastructure over the next three decades, such as a rapidly growing population and increasing traffic. ATCMTD was established under the "Fixing America's Surface Transportation" (FAST) Act. The U.S. DOT has established a network of 16 Beyond Traffic Innovation Centers, one of which is located at the University of Denver (USDOT, 2017b).

COLORADO
Department of Transportation

IV. TDM EMERGING TECHNOLOGIES

This chapter addresses the following topics:

- Carhailing (e.g., Uber, Lyft)
- Carsharing (car rental)
- Bikesharing (bike rental)
- Managed Lanes, Express Lanes and Tolled Lanes
- Automated and Connected Vehicles/RoadX

IV.1 Carhailing (Uber, Lyft)/Transportation Network Companies

Carhailing, or ridesourcing, is similar to taxicab service, in that a person wishing to get a ride contacts a dispatcher and a nearest available driver responds. However, the carhailing vehicle is privately owned, not a marked taxicab, and the rates are not set by the Public Utilities Commission. Payment is made electronically from the passenger to the dispatching company, which then pays the driver. Drivers may be full-time or part-time.

Colorado enacted legislation in 2014 to embrace carhailing by creating a new vehicle class called "Transportation Network Companies" (TNCs, for short). Senate Bill 125 requires that:

- Every driver-partner pass a rigorous screening process that includes driving and criminal history checks, including county, federal and multi-state checks;
- Every vehicle on the road has been inspected for safety and quality with a 19-point inspection by a certified mechanic;
- Every trip is insured up to $1 million from the moment a driver accepts a ride request.

The two best-known TNCs in the U.S. are Uber and Lyft. Uber started in San Francisco in 2009 and in 2016 reportedly operates in 66 countries and more than 500 cities. Lyft began in San Francisco in 2012 and in 2016 operates in over 200 cities. Under each service, the mobile-phone application facilitates peer-to-peer ridesharing by connecting passengers who need a ride with drivers who have a car. These carhailing services generally are not available in rural areas, but seem to be rapidly and continually expanding their service areas:

- Uber began service in the Denver metro area in 2012. It expanded to the Boulder, Colorado Springs and Fort Collins areas in 2014. It is now available also in the mountains in Summit and Eagle counties.
- Lyft began service in Denver, Boulder and Colorado Springs in 2014, and Fort Collins in 2016. Additional Front Range locations now include Aurora and Centennial (in the Denver area), Fountain (near Colorado Springs), and Loveland (near Fort Collins). In the mountains, Lyft service is now available is in Summit County, Vail, Beaver Creek, Aspen, Snowmass, Winter Park and Steamboat Springs.

Most TNCs will not transport children who are unaccompanied by an adult, for strong reasons regarding safety and liability. Recognizing this as a transportation market need, a company called HopSkipDrive specifically markets itself as a service to transport unaccompanied minors. This company, described as "Uber for kids", started in California (Los Angeles and San Francisco) and began operating in Denver as its third market in 2018. Initially, the HopSkipDrive service area is limited to a small portion of central Denver. An April 2018 news report indicated that plans for providing service in Colorado Springs were actively under consideration (ABC News Channel 13, 2018).

In 2014, Uber announced a new variation of its service called UberPool. This service allows travelers to request an Uber ride shared with other passengers, to save money, not unlike sharing a taxicab. Taken one step beyond, it is possible to coordinate with several other passengers to form an impromptu vanpool, provided that an adequately large vehicle is available.

In April 2018, Uber announced yet another service variation, called Uber Express Pool, providing less than door-to-door transport, in the Denver region. This service links riders in the same area who want to travel to similar destinations. Once linked, riders would need to walk a couple of blocks to be picked up at a common location. They also would be dropped off at a site that would be a short walk from their final destinations. It was reported that Express Pool service could cost up to 75 percent less than a regular Uber ride. As part of the service, the rider also receives walking directions to their final destination. Besides Denver, this service reportedly was offered in San Francisco, Boston. Los Angeles, Philadelphia, Washington, Miami and San Diego, as of April 2018 (Fox31 News, 2018).

Airports are a large producer and destination for ground transportation services. Uber rides are definitely available at Denver International Airport. The Uber website describes eight different variations of service that might be of interest to passengers arriving in Denver, as detailed below in **Table IV.1**.

Table IV.1: Uber Service Variations Offered at Denver International Airport

Uber Service Offered at DIA		
Service	***Uber's Description***	***DIA Pickup Location***
UberX	Affordable private rides for 1 to 4 people	Level 6
Uber XL	SUVs for groups of up to 6	Level 6
Uber SUV	Luxury SUVs for groups up to 6	Level 5
Uber POOL	Shared rides, shared costs; maximum 2 seats per request	Not specified
Uber BLACK	High-end rides with professional drivers	Level 5
UberSELECT	High-end rides; "stylish" rides; highly-rated drivers	Not specified
UberWAV	Wheelchair-accessible vehicles	Arrivals level
UberTAXI	Taxi rides; no cash necessary	Not specified

Source: Uber, 2018.

Additionally, a variation called UberSKI allows riders to request a vehicle equipped with either a ski rack or a truck bed. This service is available in Denver and most ski resorts in Eagle and Summit counties.

TNC use at Denver International Airport is reducing demand for rental cars and airport parking, to some degree, according to a researcher at the National Renewable Energy Laboratory. It also increases demand for curb space at the terminal. To help offset revenue losses, DIA began charging TNCs a fee for accessing the airport.

Carhailing is taking an expanded role in transporting people to ***medical*** appointments as well as to hospitals. A 2017 study by University of Kansas economists found that ambulance rides dropped by at least seven percent in cities after Uber entered the market. Drivers have reported people with broken bones, bloody gashes and other serious injuries opting for a $15 Uber or Lyft ride rather than paying $1,000 or more to use an ambulance (Denver Post, 2018).

Carhailing has been identified as a convenient solution for the "first-mile/last-mile" issue associated with public transit. A particular bus route or light rail line may take a passenger from somewhere near the trip origin to somewhere near the trip destination, but typically does not provide door-to-door service. Transit users often walk or sometimes take a bicycle to complete their trip, or they drive a vehicle to a park-and-ride lot. Since park-and-ride lots are expensive to build and have limited capacity, transit operators nationally are recognizing the benefit of coordinating intermodal service that includes carhailing.

In August 2016, the Go Centennial public private partnership announced a six-month pilot program of free Lyft service to and from the Dry Creek RTD Light Rail station. This service was limited to RTD's Call-and-Ride service area in Centennial. It was hoped that use of Lyft drivers would be more convenient for passengers and more cost-effective than existing RTD Call-and-Ride service which requires advance reservations and costs $21 per ride (CityLab.com, 2016).

The cost of the pilot program was $400,000, with Centennial and the Southeast Public Improvement Metropolitan District (each providing $200,000. The sponsors' June 2017 after-report concluded that the program did not meet its ridership expectations and was not as successful as the nearby Lone Tree Link program. It also concluded that its very small service area was not sufficient to achieve satisfactory economies of scale. It is believed that serving a larger project area would achieve higher ridership and lower average costs (GoCentennial, 2017).

In August 2017, the City of Lone Tree launched a partnership with Uber whereby persons wanting a free ride anywhere within the city limits can request it via the Uber app and will be picked up by a Lone Tree Link On-Demand 12-passenger van.

In early 2017, a representative in the Arizona legislature proposed a bill requiring the state to cut its 13,000-vehicle fleet by 20 percent and to launch a program that could use ride-hailing services like Uber, Lyft or other companies to provide transportation for state workers (Associated Press, 2017). This legislation did not get enacted.

It is widely understood that Uber hopes to convert its business to driverless autonomous vehicles in the future, a topic discussed later in this chapter. A setback to this plan occurred in March 2018 when a self-driving Uber car hit and killed a pedestrian at night in Tempe, Arizona. Uber Technology Inc. thereupon suspended its on-road testing in Tempe, Pittsburgh, San Francisco and Toronto. (New York Times, 2018).

A company called Zimride (an Enterprise Rental Car subsidiary) arranges Uber-like service for specific employers, rather than the general public. Their website indicates that they have four networks in Colorado: University of Colorado at Denver; Verizon Wireless; PriceWaterhouse- Coopers; and Intuit (Zimride, 2016).

CARHAILING UNINTENDED CONSEQUENCE: INCREASED CONGESTION?

Researchers nationwide are examining the possibility that TNCs may actually increase traffic congestion, especially in large cities, as service providers cruise empty ("dead-heading") awaiting their next customer pickup, like taxicabs. One study included surveys of 944 ride-hailing users over four weeks in late 2017 in the Boston area. Nearly six in ten said they would have used public transportation, walked, biked or skipped the trip if the ride-hailing apps weren't available.

After initial studies identified carhailing as a cause of congestion, other new studies suggest it is not a problem. Additionally, if TNCs help a customer to avoid owning a vehicle altogether, this at least reduces the number of parking spaces needed (Chicago Tribune, 2018).

Another unintended consequence arises from online shopping. The customer no longer has to travel to the store to shop, but more delivery trucks may be on the road to deliver online purchases. To reduce labor costs, the world's largest online retailer, Amazon.com, reportedly in working to develop aerial delivery drones. Trucks would take the drones to the delivery area, and drones would take the packages to individual addresses.

DISCLAIMER

A number of private firms, products or services are mentioned in this report. Uber, in particular, is mentioned more than 70 times. Any such mention in this report is not intended as an endorsement by the Colorado Department of Transportation.

Carhailing clearly competes with traditional taxicab service. This has forced taxi businesses to adapt and modernize, to become more like carhailing. In 2016, Boulder County's taxis underwent a makeover, a name change and a technological upgrade, morphing into a new identity as "zTrip". Its fleet of 60 cars, mostly Scion XDs, can be hailed via smartphone app, like Uber or Lyft. Users can order a car immediately, schedule one in advance, or walk out to the curb and hop into a waiting vehicle, just like traditional taxis have always operated. A key difference is that zTrip does not use "surge pricing" (higher rates during times of peak demand) (Denver Post, 2016). Yellow Cab of Colorado Springs also recently morphed into the zTrip identity.

As self-described at zTrip.com, the national firm indicates that its "app" helps users to book a taxi or limousine (zTrip, 2017). The firm states that it has 17 locations, including Boulder, Colorado Springs, Denver and northern Colorado (as well as Phoenix, Houston, Tampa and others).

IV.2 Carsharing (car rental)

Carsharing is a rental car program where vehicles are parked throughout the city and a person wishing to rent one does so by mobile phone on the spot, without the hassle of traveling to a car rental office. The vehicle provider sends an access code enabling the customer to open the vehicle. The vehicle does not need to be returned to the place where it was picked up. It can be dropped off at any approved public place in the city, ready for a subsequent user to rent.

Figure IV.1: Carshare Vehicles in Downtown Denver

Photos: Wilson & Company; left: Car2Go; right: ZipCar.

A total of about 500 carshare vehicles are available in the Denver area as of 2016. **Figure IV.1** depicts two carshare vehicles spotted in downtown Denver.

Existing carshare programs in Colorado as of 2016 include:

- **Enterprise CarShare** – four programs: Metro Denver Area; Denver UCD/MSU Auraria Campus; Colorado Mesa University (Grand Junction); Colorado State University – Pueblo.
- **Car2Go** (subsidiary of Daimler Benz) – 300 vehicles in the Denver area.
- **eGo Carshare** – local non-profit began in Boulder, has received Federal CMAQ transportation funds. Approximately 50 vehicles are available in Denver, Boulder and Longmont, including University of Colorado Boulder and Naropa (Buddhist) University in Boulder.
- **ZipCar** (subsidiary of Avis Budget) – Over 70 vehicles in the Denver metro area; also available in Breckenridge (ski area), and at the University of Colorado at Colorado Springs.

Carshare Example Rental Costs

- *41 cents per minute plus 11.25% tax is 46 cents per minute (Cheaper to rent by hour if exceeding 36 minutes)*
- *$15 per hour plus tax is $16.69 per hour (cheaper to rent by day if exceeding 4 hours)*
- *$59 per day plus tax is $65.64 per day*
- *$1 insurance charge per trip (up to $90 max in one year)*

Source: Car2Go, 2017.

- **Car To Go** – City of Aspen program not associated with Car2Go; vehicles may be used within a broad service area within ski country, extending far beyond the City.

IV.3 Bikesharing (bike rental)

A bikesharing program makes bicycles available to any paying user on a short-term basis. In dock-based systems the rented bicycle needs to be returned to any bike station in the network, not necessarily where it was checked out. Casual users can pay one-time fees (e.g. $4.95 for 30 minutes in Denver), but regular users get much lower prices by purchasing a monthly or annual pass (See the price chart for Denver B-Cycle).

The bicycles are generally well equipped. Fort Collins Bike Share reports that, "The bike share fleet is brand new. Each bike is equipped with 8 speeds, GPS tracking, a lock, a rack, and lights." The Fort Collins program is sponsored by the City and a number of private businesses (Bike Fort Collins, 2017).

Denver B-Cycle Example Costs

- *$9 for 24-hour pass allowing "unlimited" (up to 48 half-hour trips*
- *$15 annually plus $3 per trip for unlimited trips up to 30 minutes (plus one-time $15 admin fee)*
- *$135 annually for unlimited trips up to 60 minutes each (plus one-time $15 admin fee)*
- *Overtime fee of $5 per 30 minutes for trips exceeding 30 minutes. (Example: 5-hour trip costs $54 = $9 pass plus $45)*

Source: Denver B-Cycle, 2017.

The largest two bikeshare systems in Colorado are in Denver and Boulder. These have stations where bikes are accessed and must be returned. The rental begins when the bike is unlocked and ends when it is locked again. Bike locations are found via computer apps. Colorado Springs downtown business interests launched a bikeshare program ("PikeRide") with 208 bikes and 28 "hubs" (stations) in June 2018 (Downtown Colorado Springs, 2018). New programs are being developed all the time as this industry is experiencing rapid growth.

In 2017, the City of Aurora launched Chinese-style "dockless" bikeshare that does not restrict bike pickup and dropoff to designated stations. Each bike has its own GPS-equipped "smart" electronic lock, so it is immobilized except when a user rents it by cell phone app. These bikes can be parked anywhere. They do not need to be attached to bike rack or anything else (see **Figure IV.2**). This offers greater convenience than station-based rental bike systems.

Figure IV.2. Dockless Bikeshare

Dockless Bikeshare Units Parked by Their Most Recent Users

Bikeshare programs currently operating in Colorado include:

- **Denver B-Cycle** - non-profit corporation with 87 stations, 700 bikes in Denver
- **Boulder B**-Cycle – non-profit corporation with 41 stations and 300 bikes (see **Figure IV.3**)
- **Aurora –** dockless bikes – LimeBike (250 bikes), Spin and Ofo: $1 per hour, park the bikes anywhere. Services were discontinued by the operators in August, 2018.
- **Fort Collins Bike Share** (formerly Fort Collins Bike Library) - 17 stations, 91 bikes
- **Castle Rock FreeCycle** – 25 bikes available to borrow for free at four stations (**Figure IV.4**)
- **WE-cycle community-supported bike share** serving Eagle County's Aspen, Basalt, Willits and El Jebel areas (possibly Glenwood Springs in 2018) – 43 stations, 190 bikes
- **Zagster** offers bikeshare rentals in Westminster to serve the RTD's light rail station
- **Golden Bike Library** – CDOT-funded seasonal program with 1 station and 40 bikes.

In addition to the bikeshare systems listed above, many colleges and universities in Colorado have bikeshare programs for the benefit of their students and employees, rather than the general public. Please see a discussion of school-based (colleges and universities) bikeshare programs in **Section V** of this *Colorado Transportation Options* report.

Figure IV.3: Boulder B-Cycle Stations

Map of Boulder B-Cycle Station Locations

Figure IV.4: Castle Rock FreeCycle Bikes

Fort Collins Bike Share reportedly is planning expansion with additional stations at Colorado State University. The expansion would be done through a partnership with Zipbike, a new national effort aimed at placing bike-share programs on college campuses. Zipbike is a collaboration between the car-sharing network Zipcar and Zagster, which owns and operates 135 bike-share systems across the country.

A FHWA report regarding bike sharing implementation states that use of bike share systems by low-income and minority communities has been limited, perhaps because low income persons have difficulty obtaining credit cards, which are needed to check out a bicycle (FHWA, 2012b). The report adds that, "[Bikeshare] programs in Boulder and Denver have worked with their local housing authority to offer reduced-rate or free memberships when new tenants sign a lease on an apartment near a bike sharing station."

The Denver B-Cycle operation offers a significant discount ($10 instead of $135 annually) and a free helmet for: residents of subsidized or free housing; enrollees in Electronic Benefits Transfer (Food Stamps), Qwest or Snap card program; enrolled in Medicare or Medicaid; or enrolled in the federal Temporary Assistance for Needy Families program (Denver B-Cycle, 2017).

A variation on the bikesharing concept is the availability of ***electric rental scooters*** in downtown Denver. Several vendors offer this service.

IV.4 Managed Lanes, Express Lanes and Tolled Lanes

"Managed lanes" are defined as highway facilities or a set of lanes where operational strategies are proactively implemented and managed in response to changing conditions. Examples of operating managed lane projects include high-occupancy vehicle (HOV) lanes, value priced lanes, high-occupancy toll (HOT) lanes, and other special use lanes. The managed lane concept may vary in from one facility to the next, involving the following common elements:

- The managed lane concept is typically a "freeway-within-a-freeway" where a set of lanes within the freeway cross section is separated from the general-purpose lanes, by barrier or by panted barrier.

- The facility incorporates a high degree of operational flexibility so that over time operations can be actively managed to respond to growth and changing needs.
- The operation of and demand on the facility is managed using a combination of tools and techniques to continuously achieve an optimal condition, such as free-flow speeds.
- The principal management strategies can be categorized into three groups: pricing, vehicle eligibility, and access control.

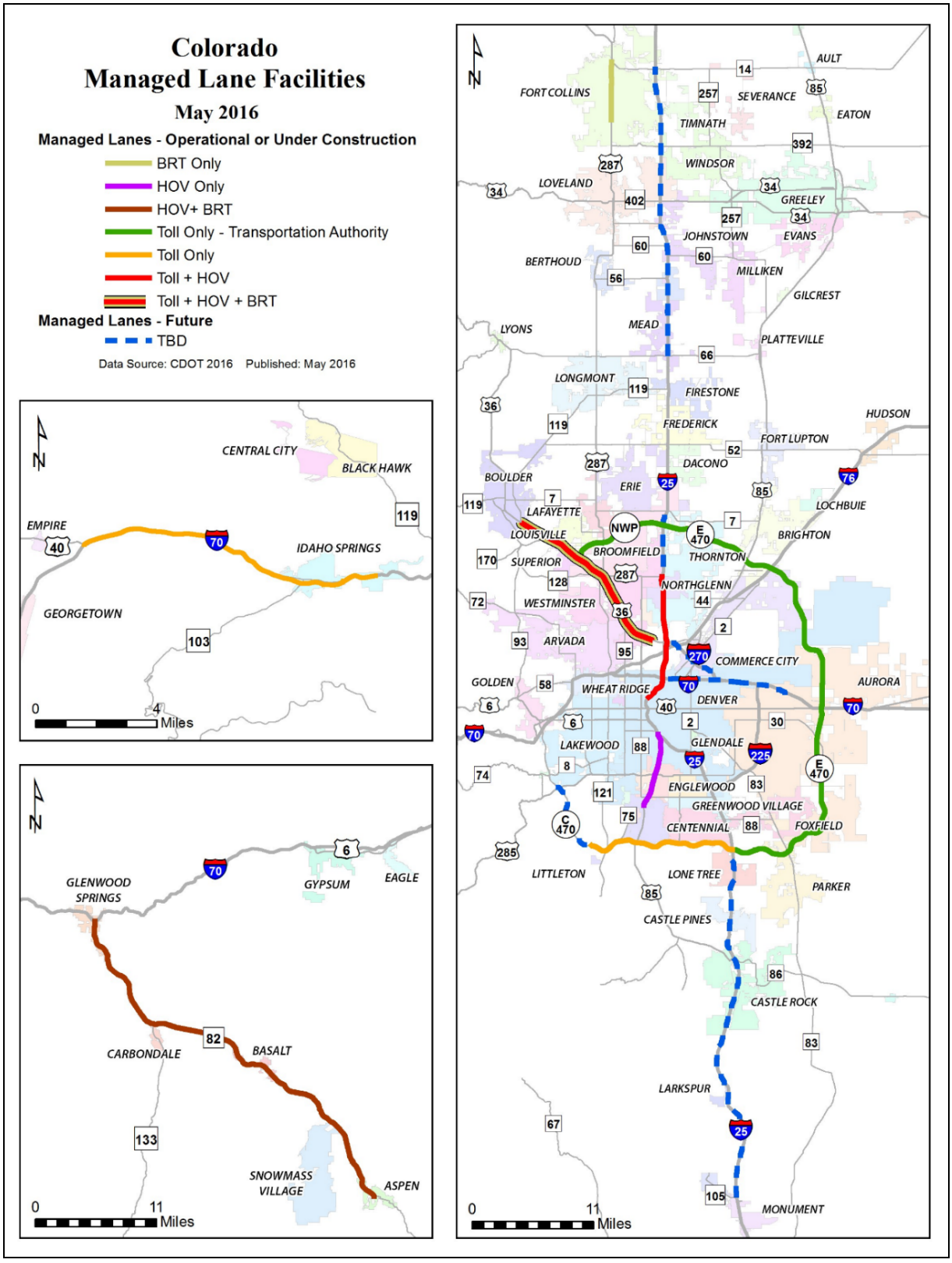
CDOT has a number of Express Lanes built or planned in the Denver metro area. Please see **Figure IV.5**, which shows the location of these facilities. Each of these facilities includes some lanes that are tolled and other lanes that are not tolled. These are:

- U.S. 36, I-25 to Table Mesa Drive in Boulder
- I-25, downtown Denver to U.S. 36
- I-25 North, 120th Avenue to Northwest Parkway (under construction, 2016-2018)
- I-70 Central, I-70 to Chambers Road (planned)
- I-70 Mountain Corridor, Empire to Idaho Springs (peak period shoulder lane)
- C-470, I-25 to Wadsworth Boulevard (under construction, 2016 to 2018)

On many of the Express Lanes, high-occupancy vehicles (with three or more occupants) are able to use the reserved lanes at no charge, while other drivers may pay to use the lanes.

The I-70 Mountain Express Lane is a wide shoulder that, only during peak travel periods, operates as a third travel lane. CDOT uses dynamic pricing to keep traffic moving. Prices fall when CDOT wants to encourage drivers to use the lane and increase as the lane reaches capacity. This is a 13-mile eastbound facility used to mitigate congestion primarily on winter ski weekends, as well as summer weekends and holidays.

Figure IV.5: Existing and Planned Managed Lane Projects in Colorado



Payment of tolls for all of CDOT's Express Lanes is accomplished via transponders and/or license plate detection, with automated billing so there are no toll booths to impair traffic flow. All toll facilities operate under a single billing system called ExpressToll, including the E-470 tollway around the southeastern portion of the Denver metro area. Unlike the other Express Lanes in Colorado, E-470 is privately owned. The first segment of the highway opened in June 1991 and the final segment opened in January 2003. Due to increasing demand, portions of E-470 were widened in 2017. Although it uses the same billing system, the E-470 Tolling Authority is a private entity completely separate from CDOT.

IV.5 Automated and Connected Vehicles/Road X

It now seems clear that the future of America's transportation system will be automated and connected vehicles. It is not a question of if, but when. Major corporations including vehicle manufacturers, Uber, Intel, Apple and Google are investing heavily and pioneering this new form of mobility (Economist, 2016). Google rebranded its "Self-Driving Cars" initiative as "WayMo" in late 2016 (see **Figure IV.6**). A Denver Post article reported that Volvo and other manufacturers will have autonomous vehicles for sale by 2021 (Denver Post, 2016c). General Motors plans to have driverless vehicles on the streets in major U.S. cities in 2019 for deliveries and carhailing (Denver Post, 2017b).

Figure IV.6: Google Driverless Car

Driverless heavy trucks are being developed by Peloton, Daimler, Uber's Otto division, and even the U.S. Army (Wired.com, 2016). A milestone for Colorado was a 120-mile beer run from a Budweiser brewery in Fort Collins to Colorado Springs in October 2016, made by a driverless Otto truck, as shown in **Figure IV.7** (Trucks.com, 2016).

Figure IV.7: Driverless Beer Truck

Driverless Yruck on Interstate 25 in Colorado.

The same Denver Post article noted above reported that one autonomous vehicle has the potential to remove 11 vehicles from the road, by sharing the third-party-owned autonomous vehicle (Martin, 2010). It cited Denver real estate developers who now are planning new projects with parking spaces that can ultimately be converted to retail use (Denver Post, 2016d). Reducing the number of vehicles on the road and the space needed for them to drive and park has potential to reclaim expensive downtown real estate for more economic use, while at the same time making downtown more walkable.

CDOT is keeping pace with the rapid technological change with an initiative called ***RoadX***. This project was kick-started with $20 million in state funding in 2016, and has a budget of $12 million for fiscal year 2017. Its goal is to partner with private industry to advance technology that will bring increased safety and efficiency to the state's transportation system.

Potential benefits of advanced technology, ***RoadX*** reports, include:

- Reducing 80% of all traffic crashes
- Nearly quadrupling the vehicle-carrying capacity of existing highways
- Saving about 50 minutes of travel time daily in congested areas
- Improving mobility for elderly and handicapped populations
- Reducing congestion and vehicle emissions
- Make a dramatic leap toward zero deaths on Colorado highways

According to CDOT's website (CDOT, 2017e), current RoadX projects include:

- SMART 25, RidgeGate to University - Colorado will be undertaking a significant software- and traffic-sensor upgrade to the aging traffic management and ramp-metering systems on the highway. This hyper-smart system will help to better manage the flow with vehicles, which could have the result of effectively adding a new lane on I-25 at a fraction of the cost. CDOT expects to see an improvement in operational capacity - improvements could range from 5 to 20 percent.
- PHASE 1: Smart Truck Parking: Using detection and cloud-based software that understands and can report available parking spots to truckers will improve truckers' time and fuel consumption; reduce excess wear and tear on Colorado's roadways; and reduce excess air pollution. The first phase of this project will integrate six existing parking facilities into the Smart Truck Parking System.
- Demonstration of Otto self-driving truck: (conducted in October 2016, as discussed above).
- SMART 70: Golden to Vail: CDOT has partnered with an international mapping firm, HERE, to provide drivers the most real-time data possible to allow them to make better decisions when traveling through the mountains.
- Vehicle Communication: CDOT has partnered with Panasonic to build an ecosystem for connected transportation where smart vehicles, self-driving vehicles, and infrastructure share instantaneous data and information about road and safety conditions. In fewer than ten years, it's expected that up to 4 million vehicles in Colorado will be "talking" to each other and to the roadway infrastructure. Panasonic is planning to test internet-connected and self-driving cars on a 90-mile stretch of Interstate 70.
- SMART Pavement: CDOT will improve the reflectivity and durability of roadway pavement markings throughout major corridors in the state, allowing vehicles to better use these markings for guidance and lane designations.
- Sustainability: CDOT has partnered with the National Renewable Energy Laboratory (NREL) to create a map of electric vehicle charging stations in Colorado.

Additionally, in early 2017, in partnership with Bicycle Colorado and the Colorado Innovation Network (COIN)'s Imagine Colorado project, CDOT issued a RoadX Bicycle and Pedestrian Challenge, seeking innovative approaches to improving safety for bicyclists, pedestrians and motorists alike. A robust response was received from the public. In May 2017, five entrants received cash prizes of $10,000 each for their groundbreaking technological ideas to improve bicycling and pedestrian safety, while three other entrants received larger awards so that they can develop working prototypes of their concepts. The five "Track One" winning ideas were:

1. **Diffracted optic laser U-light** – makes riders more visible using a neon red three-foot arc surrounding the bicycle.
2. **Bicycle/pedestrian early detection system** - Marries radio frequency ID technology with reactive road signage to alert drivers at intersections: "Bicycles Present When Flashing".
3. **Obligatory web-based review of bicyclist and pedestrian information** with visuals in the Colorado Driver Handbook.
4. **Smart Signage** - Combines pedestrian and bicycle detection device with a smart sign to alert drivers; oscillating light illuminates the presence of pedestrians or bicyclists.
5. **Guardian Smart Road Beacon** - Infrared sensor array detects people or animals on roadway; matching array of LED lights highlights them to drivers

The three "Track Two" winning ideas, which will continue on to prototype development, were:

1. **Liberty Bell: The Smart Bicycle Bell** - Collects important data to inform planning, design, auditing and maintenance of bike and multi-use paths.
2. **Big Foot lighting system** - Increases the footprint and visibility of bikers with illuminated LED raised pavement markers along the side of the biker.
3. **ColoRoadie Safety System** - Specially engineered solar panels illuminate paths and driving surfaces. (CDOT, 2017f)

Another futuristic transportation idea of note is the ***HyperLoop concept*** that has been advanced by tech guru Elon Musk, Chief Executive Officer of SpaceX (private space exploration company) and Tesla (electric cars), among others. In 2016, he issued a call for proposals to build a high-speed ground transportation system that could propel a capsule full of freight or people for hundreds of miles at a speed of over 700 miles per hour. The capsule would travel in a low-pressure tube supported above the ground on pillars. Business magnate Richard Branson invested in the firm in October 2017 and the entity has been rebranded as Virgin HyperLoop One.

With HyperLoop One, passengers and cargo are loaded into a pod, and accelerate gradually via electric propulsion through a low-pressure tube. The pod quickly lifts above the track using magnetic levitation and glides at airline speeds for long distances due to ultra-low aerodynamic drag. Hyperloop One made headlines in 2017 with the successful completion of the world's first full-scale HyperLoop test, achieving record speeds. The firm began construction of two short test tracks near Toulouse, France, in April 2018.

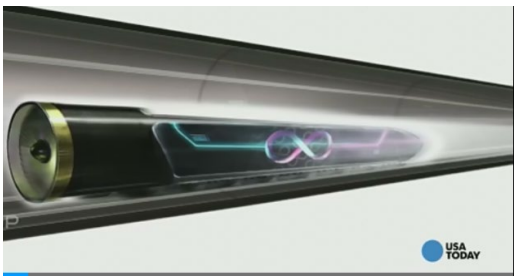
Colorado is one of the finalists in a global competition to pursue implementation of an initial HyperLoop high-speed transportation system.

Two of the finalist proposals in this global HyperLoop competition were in Colorado, one with CDOT involvement between Denver International Airport and Greeley, the other a private consortium proposal for service between Pueblo and Cheyenne, Wyoming. Now, as one of the ten winners of the HyperLoop One Global Challenge to identify the strongest HyperLoop routes in the world, Colorado is getting closer to the reality of a full-scale HyperLoop system. HyperLoop One and the Colorado Department of Transportation, supported by AECOM, will enter a public private partnership to begin a feasibility study that considers a Front Range route from Cheyenne to Pueblo (CDOT, 2017e).

Colorado is also sponsoring a test of HyperLoop's competitor, Arrivo's "High Speed Super Urban Network"

In February 2017, one of HyperLoop's founders started his own company called Arrivo to compete with HyperLoop for the market with similar technology. In November, 2017. It was announced that this firm would build a half-mile test track for its technology along the E-470 tollway in the southeastern portion of the Denver metro area. The state, through its Strategic Fund incentive, approved up to $760,000 grant to Arrivo over five years if the company invests $4.4 million in a new research facility and creates 152 new jobs with an average annual wage of $99,704. The incentive, however, must be matched by local governments before the state's Office of Economic Development and International Trade give its final approval. Arrivo is expected to invest $10 million to $15 million into the research and development office and track (Denver Post, 2017c). **Table IV.2** contrasts key features of the Arrivo and HyperLoop One concepts.

Table IV.2: Differences between Arrivo and Virgin HyperLoop One

Comparison: Arrivo vs. HyperLoop One		
	Arrivo	***Virgin HyperLoop One***
Technology	Above-ground tubes in existing highway right-of-way. Vehicles are placed on moving platforms.	Above- or below-ground vacuum-sealed tubes inside with magnetically levitated pods.
Speed	200 miles per hour	Up to 700 miles per hour
Backers	Brogan BamBrogan	Elon Musk, Richard Branson
Concept		

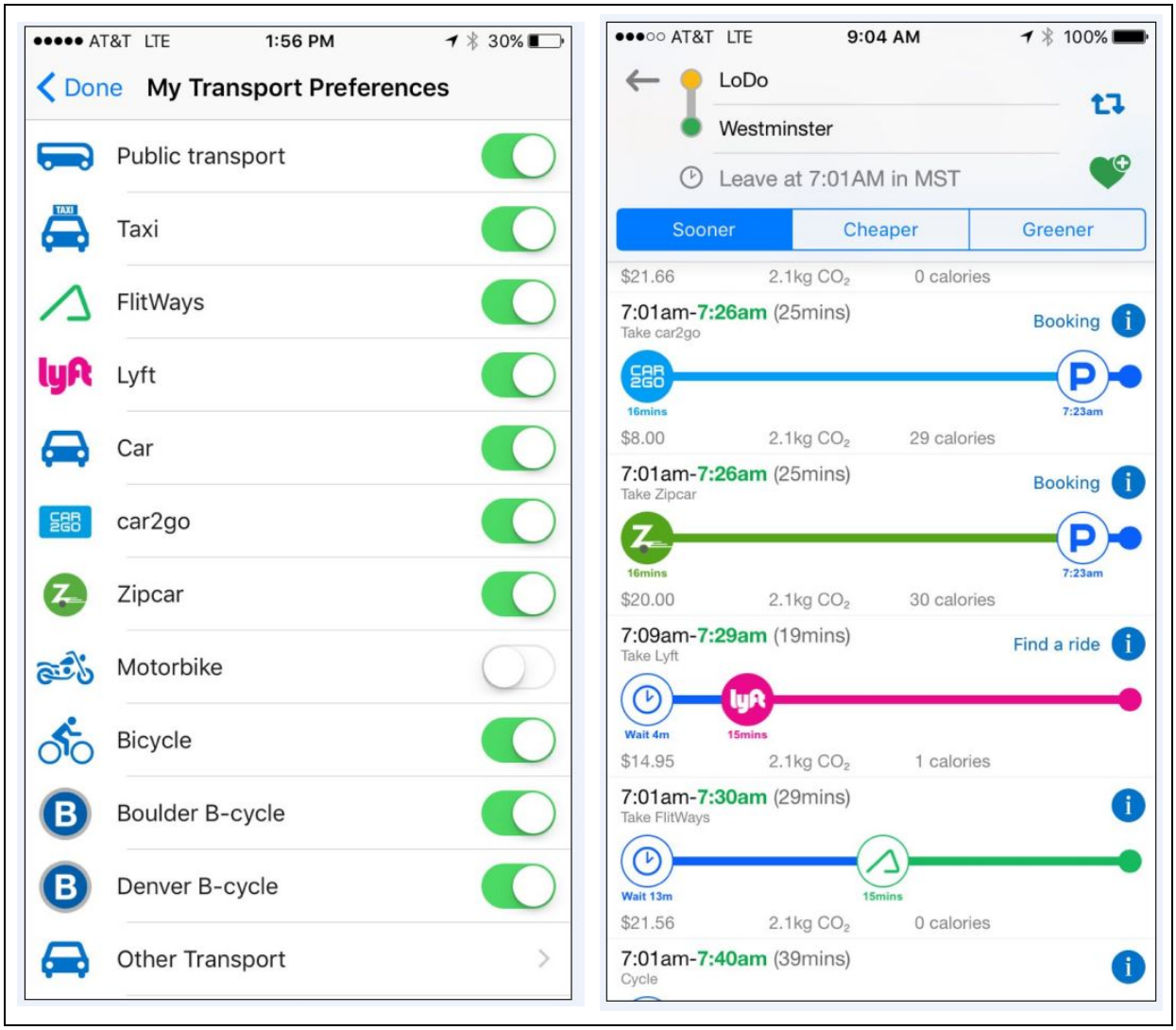
Source: USA Today, 2017.

IV.6 Mobility as a Service (MaaS)

As can be seen from the information above in this chapter, transportation technology is changing very rapidly and this will affect the way that society views transportation assets such as the privately owned vehicle. For example, with the combined power of shared vehicles and linked information systems for booking and payment, multiple transportation modes can be used to link a single trip through placing an order on a cell phone app. This is an emerging concept that cannot yet be chronicled in an inventory of existing TDM efforts, so it is not discussed further in the main body of this report. For more information, please see a Wikipedia article on the topic that is provided in **Appendix C**.

Multimodal transportation information applications are a major step in the direction of MaaS. Such apps show choices to commuters, enabling them to plan a trip consisting of one or more transportation modes. As an example, see the screen capture image from the GoDenver app (mentioned earlier), presented in **Figure IV.8**.

Figure IV.8: Screen Capture Images from the GoDenver App



Progress toward the MaaS concept is also evidenced by Uber's 2018 purchase of Jump, a dockless electric bike-share system that operates 12,000 bikes in 40 cities around the world. Lyft reportedly is preparing to purchase Motivate, a leader in U.S. bike-share systems. Motivate's CitiBike program in New York City reportedly sold 1.8 million bikeshare rides in May 2018 alone. Both Uber and Lyft reportedly are also interested in providing electric scooter rentals (Curbed, 2018).


Walk
Bike
Carpool
Vanpool
Transit
Telework

COLORADO
Department of Transportation

V. TDM FOR SPECIFIC MARKETS

Notwithstanding the work trip focus in the prior chapters, FHWA's 2004 report, Mitigating Traffic Congestion: Demand-Side Strategies, notes that strategies facilitating efficient traveler choices can be tailored for a wide range of different program applications, each addressing different trip types of travel market segments:

- Schools and Universities
- Special Events
- Recreation and Tourism Destinations
- Transportation Corridor Planning and Construction Mitigation
- Employer-Based Commute Programs
- Airports
- Incidents and Emergencies/Courtesy Patrol/Heavy Tow
- Freight Transportation

Colorado TDM applications regarding these travel market segments are discussed below.

V.1 Schools and Universities

This section first discusses local schools (elementary, middle and high), then colleges and universities.

In 1969, roughly half of all 5 to 18 year olds either walked or biked to school. These two modes, which involve physical exercise, are referred to as "active transportation". Use of active transportation has declined significantly, perhaps due in part to concern over student safety.

By 2001, only 10 percent walked or biked to school. In some communities, the desire for school choice has resulted in parents taking their children to schools farther away from their home neighborhood. The result is that school trips made by automobile have become a larger traffic and congestion issue than was traditionally the case. It is estimated that school trips account for 10 to 14 percent of traffic on the road during the morning commute (National Center for Safe Routes to School, 2011).

The consequences of driving to school include additional traffic in school zones, additional cost, additional fuel use, additional pollutant emissions, and increasing levels of childhood obesity.

The Colorado Department of Education indicates that approximately 905,000 students were enrolled in Colorado public schools in 2016-17, at 1,854 schools in 178 school districts. Many of these districts offer school bus service to their students (CDE, 2017). One particularly large example is the Douglas County School District, which reportedly provides 13,000 rides per day for its eligible population of 33,000 students. This district is 926 square miles in size and has three separate bus terminals. This district has a voluntary "Z-pass" program where students swipe their ID card to report electronically for their parents when they arrive at school (DCSD, 2017).

Two current efforts geared toward reducing school trip vehicle traffic are SchoolPool carpool matching programs and the federal Safe Routes to Schools initiative.

Schoolpools

In 2014, DRCOG's regional rideshare matching agency, called Way to Go, enrolled a total of 16,882 families in its Schoolpool program, and 38 percent of these families reported forming school carpools. This was a total of 6,415 families. Of these, 43 percent maintained carpool arrangements from the previous year, while 57 percent involved carpooling with at least one new family. The Way to Go Schoolpool families reported that their average one-way distance from home to school was 7.8 miles, and the average carpool involved

2.6 families (DRCOG, 2015b). Over 18,000 families received matchlists in 2015, and again more than 6,000 families participated (DRCOG, 2016b).

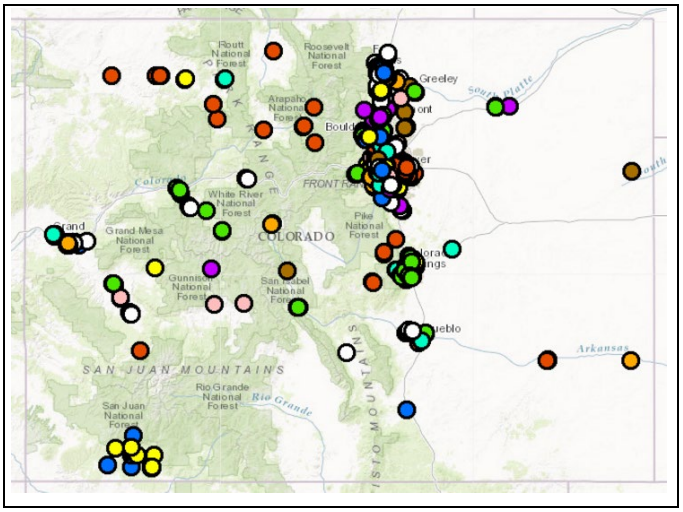
The Way to Go Schoolpool average distance is longer than the average school trip distance in Denver, which may be a reason why the families chose to participate. For the Denver metro area, the DRCOG regional transportation model reports an average one-way distance to school by automobile in 2015 was 5.12 miles, while the average for bike trips to school was 3.19 miles, and the average for walk trips to school was 0.74 miles. For smaller communities throughout the state, average school trip distances are likely shorter.

The Mountain Metro Rides program in Colorado Springs and the Smart Trips program in northern Colorado also offer Schoolpool matching services.

Safe Routes to Schools

In 2005, Congress passed transportation legislation that created the Safe Routes to School (SRTS) program, with dedicated funding. As of 2015, the Fixing America's Surface Transportation (FAST) Act maintains funding for Safe Routes to School, bicycling and walking improvements and provides a small increase in funding for the Transportation Alternatives Program, renamed the Surface Transportation Program (STP Set-aside)[National Center for Safe Routes to School, 2017].The goal of SRTS is to help kindergarten through eighth grade students walk or bicycle safely to school. Applicants can apply for grants up to $350,000 for educational use or for infrastructure within two miles of the elementary or middle school. Since the program began, CDOT has awarded 130 grants for education and 96 projects for infrastructure in communities throughout the state (CDOT, 2017g). The location of the various grant recipients is indicated in **Figure V.1.**

Figure V.1: Safe Routes to School Grant Recipient Locations, FY 2005-2016



Source: CDOT, 2017.

Some schools have built sidewalks or painted crosswalks to enhance safety; while others have focused on education or encouragement by starting programs such as a Walking School Bus to motivate children to be active. Regardless of the focus, safety is the first concern.

An individual grant recipient (e.g., a school district) can include multiple schools. The *Colorado Statewide Bicycle and Pedestrian Plan* (amended 2015) states that, "CDOT's SRTS program currently provides funding to more than 500 schools across Colorado" (CDOT, 2015d).

Colleges and Universities

At colleges and universities, where typically a large number of students and their cars are found, parking constraints are often an issue. College-age students are typically healthy and have low incomes, so they are willing and able to walk, bike, carpool, or use transit instead of driving alone. Since colleges and universities are often major employers in their community, their faculty and staff have a common trip destination and work schedule, so they are potential candidates for ridesharing. The website of Colorado State University (Fort Collins) indicates that a survey found that half of its students and faculty use alternative forms of transportation, rather than drive alone, to the school (Colorado State University, 2016).

Some of Colorado's colleges and universities are residential, meaning most students live on or near campus, while others are more of a commuter operation. As of 2015, it is estimated that there more than 300,000 college and university students in Colorado, as seen in **Table V.1**.

Table V.1: Enrollment at Universities and Colleges in Colorado

2015 Enrollment at Colorado Universities and Colleges Grouped by Region			
Institution	***Location(s)***	***Enrollment***	
University of Colorado Boulder	Boulder	32,000	
Metropolitan State University of Denver	Denver	24,200	
University of Colorado Denver	Denver and Aurora	13,400	
University of Denver	Denver	11,700	
Regis University	Denver and Colorado Springs	9,200	
Colorado School of Mines	Golden	4,500	
University of Phoenix	Lone Tree	1,700	
Colorado Heights University	Denver	400	
Denver Region Subtotal			**97,100**
Colorado State University	Fort Collins	23,900	
University of Northern Colorado	Greeley	12,000	
Aims Community College	Greeley, Loveland, Ft. Lupton	5,000	
Northern Colorado Subtotal			**40,900**
Pikes Peak Community College	Colorado Springs	14,600	
Univ. of Colorado at Colorado Springs	Colorado Springs	13,000	
Colorado College	Colorado Springs	4,500	
United States Air Force Academy	Colorado Springs	4,200	
Colorado Technical University	Colorado Springs	2,000	
Central Colorado Subtotal			**38,300**
Colorado State University - Pueblo	Pueblo	4,800	
Colorado Mesa University	Grand Junction	11,000	
Colorado Mountain College	Glenwood Springs/more	20,000	
Fort Lewis College	Durango	3,800	
Western State University	Gunnison	2,400	
Colorado Community College System	Various	72,000	
Other Locations Subtotal[1]			**114,000**
Many Other Small Institutions Subtotal			**11 ,900**
	TOTAL		**302,200**

Source: Wikipedia, 2016; Note: 1) Wilson & Company estimate.

Many colleges and universities have shuttle buses or other transportation programs to provide mobility for their students. A number of the state's largest schools provide transit passes to their students (a mandatory student fee) and some do the same for their faculty and staff. Examples for some of the state's largest schools are listed below.

- **University of Colorado Boulder**: CU NightRide provides service on the main CU-Boulder campus and from or to any point off campus within the Boulder city limits. CU NightRide is for CU students, faculty and staff only who call ahead to schedule service. Additionally, RTD CollegePasses are issued to all (e.g., 23,000) incoming students each year upon move-in. There are separate card activation periods for the spring, summer and fall.
- **Colorado State University**: CSU has a campus shuttle bus service called Around the Horn. Additionally, all students receive a TransFort transit pass (on their Ramcard student ID), included in their student fees. CDOT provides Rams Route Bustang service with one bus taking CSU students to Denver on Friday afternoons, returning on Sundays.
- **University of Northern Colorado**: The Boomerang Shuttle runs each day, Monday - Friday, beginning just before 8am and ending in the early afternoon. The shuttle is paid for by student fees. With a student ID, UNC students use the Boomerang Shuttle without additional costs. They also have free use of all Greeley Evans Transit routes.
- **University of Colorado Denver**: All UCD students pay for and receive RTD CollegePasses.
- **Metropolitan State University of Denver:** All students receive an RTD CollegePass smart card. Faculty and staff can purchase an RTD EcoPass for $25 per month.
- **University of Colorado at Colorado Springs; and Colorado College**: As a College Pass pilot program, Mountain Metro Transit is offering UCCS and CC students unlimited fixed-route transit for $5 per semester during the 2017-2018 academic year (CSBJ, 2017).
- **Pikes Peak Community College**: Starting in autumn 2018, PPCC students will be assessed a $10 per semester fee that will give them unlimited free use of Mountain Metro Transit.
- **Fort Lewis College**: FLC students can purchase an annual transit pass for $30 for the City of Durango transit system.

Bicycling is very popular at many colleges and universities. Local traffic engineering departments are fully aware of this and generally try to provide bicycle-friendly transportation systems to accommodate this demand.

States, cities, universities and businesses have the opportunity to obtain a Bicycle Friendly grade each year from the League of American Bicyclists. Those meeting the various criteria can be scored as Bronze, Silver, Gold (like Olympic medals) or Platinum (highest grade). Nationwide, there were only five Platinum Bicycle Friendly universities in 2015, and Colorado State University was one of them. Note that CSU has hundreds of bike racks to accommodate an estimated 14,200 bicycle parking spaces on the main campus and 1,100 spaces at the satellite campuses.

There were only five Platinum Bicycle Friendly Communities nationwide, and two of them were Boulder and Fort Collins. Four Colorado schools in were rated as Bronze: University of Northern Colorado, University of Denver, Colorado College and the UC-Colorado Springs.

Some Colorado colleges and universities have their own private bikeshare operations that rent bicycles to students. Others have access to non-university programs.

- **University of Northern Colorado Blue Cruiser**. UNC has a free campus bike program that is offered through the Department of Campus Recreation. Through this program a student can rent a bike for free with student ID for a week at a time. The campus rec center operates this program to offer an affordable and environmentally sustainable alternative to driving on campus.
- **Colorado College CCCycle**. Ten bikes are available for sharing by 25 program members.

- **University of Denver Bikeshare**. For $25 a quarter plus a $150 deposit or $75 a quarter plus a $100 deposit, students are provided bike rental, helmet, and a University-approved U-lock, as well as free tune-up. To replace this program, the University is planning to begin a Dockless bikeshare pilot project in 2018.
- **B-Cycle in Boulde**r. B-Cycle is not a university program but this non-profit organization offers 400 bikes for short-term rental, and at least ten of its 40 existing bike stations are near the University of Colorado campus. Additionally, the CU Environmental Center makes available a number of free B-Cycle "Republic Rider" passes available to CU students.
- **Colorado State University – Pueblo Soco Blue Bikes**. This program began in 2013 with 10 bikes available to rent for $15 per day or for students to share for a semester for $25.
- **Fort Collins Bike Share (formerly Fort Collins Bike Library)**. Short-term Zagster bike rentals are available at 13 locations, including several near Colorado State University (CSU). A CSU Bicycle Master Plan in 2014 focused heavily on provision of adequate bicycle parking facilities (Colorado State University, 2014).
- **Denver B-Cycle in Denver**. Denver B-Cycle stations are conveniently located to serve University of Colorado Denver and Metropolitan State University of Denver students whose schools are located at the southern edge of downtown Denver.
- **Fort Lewis College**. This college in Durango announced in 2016 that it is joining with the Partnership for a Healthier America and that as part of this effort it will offer a bicycle share/rental program and/or a subsidized bicycle purchase program for all students (Fort Lewis College, 2016).

Some Colorado colleges and universities have third-party carshare operations, offering convenient short-term car rentals.

- **The University of Denve***r* has two Enterprise CarShare locations on its campus, offering hourly and daily car rentals. Competitors eCarGo and Zipcar offer discounts to University of Denver students.
- **The University of Colorado at Boulde***r* has collaborated with non-profit eCarGo to have 20 cars and a pickup truck available for short-term rental by students and faculty.
- **Colorado State University** reportedly has at least five carshare vehicles available from Zipcar.

Colleges and universities typically exercise parking management. As the owners of parking lots on their campus, they have power to manage their parking supply through pricing, time restrictions and other policies. For example, the University of Colorado at Boulder offers priority parking spaces for carpools. Schools need to exercise care that their policies do not cause unwanted student parking in nearby non-campus areas, especially neighborhoods. In the past, this has been a problem at the University of Colorado at Colorado Springs, which now has remote parking lots and free shuttle buses to take students to those lots.

The Colorado State University website indicates that by state statute, parking on campus is self-funded, meaning that parking must generate revenue to pay for parking expenses. Parking permit fees are the primary revenue source for parking lot maintenance, parking operations, and the construction of new parking lots and garages. The University does not receive any tuition, student fee or tax revenue for its parking operations (Colorado State University, 2017).

V.2 Special Events

Special events can attract a large number of people to a single location for a limited number of times per year. One of Colorado's largest event venues is the home of the Denver Broncos pro football team, Sports Authority Field at Mile High (likely to have a name change because the sponsor has declared bankruptcy). This stadium has a capacity of just over 76,000 fans. Eight regular season games and two pre-season games typically attract capacity crowds, usually on Sunday afternoons but occasionally at other times. Venues with much less capacity handle pro baseball, basketball and hockey teams, as well as rock music concerts. These occur in Denver, where there is a relatively robust street and transit system, now including light rail service.

The lack of a robust transportation system for a large event can cause major congestion, as exemplified by Colorado Renaissance Festival traffic on Interstate 25 near Larkspur, between Denver and Colorado Springs, on many summer weekends.

Unlike work commute trips, which often involve solo driving, special events tend to attract couples, families, or groups of friends, so they have a much higher automobile occupancy. This is often reinforced by limited parking supply and high parking costs. Despite the high auto occupancy, special event traffic temporarily overwhelms road and transit systems because too many people arrive or depart from the venue at the same time. Any event expected to attract high attendance is an opportunity for event planners to plan and implement transportation demand management, both for increased enjoyment of the attendees and for public safety.

Special events start at a known specific time and end at an unknown specific time, which concentrates traffic. Some football fans arrive early to beat the traffic by having tailgate parties, and some fans leave games early to "beat the traffic." Remote parking and use of shuttle bus service is an effective approach for addressing congestion at special events.

Denver's Regional Transportation District has developed a number of special event services geared toward athletic invents. RTD promotes these programs as follows:

- **BroncosRide** - "Why tackle the traffic? Get to Sports Authority Field at Mile High on BroncosRide!"
- **BuffRide** - "Catch BuffRide to Folsom Field. It's a smart play." (This refers to University of Colorado football games.)
- **CU vs CSU special service** - "Take RTD to the annual showdown between arch rivals CU and CSU." This college football game is played in Denver.
- **Race for the Cure** - "Ride RTD to the annual Komen Race for the Cure."
- **RockiesRide** - "Let RockiesRide take you out to the ballgame!"
- **BolderBOULDER** - "RunRide, hassle-free transportation to the BolderBOULDER."

RTD offered free transit service on New Year's Eve, 2016 (and again in 2017), to reduce the potential for drunken driving. This "Freeze the Keys" event lasted for twelve hours from 7 pm New Year's Eve to 7 am New Year's Day (RTD, 2016b).

CDOT partnered with Uber and Lyft to provide 1,200 discounted rides to marijuana users in an effort to reduce Driving under the Influence (DUI) during April 2017, before and after April 20, the annual date of a major marijuana users' celebration in downtown Denver (CDOT, 2017h).

In 2016, CDOT's Bustang service operated on five Sundays for the purpose of taking riders from Fort Collins and Colorado Springs to Denver Bronco games, carrying about 90 passengers per game (CDOT, 2017b).

In 2017, the City of Manitou Springs offered free remote parking and bus shuttle service for its annual "Coffin Races," a Halloween-related weekend event attracting an estimated 10,000 to 15,000 spectators (Gazette, 2017).

While many of the special events discussed above are annual or more often than annual, other special events can be one-time only or similarly rare. This was the case for an August 2017 ***total eclipse of the sun,*** which was predicted to draw 600,000 people from Colorado northward into Wyoming for prime viewing opportunities. CDOT partnered with the Wyoming Department of Transportation to accommodate unprecedented weekend traffic prior to the Monday event and return traffic after the event. CDOT efforts included extensive public information campaign, traffic monitoring, and extra emergency response resources. The event went smoothly.

V.3 Recreation and Tourism Destinations

The top recreation traffic issue facing Colorado is winter weekend traffic from the Denver metro area to mountain ski resorts via Interstate 70 (see **Figure V.2**). Extremely heavy ski traffic is a problem by itself, but often inclement weather and crashes aggravate the congestion. There is not a robust network of alternate routes in the mountains, so lengthy delays on I-70 are commonplace. Also, similar to special event traffic, recreational traffic often involves families or small groups, so much of this traffic already consists of carpools. I-70 traffic is also heavy on summer weekends, especially for Memorial Day, Independence Day and Labor Day.

Figure V.2: Heavy Recreation Traffic on Interstate 70

Photo: GoI70.com; Heavy Recreation Traffic on the I-70 Mountain Corridor

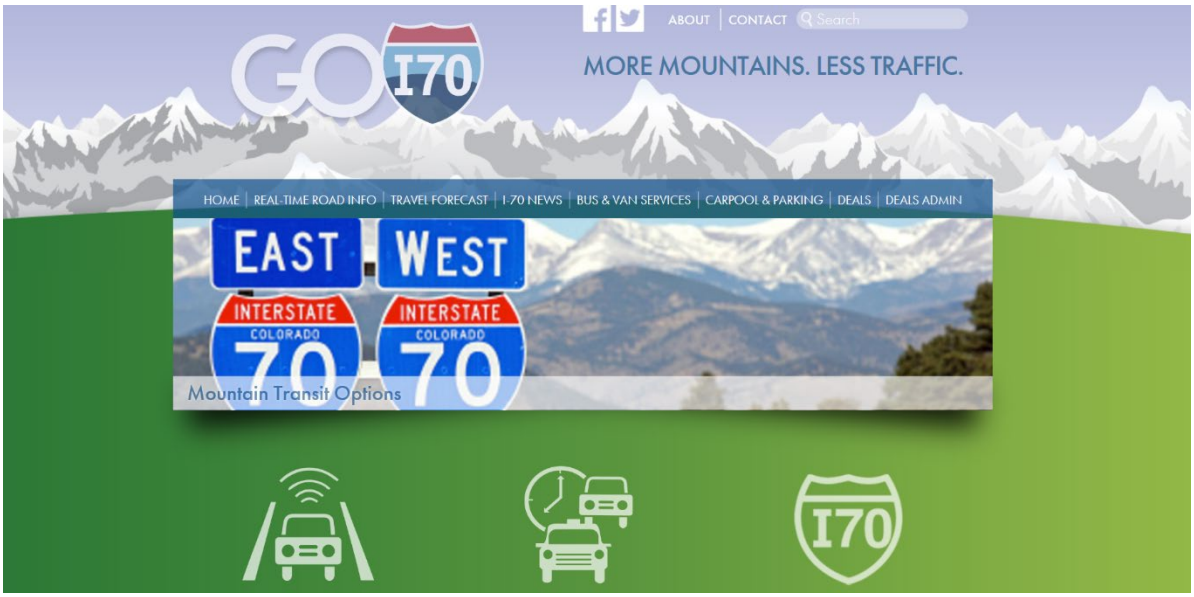
CDOT has carefully studied transportation needs and potential solutions for the I-70 Mountain Corridor. In 2011, a combination of highway improvements and construction of an Advanced Guideway System (AGS, meaning some type of high speed transit) was recommended in the Record of Decision (ROD) subsequent to the *I-70 Final Programmatic Environmental Impact Statement* (FPEIS). A subsequent AGS Feasibility Study completed in 2014 identified feasible technologies but concluded that the project faced a funding shortfall of many billions of dollars.

Pursuant to the FPEIS and ROD, CDOT has made important roadway improvements, including the expansion of the Twin Tunnels east of Idaho Springs and the addition of a tolled express lane that is opened and operated on ski weekends.

Operationally, CDOT has instituted well publicized requirements for chains or snow tires in the form of a Traction Law and a Passenger Vehicle Chain Law. These requirements reduce the likelihood of crashes during inclement weather. CDOT also has stationed heavy tow trucks along the I-70 corridor for the purpose of being able to more quickly clear a crash involving a heavy truck.

CDOT has contracted with the I-70 Coalition, a consortium of local governments and other stakeholders, including the ski industry, to undertake outreach to I-70 travelers regarding current and expected traffic conditions, for the purpose of helping travelers avoid peak congestion. The Coalition's website also identifies a wide variety of bus and shuttle options (see **Figure V.3**). The Coalition consists of government entities and private sector partners. See **Appendix A** for a list of the extensive TDM efforts being undertaken by Coalition members.

Figure V.3: Screen Capture of I-70 Coalition's website - GoI70.com



CDOT provided "Snowstang" bus service as a pilot project on two weekends in February 2017, serving the A-Basin, Breckenridge, Keystone, Vail and Winter Park ski areas. The cost to users was $45 to $60 per round trip from Denver, depending on the destination. In March 2017, two CDOT Bustang buses provided service from Denver to the Burton U.S. Open Snowboard Championships in Vail for a $34 round-trip charge. The buses did not use the I-70 Peak Period Shoulder Lanes because the lanes are too narrow. Both Snowstang and the Snowboard Championships service generated low ridership and were not reprised in 2018.A non-profit organization called SkiCarpool facilitates carpooling to Colorado resorts by offering a free matching service for those trips. A new carpooling matching service for ski trips called the Gondola App launched in November 2017.

RTD offers seven trips daily between Boulder and the Eldora Ski Resort (a 21-mile trip) every day of the skiing season. These buses have accommodations for transporting ski equipment, which would be a challenge using normal commuter buses.

A public interest group called CoPIRG in February 2017 compiled and released online a free guide called "A Guide to Car-Free Skiing in Colorado: The Growing Ways to Get from the Denver Region to the Slopes without Your Personal Car" (CoPIRG Foundation, 2017).

According to the I-70 Coalition, Uber and Lyft carhailing services are available in the mountain ski areas as follows:

- Uber is in Summit and Eagle counties, offering rides with or without ski racks
- Lyft is in Summit County, Vail, Beaver Creek, Aspen, Snowmass, Winter Park and Steamboat Springs

In addition to winter ski weekends, I-70 experiences heavy traffic during summertime, for other recreational opportunities such as camping, fishing, hiking, biking and local festivals. This congestion is predictably bad for three-day weekends – Memorial Day, Independence Day, and Labor Day. I-70 traffic is continuously counted between Denver and the main mountain destinations at the Eisenhower-Johnson Memorial Tunnel, which in July 2016 carried a total of 1.3 million vehicles.

The 415-square-mile Rocky Mountain National Park in north central Colorado is the State's largest tourist draw, attracting 4.5 million visitors in 2016, including over 900,000 in July 2016 alone (National Park Service,

2017). This park is accessed by a single highway, U.S. 34, either from Estes Park on the east side or from Grand Lake on the west side. This highway is called Trail Ridge Road and reaches elevations near 11,500 feet, with plenty of slow recreational vehicles winding their way up and down tight switchback curves.

Many national parks experience a level of visitation that often exceeds the capacity of the parks' facilities and resources, such as Trail Ridge Road in Rocky Mountain National Park. For this reason, the National Park Service developed its own Congestion Management Toolkit (National Park Service, 2014). One of the strategies in this toolkit is to restrict vehicle access and provide shuttle bus service. In Rocky Mountain National Park, vehicle access is not restricted, but three shuttle routes operate largely for the benefit of hikers.

A CMAQ grant in the amount of $329,000 was awarded in 2014 to help create a parking garage and shuttle system in the Town of Estes Park. Estes Park is an extremely popular visitor destination during summertime as it is situated at the eastern edge of Rocky Mountain National Park. It is highly congested with pedestrians, through traffic, and traffic looking for a place to park (Town of Estes Park, 2017). The Town will operate five shuttle routes during the 2018 summer season.

Another recreation destination with a shuttle system is ***Maroon Bells,*** near Aspen, which reportedly receives over 300,000 visitors annually. Decades ago, when these visitors were allowed to drive automobiles to the site, environmental damage to roadside vegetation occurred. Since 1977, the road has been closed to private cars from 7:30 am to 5:00 pm with the exception of handicap vehicles and those with 12 passengers or more. Instead, RFTA buses take visitors from a visitor center to the picturesque lake at a cost of $8 per adult.

A CDOT grant of $593,000 was provided in 2015 for the redesign of the Frisco Transit Center, which subsequently began a Bustang transit stop. Since its creation in 1998, this multimodal hub near mountain ski areas has experienced greatly increased demand (summitdaily, 2015).

Colorado has a system of 26 ***Scenic Byways***, 11 of which are also designated as America's Byways by the U.S. Department of Transportation. These attract visitors all year round. One of these routes receives particularly heavy visitation, accounting for one quarter of all statewide byway traffic, according to a recent study. That is the Mount Evans Scenic and Historic Byway, the highest paved auto road in North America (at 14,271 feet, Mount Evans is slightly higher than Pikes Peak, elevation 14,115 feet). Mount Evans is accessible from Idaho Springs along I 70, just a short half-hour drive from the Denver metro area of three million residents, plus visitors who fly in to Denver International Airport. Mount Evans gets about 200,000 visitors each summer between Memorial Day and Labor Day. For much of the year it is closed due to snow.

Pikes Peak is a popular tourist destination towering over the City of Colorado Springs. Motorists can drive to its summit on the city-owned Pikes Peak Highway, and approximately 500,000 people make the drive annually, at a cost of up to $50 per vehicle. Two major events in 2018 may change this. A popular, privately-owned cog railway carried an additional 300,000 people (not vehicles) to the summit annually, but ceased operations in 2018 for a multi-year safety assessment that may or may not result in its permanent closure. Some would-be cog railway users will opt to drive to the summit instead. However, the outdated Summit House (visitors' center) is being replaced with a modern new facility, and available parking room atop the peak is needed for construction vehicles. Therefore, in 2018, the City of Colorado Springs will restrict parking at the peak and offer free shuttle bus service instead, from May 31 to September 15. This situation will continue during construction of the new Summit House, to be completed in 2020.

The ***United States Air Force Academy***, in northern ColoradoSprings, reportedly once attracted over a million visitors per year, but this number dropped in half after the September 11, 2001 terrorist attack on the Uninted States force military installations to tighten their security. (Gazette, 2019).

The former gold-mining towns of Cripple Creek (west of Colorado Springs via U.S. 24), Black Hawk and Central City (both west of Denver via I-70) are Colorado's only casino gambling venues. Various casinos have organized shuttle bus services for the convenience of their customers. These shuttles reduce parking demand in the space-limited gaming areas while also improving travel safety for customers who may consume alcohol at the casinos. The roads getting to the gaming areas are somewhat winding and have snow and icy conditions in wintertime.

Accommodating recreation trips can be an issue not just in the mountains but even in metropolitan areas. The City of Boulder has a very popular open space area called ***Chautauqua Park***. This resource experiences demand that exceeds its parking capacity, which has led to motorists parking in adjacent residential neighborhoods, to the detriment of their mobility and safety. Working with neighborhood residents, the City instituted a neighborhood parking permit program and offered free shuttle bus service to the park on summer weekends, offering service every 15 minutes. Free parking and shuttle service were available at the CU Regent and downtown parking garages (see **Figure V.4**). The Chautauqua Access Management Plan (CAMP) 2017 pilot program received a total of 22,000 boardings over the summer, or about 900 boardings per service day. This successful program will be continued, going forward.

Figure V.4: Logo for Boulder's Park-to-Park Shuttle Bus Service

Similar to Boulder's Chautauqua Park experience, the City of Colorado Springs has experienced traffic congestion at its free west-side tourist attraction, Garden of the Gods Park. The Park's internal circulation consists of winding one-way roads that are easily overwhelmed on weekends and during the summer tourist season, especially by TV and tour bus traffic. According to a 2017 report, the park's adjacent Visitor's Center attracted ***more than one million visitors in 2016*** (USDOT, 2017c), and the park itself likely attracted even more, possibly up to two million visitors. In June 2018, the City initiated free, voluntary shuttle bus service with a 400-space parking lot to try to cut down the amount of vehicle traffic that drives through this area of picturesque rock formations.

A 2018 study by the U.S. Forest Service (USFS) examined the feasibility of shuttle services to serve a number of popular recreation destinations, which were, specifically:

- Mount Evans, in Clear Creek County
- Brainard Lake, near Ward in Boulder County
- Hanging Lake, near I-70, seven miles east of Glenwood Springs – 150,000 annual visitors
- Guanella Pass, in Clear Creek County, south of Idaho Springs (USFS, 2016)

In the case of Hanging Lake, USFS issued an Environmental Assessment in 2018 proposing a management plan that would require shuttle use and limit visitation to 615 persons per day, to protect the resource, beginning in 2019 (USFS, 2018b).

The 2018 USFS study identified five other active or proposed recreation shuttle services in Colorado:

- Nederland to Hessie Trailhead – operational (Boulder County)
- RFTA Buttermilk to Maroon Bells, piloted in September 2017
- RFTA Aspen Highlands to Maroon Bells, operational/undergoing revision
- Colorado Springs Pikes Peak shuttle, beginning 2018
- Salida to Monarch Skier Shuttle, conceptual

V.4 Transportation Corridors and Construction Mitigation

When undertaking a large highway improvement project that is expected to cause congestion associated with the construction activity, CDOT proactively plans TDM efforts to help mitigate that effect. Two examples include the T-REX project on I-25 in Denver and the U.S. 36 Corridor between Boulder and Denver.

A report by FHWA in 2004 cited CDOT's $3 million TDM commitment for the T-REX project (FHWA, 2004). A 2007 DRCOG report described it as follows:

"The T-REX Project partnered with businesses, DRCOG, and other transportation organizations to develop the TransOptions program. Through the T-REX Web site, special events, and outreach efforts, TransOptions supported carpooling, vanpooling, transit, teleworking, walking and bicycling as means to reduce the impacts of the construction on the traveling public. The benefits of introducing people and businesses to the commuting options during the construction should extend well into the future" (DRCOG, 2007).

Another report (CDOT, 2008) indicated that the principal TDM elements used for T-REX were:

- Subsidization of employer provision of free EcoPass transit passes to commuters.
- Creation and marketing of an Internet-based information network for alternative transportation (called a Smart Community).
- Subsidization of new vanpools for I-25 commuters.
- Promotion and marketing of commuter information for the corridor.

In 2014, a U.S. 36 TDM Construction Mitigation Plan was developed by 36 Commuting Solutions (Note: name now changed to Commuting Solutions), in cooperation with CDOT, RTD and other stakeholders. This plan called for a mitigation budget of $943,000, including $325,000 in subsidies for RTD EcoPass transit passes, and about $600,000 for localized marketing and company support (CDOT, 2017i).

In 2017, CDOT paid for the operation of two pedicabs to carry pedestrians across I-25 when the temporary closure of an existing pedestrian tunnel for I-25 express lane construction left pedestrians facing a one-mile detour to cross the highway. See **Figure V.5.** (CDOT, 2017j).

In October 2017, CDOT and its High Performance Transportation Enterprise (HPTE) announced a partnership with Northeast Transportation Connections (NETC) to provide Transportation Demand Management (TDM) services as preparations for construction begin on the $1.2 billion Central 70 project as it gets underway.

Figure V.5: U.S. 36 Pedicabs

The goal of this partnership is to provide information and mobility choices that will help to improve neighborhood access for residents, provide employers and employees with commuting options, as well as to reduce single-occupancy vehicles usage along the corridor (CDOT, 2017k).

The Central 70 program is unique in its focus on local resident connectivity, particularly for neighborhoods adjacent to the I-70 viaduct. The Central 70 project will remove the aging viaduct and lower the interstate 30 to 40 feet below grade along this section. NETC will offer shuttle services, bike libraries, walking programs, and bus passes to local residents.

Outside of the Denver area, replacement of the aging, structurally-deficient Grand Avenue bridge connecting State Highway 82 to Interstate 70 was a project of great importance to the city of Glenwood Springs. CDOT called it the largest infrastructure project on the Western Slope in the last quarter century. Normal traffic volumes of 25,000 vehicles per day had to be detoured to the next nearest Interstate access point. An extensive public information campaign was used to encourage a 35 percent traffic reduction during an unavoidable 95-day detour period.

V.5 Employer-Based Commute Programs

Employer involvement in TDM efforts can greatly enhance TDM effectiveness compared to situations without employer support. When the employer's corporate culture genuinely embraces TDM, the employees get the message and are more likely to use alternate modes.

A notable employer-based TDM effort in Colorado is the New Belgium Brewery in Fort Collins. After one year of employment with the firm, employees receive a custom cruiser bicycle. The company also has cruiser bikes available for employees to borrow for doing errands or lunch (New Belgium, 2016). As noted earlier, this company is a Platinum-level Bicycle-Friendly Business as recognized by the League of American Bicyclists.

Firms strongly committed to trip reduction typically have a position called an Employee Transportation Coordinator (ETC) who is responsible for disseminating information about transportation options. Strongly committed firms will typically survey their employees on an annual basis to determine whether or not any reduction is occurring.

In downtown Denver, where parking is expensive, some employers offer RTD EcoPasses to their employees, instead of providing them a parking space.

Prior to moving its headquarters in 2018, CDOT provided EcoPasses for 1,245 employees in the Denver metro area. The new headquarters location is adjacent to a light rail station, served by several bus routes and trails. CDOT is working with the DRCOG Way to Go program to explore commuting alternatives for the new headquarters location. A survey of CDOT employees who would be working at the new location showed that 81 percent drove alone pre-move (see **Table V.2**).

Aggressive commute reduction goals are under development. CDOT anticipates that the new Headquarters location will be more attractive to job candidates who can take advantage of the easy connection between CDOT offices and light rail. CDOT has an existing Commuter Options Plan from 2010 (see **Appendix D**) that is somewhat outdated due to rapid technological change.

Table V.2: Mode Share of CDOT Denver Employees Prior to Headquarters Relocation

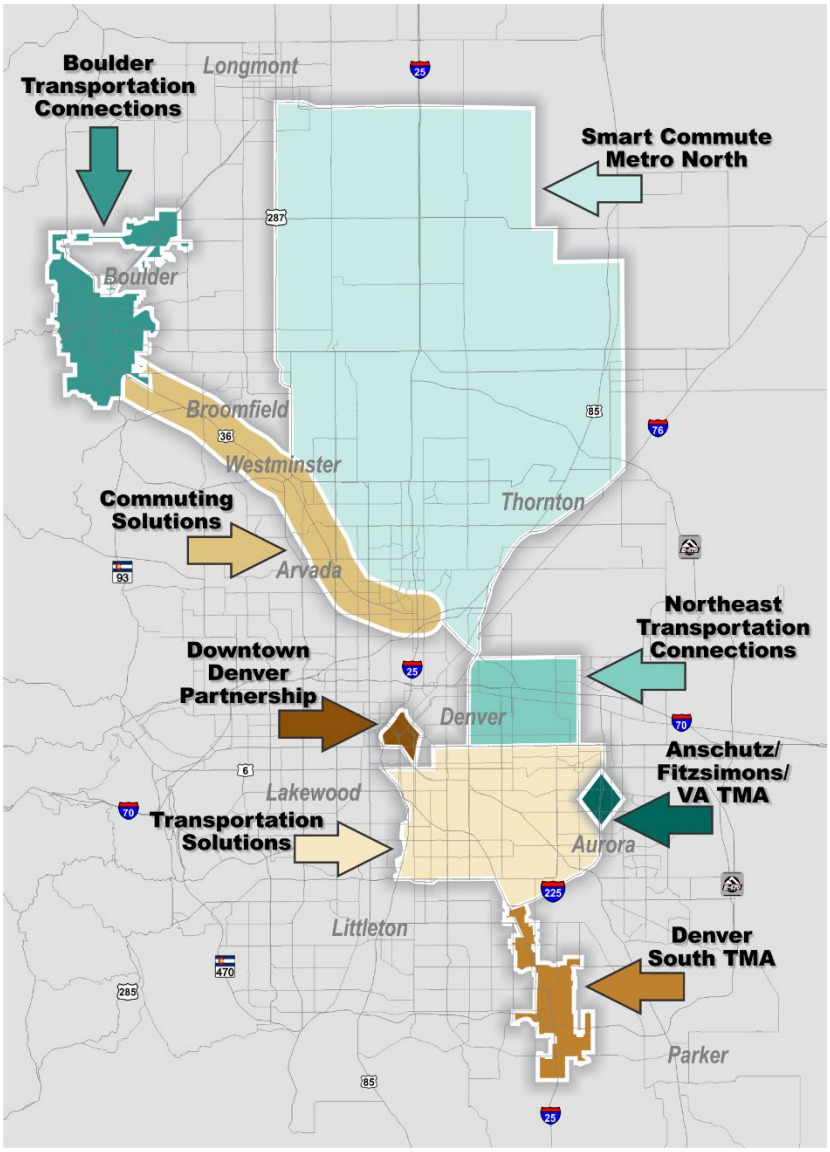
Mode Share of CDOT Denver Employees	
Mode of Commuting	*Reported Current Use*
Drive Alone	81%
Carpool/Vanpool	7%
Bus (Note: Light Rail available at new site)	5%
Bicycling	4%
Work at Home	3%
Totals:	**100%**

In the Denver area, coalitions of employers in specific corridors or subareas have created Transportation Management Organizations (TMOs) or Transportation Management Associations (TMAs) to address traffic congestion issues that affect them. The areas served by these TMAs are shown in **Figure V.6**.

Funding from the federal Congestion Mitigation and Air Quality (CMAQ) program has been allocated to TMOs and TMAs on a limited basis to help them get started, but their long-term revenue source is to be employer donations.

The DRCOG Way to Go program in 2016 conducted its third annual WaytoGoTober campaign ("Go-tober"). A total of 42 metro-area employers competed in this challenge. Employees who carpool, vanpool, take transit, bike or walk at least one day each week in October and log their trips at mywaytogo.org were entered to win prizes.

Figure V.6: TMAs/TMOs in the Denver Metro Area



The City of Boulder's TDM webpage (City of Boulder, 2017b) indicates that the development of up to six TMOs in that community are actively under consideration:

1. Crossroads
2. 28th Street
3. Arapahoe/55th Street
4. Gunbarrel
5. Central Area General Improvement District Areas (existing)
6. University of Colorado (existing)

A 2004 report on TDM by FHWA mentioned a Denver employer that had a "Look before You Leave" program. The worksite was adjacent to busy I-25 and employees were urged not to get on the freeway if it was jammed.

An interesting but highly atypical employer TDM situation is Fort Carson, the largest employer in the Pikes Peak Region. This large military base is not open to the general public. For security reasons, Mountain Metro buses are not allowed to enter the base. Fort Carson established aggressive trip reduction goals as part of an Environmental Sustainability Program, and in 2012 reported no success in lowering its single-occupant vehicle rate of 94 percent toward a goal of 88 percent.

Figure V7: "Give a Buddy a Ride" Program

Fort Carson Soldier Awaiting Pickup at "Give a Buddy a Ride" Location

Then Fort Carson implemented a free on-base shuttle and a voluntary on-base carpooling campaign called "Give a Buddy a Ride" (See **Figure V.7**). The shuttle carried an average of 10,000 riders per month in 2015. The base also has a Sustainable Fort Carson Rideshare matching program. With these and related institutional efforts, Fort Carson reported meeting its 88 percent SOV goal in 2015 (U.S. Department of Defense, 2016).

As of 2016, four employers in Colorado have achieved designation as ***Best Workplaces for Commuters*** under a voluntary program established by the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Transportation (DOT), by meeting a National Standard of Excellence created by these agencies. The four employers in Colorado are:

- The Cadmus Group Inc. in Boulder
- IBM in Boulder
- National Renewable Energy Laboratory in Golden
- National Renewable Energy Laboratory in Louisville

In addition to the four firms currently listed, other Colorado employers possibly could qualify for the designation but may be unaware of the program or have not submitted the necessary documentation to apply for recognition. FHWA reported that in 2003, the City of Aspen was the first city to be recognized by the U.S. Environmental Protection Agency as a Best Workplace for Commuters (FHWA, 2004).

Many employers or multi-tenant office buildings facilitate bicycle commuting by providing showers and bicycle storage accommodations.

The City of Durango conducts a Clean Commute Week promotion in June each year and specifically seeks employers to participate in an Employer Challenge as part of that effort.

Employers that meet the program-established National Standard of Excellence agree to:

- Centralize commute options information so that it is easy for employees to access and use
- Promote the availability of commuter benefits to employees
- Provide access to an emergency ride home program
- Provide one or more of the following primary commuter benefits:
  - ✓ Cash in lieu of free parking worth at least $30 per month
  - ✓ Telework program that reduces commute trips by at least 6 percent
  - ✓ Other option proposed by employer and agreed to by the organization that offers the BWC designation. These services must reduce the rate at which employees drive to work alone and be perceived by employees as a significant workplace benefit
- Provide three or more of the following additional commuter benefits:
  - ✓ Active membership in a Transportation Management Association or participation in a voluntary regional air quality management program or another employer-based commuter program
  - ✓ Active membership in a local ozone awareness program, in which you agree to notify employees of expected poor air quality and suggest ways that they might minimize polluting behaviors
  - ✓ Ridesharing or carpool matching, either in-house or through a local or regional agency
  - ✓ Pre-tax transit benefits
  - ✓ Pre-tax vanpool benefits
  - ✓ Parking cash out less than $30 per month or less than 75 percent of the actual parking benefit
  - ✓ Shuttles from transit stations, either employer-provided or through a local TMA or similar service provider
  - ✓ Provision of intelligent (i.e., real-time) commuting information
  - ✓ Preferred parking for carpools and vanpools
  - ✓ Reduced parking costs for carpools and vanpools
  - ✓ Employer-run vanpools or subscription bus programs
  - ✓ Employer-assisted vanpools
  - ✓ Employer-provided membership in a carsharing program
  - ✓ Secure bicycle parking, showers, and lockers
  - ✓ Electric bicycle recharging stations
  - ✓ Employee commuting awards programs
  - ✓ Compressed work schedules
  - ✓ Telework (less than 6 percent of commute trips on a monthly basis
  - ✓ Lunchtime shuttle
  - ✓ Proximate commute (where employees work at locations closer to their homes)
  - ✓ Incentives to encourage employees to live closer to work
  - ✓ Incentives to encourage employees to use alternative transportation (e.g., additional vacation time)
  - ✓ On-site amenities (e.g., convenience mart, dry cleaning, etc.)
  - ✓ Concierge services
  - ✓ Other options proposed by employers

In addition, employers commit to ensuring that within 18 months of applying, at least 14 percent of commute trips are taken using a mode other than driving alone (EPA, 2005).

A 2004 report on TDM by FHWA mentioned a Denver employer that had a "Look before You Leave" program. The worksite was adjacent to busy I-25 and employees were urged not to get on the freeway if it was jammed.

V.6 Airports

FHWA's 2004 report called The Role of Demand-Side Strategies states that, "Besides encouraging travelers to use alternative means to travel to, from and within airport property, successful planning efforts have incorporated transportation options for airport employees" (FHWA, 2004).

Colorado's largest airport is Denver International Airport (DIA), the 18th busiest passenger airport in the word as of 2015, and the sixth busiest in the United States. It is also the busiest freight facility in the Rocky Mountain west. DIA is located approximately 25 miles east-northeast of downtown Denver, which is a lengthy trip for most users. It attracts travelers from throughout Colorado due to its advantages in prices and number of direct flights to local, national and international destinations. DIA has over 40,000 parking spaces available to the general public, plus an additional 7,400 spaces for airport employees (City and County of Denver, 2014b).

DIA is a major employer in the Denver region. Some employees work for the airport or the Transportation Security Administration, others work for vendors or airlines at the airport, and others are flight crews or ground crews for airlines with a Denver hub. DRCOG reports that in 2014, over 4,100 DIA employees had an RTD EcoPass and thus were eligible for a guaranteed ride home (free taxi ride) if they missed their last available bus. DIA employees used this service at an annual rate of 0.36 ride per employee, which was 40 times the rate of all other employees in the region (DRCOG, 2015b). With the opening of light rail service to the airport in 2016, DIA employee use of guaranteed rides home is expected to decline significantly.

Denver's RTD bus service includes SkyRide bus service connecting DIA to Boulder, Northglenn, and the Denver Tech Center. A major advancement occurred in April 2016 with the opening of A-Line commuter rail service between DIA and Denver's Union Station (downtown). This 37 minute trip costs $9 each way and greatly improves travel time reliability for travelers.

Shuttle bus services carry DIA passengers from Front Range (I-25 corridor) communities. Carriers making the trip between DIA and Colorado Springs include the Front Range Shuttle and the Colorado Springs Shuttle. The relatively new Green Rides shuttle service in northern Colorado offers its customers 300 parking spaces at the Fort Collins-Loveland Airport. Customers park there and take the shuttle to DIA or other destinations.

Shuttle services between DIA and the ski resort communities in the mountains along the I-70 corridor include the Colorado Mountain Express. Traffic on I-70 west between Denver and mountain ski communities is notoriously congested on winter weekends, but skiers arriving at DIA from out of state may not be aware of this. More visitors might choose shuttles in lieu of renting a car if they had information readily available regarding current traffic conditions in Denver and on I-70.

DIA and the Colorado Springs Airport both have "cell phone waiting lots" where persons wishing to pick up arriving passengers can wait without congesting the arrival curbs or circling the airport in attempts to meet the arriving parties. This reduces vehicle travel and reduces emissions while improving safety.

V.7 Incidents and Emergencies, Courtesy Patrol and Heavy Tow

FHWA's 2004 report called The Role of Demand-Side Strategies states that, "Strategies to improve traveler awareness of an unplanned event and to expedite the response to incidents on the roadway are essential for maintaining freeway operations" (FHWA, 2004).

CDOT's Statewide Transportation Plan reflects the FHWA estimates cited above for urban areas, and also presents data for rural areas. As there is much less routine congestion in rural areas, an estimated 95 percent of traffic congestion in rural areas is attributed to non-recurring circumstances, as shown in **Figure V.8**.

Separately, a report by the FHWA Office of Operations states the following:

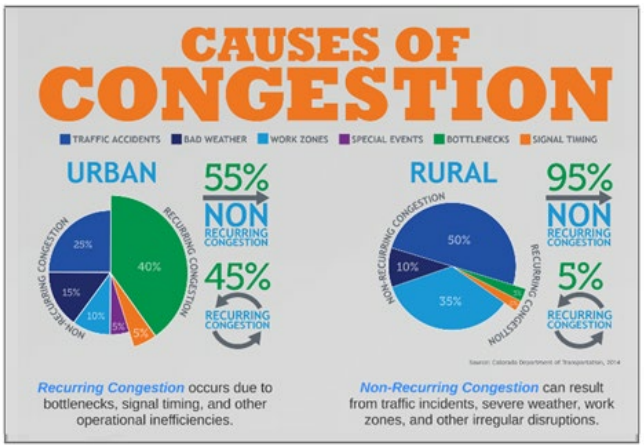
> Roughly half of the congestion experienced by Americans happens virtually every day – it is "recurring". This is the type of congestion where there are simply more vehicles than roadway. The other half of congestion is caused by temporary disruptions that take away part of the roadway from use – or "nonrecurring" congestion. The three main causes of nonrecurring congestion are: incidents ranging from a flat tire to an overturned hazardous material truck (25% of congestion), work zones (10% of congestion), and weather (15% of congestion). (FHWA, 2016a).

CDOT's Statewide Transportation Plan reflects the FHWA estimates cited above for urban areas, and also presents data for rural areas. As there is much less routine congestion in rural areas, an estimated 95 percent of traffic congestion in rural areas is attributed to non-recurring circumstances, as shown in **Figure V.8**.

CDOT and transportation departments around the nation do their best to clear crashes as quickly as is safely possible. CDOT has a statewide traffic operations center that monitors video and other data from sensors on major highways, depicted in **Figure V.9**. Early identification of the problem can help to expedite dispatch of the appropriate first responders. A system of roadside variable message signs on major highways is able to alert motorists of a problem ahead and give them an estimate of the travel time.

CDOT makes traffic and road conditions available online on its website, and also issues alerts to the news media. A number of traffic report applications are available for cell phone users as well, such as one called Waze (purchased by Google in 2013).

Figure V.8: Causes of Congestion



Source: CDOT, 2015a.

Figure V.9: CDOT Traffic Operations Center

In the busy I-25 and I-70 corridors, and elsewhere when major construction is underway, CDOT provides a Motorist Safety Patrol unit that supplements normal highway patrol activity to quickly respond to minor incidents (e.g., flat tire) and hasten the clearing of that incident from the roadside.

In the I-70 Mountain Corridor, between Vail (Mile Marker 180) and Floyd Hill (Mile Marker 248), CDOT's Courtesy Patrol provides the following number of vehicles as requested by the operations manager:

- up to 5 Heavy Tow trucks (e.g., available to move disabled buses and semi-trailers)
- up to 5 Rollback trucks
- up to 5 Light Duty courtesy patrol trucks (with one back up truck if needed)

Additionally, Chain Station Management teams can be called out during significant storms:

- up to 3 teams each day that consist of 3 personnel per team.

I-70 Mountain Corridor Courtesy Patrol personnel are normally scheduled for weekend duty (Saturday and Sunday) as well as holidays. Courtesy Patrols can be requested out of schedule during the week for significant snow storms. Patrols can work up to 14 hours each day but typically work 9 to10 hour schedules.

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V.8 Freight Transportation

Colorado has a Freight Advisory Council and CDOT completed a Statewide Highway Freight Plan in 2015, The Plan notes that:

> The reliable movement of goods affects our daily lives. Almost every item in our homes and every product on our store shelves have been transported as freight. Every commercial enterprise requires resources delivered as freight, whether it be raw materials, or finished products to serve its clientele. The necessities of the modern world, so readily available, are delivered through a complex system of sourcing, production, and transportation that spans states, countries, and the globe. Perhaps most importantly, every shipment of goods provides tangible economic benefits to Colorado's people, businesses, communities, and the broader state economy (CDOT, 2015e).

The saying that "time is money" is particularly true for trucking. Truckers know this and actively avoid congested rush hours if they can. The percentage of trucks in the traffic stream is higher during off-peak hours because more trucks and fewer cars travel during off-peak hours than during the peak.

Encouraging off-peak travel by trucks is the chief TDM strategy for freight noted in the FHWA 2004 report, The Role of Demand-Side Strategies. For freight, it is not desirable to reduce deliveries, as delivery adds value to the products by taking them where they are needed. It is desirable to deliver a full load (e.g., like a bus or vanpool) instead of a partial load (e.g., solo driver), but generally speaking, reducing truck trips is not the focus of freight TDM.

In Colorado, heavy truck concentrations are found in Denver where the state's two busiest highways meet: east-west I-70 meets north-south I-25. Industrial and warehouse land uses are found both near this interchange and also in the vicinity of Denver international Airport.

In the northern part of the state, I-25 links I-70 in Colorado with I-80 in Wyoming, and so is a busy truck route also, as is I-76, which does the same.

West of Denver, I-70 is busy with trucks and has the additional challenge of steep mountain grades. Heavy trucks need to use low gears going either up or down steep grades, so they have a much greater impact on traffic flow on grades than they do on level grades elsewhere around Colorado. Snow and ice make particularly challenging during winter months.

The Colorado Motor Carriers' Association (CMCA) reports that many businesses in the mountain ski communities do not have access to warehouses for inventory storage so they need to be resupplied on a very frequent basis.

The CMCA is much attuned to I-70 Mountain Corridor issues and has proactively prepared guidance for its members to reduce their potential for causing traffic problems. In 2012, this organization prepared a Best Practices report containing a number of safety recommendations, along with the advice to avoid I-70 peak travel periods, defined as westbound on Friday evenings (6-10 pm) and Saturday mornings (6 am-10 am) and eastbound on Saturday evenings (5-10 pm) and Sunday afternoons (2-7 pm) [CMCA, 2012]. The CMCA has worked closely with the I-70 Coalition to address motor freight transportation issues on the I-70 Mountain Corridor (I-70 Coalition, 2013).


Walk
Bike
Carpool
Vanpool
Transit
Telework

COLORADO
Department of Transportation

VI. PARTICIPATION IN COLORADO TDM PROGRAMS

VI.1 Participation in TDM Core Strategies

Assessing the amount of participation in TDM programs is easy in some cases and more difficult in others. As an example of "easy", publicly sponsored vanpool programs have records of where vans traveled and how many passengers they carried. As an example of "difficult", most marketing programs spread the word about TDM options but result in no feedback about whether or not that message persuaded someone to try them. Certain physical features can be counted (e.g., number of Park-n-Ride spaces, or number of pedestrian overpasses). Some TDM programs involve self-reporting of travel behavior (e.g., RAQC Every Trip Counts Program, Durango Way to Go! Club). Some private companies (e.g., Uber, Lyft) do not release proprietary sales data. Generally, a lot of assumptions must be made to estimate program participation, and therefore many assumptions are reflected in this chapter.

This chapter discusses TDM participation following the same order that core strategies and support strategies have been discussed in prior chapters: A. TDM Core Strategies; B. TDM Support Strategies; C. TDM Emerging Technologies; and, D. TDM for Specific Travel Markets.

Region-by-region participation figures for TDM core strategies are presented below in this section. First, however, **Table VI.1** presents an overview of ACS estimates pertaining to alternative transportation mode used for work trips by Colorado's roughly 2.6 million workers. About two million Coloradoans drive alone to work.

Table VI.1: Colorado Daily Commuter Participation in TDM Core Strategies

Colorado Daily Participation in TDM Core Strategies, 2015	
Means of Getting to Work	***Participants***
Carpooling (2 to 4 Occupants/Vehicle)	233,000
Telecommuting/Working at Home	172,200
Transit (Local/Regional)	82,400[a]
Walking	76,100
Bicycling	34,200
Vanpooling (5 or More Occupants/Vehicle)	9,700
Intercity Transit (long-distance)	300[b]
Park-and-Ride Lots	Included above[c]
Variable Work Hours	Some included above[d]
TOTAL	**608,000**

[a] Transit is also used extensively for non-work trips throughout the day. See transit discussion.

[b] Number shown for Intercity routes is for CDOT Bustang service only; private carriers may transport 3,000 to 5,000 passengers daily but their schedules are generally not feasible for daily commuting.

[c] About 34,000 park-and-ride spaces are available to the public, but are not 100 percent utilized. Any parked vehicles contribute to the figures shown for carpooling, vanpooling and local/regional transit.

[d] No ACS data available for variable work hours. At least 75 percent of variable work hour participants likely drive alone.

Local/Regional Transit – Participation

Table VI.2, below, indicates the number of transit commuters by CDOT planning region, based on 2015 American Community Survey (ACS) data. This total of 82,400 commuters can be related to the numbers of annual transit boardings by assuming that each commuter makes two boardings per day (one going to work and one returning home). Additionally, some transit commuters have to make an additional boarding to transfer to a different route, so some commuters need perhaps four boardings to make a single round-trip commute. Obviously, non-commuters use transit throughout the day, and in some cases also on nights and weekends, for trips that are not work-related. In addition to being an important commuting resource, transit is a mobility necessity for persons unable to drive or to afford an automobile. Attracting more non-work trips during off-peak hours and more "choice" riders to commuting can help make public transportation more viable for all.

Table VI.2: Average Daily Transit Round Trips by Planning Region

Average Daily Transit Round Trips by Region, 2015		
Planning Region/Largest City	***Program***	***Estimated Daily Transit Commuters***
DRCOG (Denver)	RTD – many services	68,300
PPACG/Colorado Springs	Mountain Metro Transit	2,500
NFRMPO/Fort Collins	Total of Transfort, Greely-Evans Transit, City of Loveland Transit, and Berthoud Transit	2,300
PACOG/Pueblo	Pueblo Transit	600
Grand Valley MPO/Grand Junction	Grand Valley Transit	300
Intermountain TPR/ Glenwood Springs	RFTA, Summit Stage and others	5,700
Gunnison Valley TPR/ Montrose	Various	350
Central Front Range TPR/ Cañon City	Various	< 100
Upper Front Range TPR/ Fort Morgan	Various	1,000
Southwest TPR/Durango	Various	600
Eastern TPR/Sterling	Various	150
San Luis Valley TPR/ Alamosa	Various	< 100
Northwest TPR/ Steamboat Springs	Various	600
Southeast TPR/Lamar	Various	< 100
South Central TPR/Trinidad	Various	< 100
TOTALS	**Various**	**82,400**
Source: U.S. Census, American Community Survey, 2015.		

Intercity Transit - Participation

As reported in the *Statewide Transit Plan*, most of the existing intercity bus routes operated by the private sector operate just one, two or three daily round trips. This is because the trips are long-distance routes. The plan identified 32 routes. If each bus carries 50 passengers per day, round-trip, a total of 1,600 round trips can be accommodated on routes throughout the state. Actually, intercity bus round-trips are probably quite rare, due to the time and distances involved. If all seats were used for one-way trips, then 3,200 daily one-way trips could be made.

This number should be reduced because buses do not operate at 100 percent capacity all the time. Also, not all seats get used just once daily for a full trip. Some passengers travel only a portion of the distance that the bus does, getting off at a stop before the end of the line. This frees up the seat for another passenger to make a partial trip. Another complication is that some routes originate out of state and enter Colorado with passengers on board (destined for Denver, for example). Taking all these factors into account, private bus lines likely carry somewhat over 3,500 daily trips in Colorado.

CDOT's Bustang service offers two daily roundtrips on I-70, six roundtrips daily on I-25 north of Denver, and seven roundtrips daily on I-25 south of Denver. The Bustang service has 16 over-the-road coaches within the system. Each coach has a 51-passenger capacity, and comes equipped with restrooms, bike racks, free WiFi, 110v outlets, USB outlets, and are wheelchair accessible.

If each of these 13 Bustang trips were full both ways, the current schedule could accommodate about 650 roundtrip passengers per day. Actual ridership will vary based on occupancy and some of the other factors noted above. Reported ridership for 2016 was 132,005 total system passengers. Dividing this by 240 weekdays per year yields a daily average of roughly 550 riders per weekday. In 2016, about 20 percent of Bustang ridership was on the West Line, and the remaining 80 percent was split fairly evenly between the North and South Lines (CDOT, 2017b).

Vanpooling - Participation

Publicly-operated vanpools noted earlier in this report include 101 by DRCOG, 64 by NFRMPO, and 24 by Mountain Metro (Colorado Springs), for a total of 189 vans. Recent numbers of participants reported for these areas were 643, 323, and 139, respectively, for a total of about 1,100 vanpoolers. This averages out to slightly more than five passengers per vanpool. Note that for a wide variety of reasons, not all registered vanpoolers use their service every weekday. Data for non-public vanpool programs are not readily available.

In January 2016, the NFRMPO VanGo program reported to the National Transit Database that its program logged 1,829,542 miles traveled in 2015 (NFRMPO, 2016a). These are van-miles traveled, not VMT reductions.

The ACS data presented earlier suggest that statewide, the number of Colorado commuters who ride in a non-transit vehicle with five or more occupants is about 9,800. **Table VI.3** provides the region-by-region breakdown of vanpooling statewide.

Carpools - Participation

In all Colorado communities, carpooling is the most-used alternative to driving alone. An estimated 233,000 Coloradoans carpool to work, as detailed in **Table VI.4**. More than half the statewide commuter carpooling occurs in the Denver metro area.

Walking - Participation

Because of the time it takes (e.g., 20 minutes to walk one mile), walking as transportation (different from walking for recreational purposes) is feasible for only relatively short trips. ACS commuter travel time for the five urbanized MPO regions and for the largest city or town in each TPR found median commuter travel times ranging from 11 to 24 minutes (11 in Alamosa, 24 in Denver). If this is the amount of time people have available for commuting, they generally cannot walk much more than one mile to work. The Front Range Travel Counts survey cited earlier (DRCOG, 2012b) indicated that average pedestrian work trips ranged from 0.3 to 0.4 mile. **Table VI.5** shows ACS estimates totaling 76,100 pedestrian commuters in Colorado.

Table VI.3: Colorado Commuters in a Non-Transit Vehicle with Five or More Occupants

Daily Transit Round Trips by Region, 2015			
Planning Region/Largest City	***Van/Carpoolers (HOV5+)***	***Vehicles***	***Includes***
DRCOG (Denver)	4,500	900	Way to Go: 643 people; 114 vans
PPACG/Colorado Springs	1,200	240	Mtn Metro: 139 people, 24 vans
NFRMPO/Fort Collins	700	140	VanGo: 323 people, 64 vans
PACOG/Pueblo	400	80	
Grand Valley MPO/Grand Junction	300	60	
Intermountain TPR/ Glenwood Springs	700	140	
Gunnison Valley TPR/ Montrose	250	50	
Central Front Range TPR/ Cañon City	< 100	< 20	
Upper Front Range TPR/ Fort Morgan	400	80	
Southwest TPR/Durango	600	120	
Eastern TPR/Sterling	150	30	
San Luis Valley TPR/ Alamosa	< 100	< 20	
Northwest TPR/ Steamboat Springs	800	160	
Southeast TPR/Lamar	100	20	
South Central TPR/Trinidad	< 100	< 20	
TOTALS	**9,800**	**1,960**	
Source: HOV5+ data are from the U.S. Census Bureau's 2015 American Community Survey.			

Table VI.4: Colorado Commuters Who Carpool to Work with 2 to 4 Occupants in Vehicle

Daily Transit Round Trips by Region, 2015			
Planning Region/Largest City	***Carpoolers (HOV 2 to 4)***	***Vehicles***	***Public Carpool Program***
DRCOG (Denver)	127,000	59,100	Way to Go
PPACG/Colorado Springs	32,000	14,700	Mtn Metro Rides
NFRMPO/Fort Collins	20,000	9,100	SmartTrips
PACOG/Pueblo	7,400	3,300	
Grand Valley MPO/Grand Junction	6,700	3,100	
Intermountain TPR/ Glenwood Springs	9,100	4,100	City of Aspen
Gunnison Valley TPR/ Montrose	6,500	2,300	
Central Front Range TPR/ Cañon City	1,600	750	
Upper Front Range TPR/ Fort Morgan	5,200	2,400	
Southwest TPR/Durango	4,600	2,100	City of Durango
Eastern TPR/Sterling	4,400	2,000	
San Luis Valley TPR/ Alamosa	2,100	900	
Northwest TPR/ Steamboat Springs	3,500	1,600	
Southeast TPR/Lamar	2,000	900	
South Central TPR/Trinidad	900	400	
TOTALS	**233,000**	**106,650**	Way to Go

Table VI.5: Estimated Colorado Commuters Who Walk to Work, 2015

ACS- Estimated Colorado Commuters Who Walk to Work, 2015	
Planning Region/Largest City	***Commuters Who Walk to Work***
DRCOG (Denver)	37,500
PPACG/Colorado Springs	11,600
NFRMPO/Fort Collins	6,000
PACOG/Pueblo	1,700
Grand Valley MPO/Grand Junction	2,000
Intermountain TPR/ Glenwood Springs	4,300
Gunnison Valley TPR/ Montrose	1,400
Central Front Range TPR/ Cañon City	500
Upper Front Range TPR/ Fort Morgan	3,100
Southwest TPR/Durango	2,300
Eastern TPR/Sterling	1,600
San Luis Valley TPR/ Alamosa	800
Northwest TPR/ Steamboat Springs	1,900
Southeast TPR/Lamar	800
South Central TPR/Trinidad	600
TOTALS	**76,100**

Bicycling - Participation

Bicycling was the reported usual commuter mode for an estimated 34,000 Colorado residents in 2015, according to ACS estimates, as seen in **Table VI.6**.

Bike to Work Day and Bike to Work month promotions occur in numerous communities throughout Colorado and throughout the nation. A DRCOG preliminary analysis of 2015 Bike to Work Day in the Denver region estimated that 32,800 riders participated in the event. About 19,400 of these had formally registered for the event and an additional 13,400 showed up and participated without registering (DRCOG, 2016b). A survey of more than 1,200 participants in this event found that 27 percent were first-time registrants while 73 percent had participated in previous years (DRCOG, 2015c). In 2018, 35,300 participated, 39 percent for the first time (DRCOG, 2018).

The City of Fort Collins estimated nearly 5,000 June Bike to Work participants in 2015 and expected to exceed that number in 2016 (Coloradoan, 2016b).

The City of Boulder planned to have 50 breakfast stations and expected 7,000 participants for its June 2016 Bike to Work Day (walkandbikemonth.org, 2016). Note that Boulder now also sponsors a Winter Bike to Work Day.

A City of Colorado Springs webpage reported that 800 Bike to Work Day participants were counted in 2016 at 12 breakfast locations set up for the June event. The city's mayor led one contingent of the riders (City of Colorado Springs, 2016).

The four reports above total roughly 45,000 participants from key metro areas. It is reasonable to assume that total statewide Bike to Work Day participation was in the range of 50,000 to 55,000 people. The point

of this event is not to just bicycle on one day a year, but to try this transportation mode and decide to use it more often throughout the year.

CDOT sponsored a "Summer Bike Challenge" for its employees from June 1st to August 31st in 2015. This attracted 119 registrants who logged 2,042 bicycle trips (CDOT, 2016a).

Table VI.6: Estimated Colorado Commuters Who Bicycle to Work, 2015

ACS- Estimated Colorado Commuters Who Bicycle to Work, 2015	
Planning Region/Largest City	***Commuters Who Bicycle to Work***
DRCOG (Denver)	19,000
PPACG/Colorado Springs	1,500
NFRMPO/Fort Collins	6,900
PACOG/Pueblo	300
Grand Valley MPO/Grand Junction	800
Intermountain TPR/ Glenwood Springs	1,800
Gunnison Valley TPR/ Montrose	400
Central Front Range TPR/ Cañon City	200
Upper Front Range TPR/ Fort Morgan	1,200
Southwest TPR/Durango	1,000
Eastern TPR/Sterling	<100
San Luis Valley TPR/ Alamosa	500
Northwest TPR/ Steamboat Springs	600
Southeast TPR/Lamar	<100
South Central TPR/Trinidad	<100
TOTALS	**34,200**

Variable Work Hours - Participation

Variable work hours are not specifically queried as part of the American Community Survey, and data regarding the use of this strategy are extremely limited. Variable work hours are more likely to be found in larger, congested communities than in smaller, uncongested communities. To some extent, the original concept of this strategy as a trip reduction tool has morphed into a matter of employee convenience. Thus, it may be increasingly offered in communities where congestion is not the motivation.

Employer size is likely a key determinant of the willingness to offer work schedule options. A study of nearly 1,400 employers in the Los Angeles area around 1990 showed a strong correlation between program offerings and employer size. Employers with more than 500 workers were much more likely to offer alternative work schedules than were smaller firms. About one-third of these employers offered flextime for ridesharers, and half this number allowed 4-day/40-hour compressed work weeks. Less common still was the 9-day/80-hour compressed work week (TRB, 2010).

Telecommuting - Participation

Working at home, or telecommuting, has become increasingly viable with advances in computers and telecommunications, combined with the shift of the U.S. economy from manufacturing to information-based jobs. This mode offers substantial trip reduction because it eliminates work-trips entirely rather than shifting them from one form of transport to another.

A 2015 Denver Post article cited a third party review of ACS data that concluded Colorado had the highest rate of telecommuting of any state in the nation. Colorado's rate was 6.9 percent, just beating Vermont at 6.8 percent. The Colorado figure was well above the reported national average of 4.3 percent. The newspaper article indicated that Boulder has one of the highest telecommuting rates in the nation at 10.6 percent (Denver Post, 2015b).

Table VI.7 indicates the ACS-estimated numbers of Colorado telecommuters by region as of 2015. Comparable ACS data for the largest city in each non-metro TPR showed a range of 1.9 percent (Alamosa) to 9.1 percent for Steamboat Springs, with many values around four percent.

Table VI.7: Estimated Colorado Persons Who Work at Home, 2015

ACS- Estimated Colorado Commuters Who Bicycle to Work, 2015	
Planning Region/Largest City	***Persons Who Work at Home***
DRCOG (Denver)	107,000
PPACG/Colorado Springs	18,600
NFRMPO/Fort Collins	14,900
PACOG/Pueblo	1,900
Grand Valley MPO/Grand Junction	3,400
Intermountain TPR/ Glenwood Springs	6,700
Gunnison Valley TPR/ Montrose	3,300
Central Front Range TPR/ Cañon City	700
Upper Front Range TPR/ Fort Morgan	2,900
Southwest TPR/Durango	3,300
Eastern TPR/Sterling	3,100
San Luis Valley TPR/ Alamosa	<100
Northwest TPR/ Steamboat Springs	2,600
Southeast TPR/Lamar	1,200
South Central TPR/Trinidad	400
TOTALS	**172,200**
Source: U.S. Census Bureau, 2016.	

Park-and-Ride Lots - Participation

It was reported in Chapter 2 that the RTD transit system in the Denver metro area has 77 Park-n-Ride lots with over 30,000 parking spaces, and that CDOT has another 27 lots along I-25, I-70 and SH 82 (Glenwood Springs to Aspen). Park-and-ride lots are not a transportation mode such as those discussed above, but are instead infrastructure supporting transit and ridesharing.

RTD's Park-n-Ride lots experience various degrees of use, which are generally higher at light rail stations (65% use in 2015) than at lots served only by bus (52% use in 2015). As of 2015, RTD reported 18 lots with high use, defined as over 85% full. RTD charges parking fees at high use lots. In 2015, 13 lots were classified as low-use lots, receiving less than 20% utilization. Approximately 25% of RTD's Park-n-Ride lots have video surveillance for security purposes (RTD, 2017a).

Listed in **Table VI.8** are park-and-ride utilization data from 2010 as reported by NFRMPO. These observations are seven years old and are thus quite outdated. For example, demand has grown significantly at the Harmony Road Transfer Center near I-25 in southeastern Fort Collins. As of mid-2015, to

accommodate all the services using this facility (i.e., car and van pooling, the Transfort city bus system and airport shuttles, as well as Bustang express bus service to Denver), it became necessary for CDOT to enforce 24-hour maximum parking restrictions.

CDOT's complex of three "dinosaur" park-and-ride lots in Morrison at the western edge of Denver (lots named T-Rex, Stegosaurus and Wooly Mammoth, celebrating fossils found nearby) caters to winter weekend ski traffic. Research conducted by the I-70 Coalition in 2014 found that the complex was 45 percent full on Fridays, 94 percent full on Saturdays, and 83 percent full on Sundays. User surveys determined that vehicles going to park at these lots arrived with an average of 1.49 occupants, and vehicles departing the lots to head for ski country had an average of 2.97 occupants, or double the occupancy. Filling up some 1,200 parking spaces therefore took 1,200 vehicle round-trips off of I-70 on busy ski weekends (I-70 Coalition, 2014).

Table VI.8: NFRMPO 2010 Data on CDOT Park-and-Ride Utilization

CDOT Park-and-Ride Utilization in the NFRMPO Region in the Summer of 2010			
Park-and-Ride Facility	***Spaces***	***Amount Used***	***Usage Rate***
Harmony Road (Fort Collins)	248	89 to 112	36 to 45%
SH 392 (Windsor)	43	11 to 12	26 to 28%
US 34 (Loveland)	142	57 to 63	40 to 44%
SH 402 (Loveland)	88	84 to 97	95 to 110%
SH 60 (Johnstown)	33	31 to 32	94 to 97%
SH 56 (Berthoud)	42	17 to 20	41 to 49%
Source: NFRMPO, 2010.			

VI.1 Participation in TDM Support Strategies

Rideshare Matching - Participation

It was noted in Chapter 3 under "Rideshare Matching" that most carpools form without the aid of regional carpool matching services. Nevertheless, carpool matching services are beneficial for persons who cannot readily find relatives, friends or co-workers with whom to carpool.

The Way to Go 2014 Annual Report indicated that there were 3,300 new registrants in 2014. Of these, 157 commuters switched from solo driving to carpooling at least one a week, and another 103 switched to carpooling at least once per month. Another 33 registrants switched to bicycling and 44 switched to transit. At the time, the total number of persons registered in the Way to Go database was reported to be around 10,000. A more recent newsletter from the program indicates there are now 13,000 registrants (DRCOG, 2015b).

In early 2016, the NFRMPO carpool matching program reported having 4,000 registrants in their database. The agency also reported activating 761 "Smart Trips" accounts during their fiscal year 2015 (NFRMPO, 2016b).

The Metro Rides program in Colorado Springs reported 733 commuters active for matching as of the end of 2015. In this program, 221 registrants received at least one match, although the ultimate outcome of these matches is not known (Mountain Metro Transit, 2016).

The City of Aspen reported that it had 200 names registered in its carpool matching database as of December 2016 (City of Aspen, 2016a).

Guaranteed Ride Home - Participation

In the Denver region, the Guaranteed Ride Home benefit is provided as part of RTD's EcoPass, an employer-paid transit pass program. In 2014, 893 employers provided EcoPasses to about 112,000 employees. The benefit is also available to participants in Way to Go vanpools, which was a total of 637 commuters at the end of 2014. The total number of free taxi rides provided to covered Way to Go commuters in 2014 was 2,457. This may include two rides annually to some individuals, but there are safeguards to prevent abuse of the program, so receipt of more than two rides by one individual in a year is highly unlikely.

The guaranteed ride home benefit is also available to NFRMPO's VanGo 323 vanpoolers.

As a support program, the Guaranteed Ride Home program does not directly reduce vehicle miles traveled. However, it is a mobility safety net that helps make vanpooling and transit more attractive commuting options. Persons who took advantage of this safety net programs knew about the program, which means that it may have been an incentive for them to use an alternative mode. It is possible that other potential users may be unaware of the program.

The City of Aspen offers a Guaranteed Ride Home for the employers that participate in its Transportation Options Program (City of Aspen, 2016b).

Parking Management - Participation

Chapter 3 indicated that the cities of Denver, Boulder and Aspen actively manage their downtown parking with the intention of encouraging alternative mode use. It was reported that there are 3,900 on-street parking spaces in Denver (plus additional spaces in city-owned parking garages), 4,000 spaces in Boulder and over 1,000 public parking spaces managed by Aspen. This is a total of about 10,000 spaces.

Additionally, colleges and universities throughout the state manage extensive inventories of parking spaces available to students, staff and visitors but not the general public. Denver International Airport has 40,000 public parking spaces plus another 7,400 spaces for employees, but these are managed for efficient airport operation.

Reserved parking for carpools or vanpools is known to be available at a small number of locations in the state. Detailed data on this topic are not readily available.

Incentives - Participation

A number of existing incentive programs were documented in Chapter 3. These include about a dozen regional incentives offered by the DRCOG Way to Go program and its cooperating TMOs. Additional incentive programs include the Durango Way to Go! Club (800 participants), 2017 Aspen Drive Less program (new program, no data available yet).

Occasional free transit days (typically not more than one per year) have been offered on newly opening RTD light rail lines and by the City of Boulder (in 2016). A Free Transit Day was held in Durango on November 28, 2017.

The Smart Commute Metro North TMA reports that during 2014-2015 it distributed 500 RTD Express 10-Ride ticketbooks, and received requests (it could not fulfill) for 700 more. It estimated that these 500 incentive recipients reduced their VMT by almost 1.4 million, or 2,736 VMT per person over a period of 188 days, or 14.5 VMT per day. It estimated that 59 percent of the recipients continued using transit after exhausting their free tickets. Additionally, the TMA provided subsidies for new vanpoolers, attracting 23 participants into five vanpools. At the expiration of the subsidies, three vanpools continued in operation. This effort was estimated to reduce an additional 120,000 VMT over 240 days, for an average of 500 VMT per day and 22 miles per person per day (Smart Commute Metro North, 2016).

Marketing and Education - Participation

The DRCOG Way to Go program and its cooperating TMOs in the Denver metro area undertake year-round extensive marketing to promote alternative mode use. Additional summertime ozone awareness programs also encourage alternate mode use. The Regional Air Quality Council (RAQC) in Denver runs a regionwide OzoneAware campaign as well as an "Every Trip Counts" program in Jefferson County. Boulder County runs a Clean Air Challenge.

RAQC's 2015 report on the OzoneAware campaign indicates that it achieved 12.3 million gross advertising impressions (the sum of the audiences reaches by the media between June and August of that year). In its third year of use, the OzoMeter (an online emissions calculator) had 585 participants tracking their ozone-causing emissions. The three-year total for 2013 to 2015 was an estimated 1.3 million vehicle miles of travel reduced, and 1.3 million pounds of carbon dioxide reduction. Dividing by three yields 433,000 VMT per year. The program targeted approximately 64 work days, yielding an average reduction of 6,800 miles per day. Dividing this by 585 OzoMeter users yields an average reduction of 11.6 miles per day per user. It is likely that other people who saw or heard the advertising also reduced some of their driving, especially on ozone alert days, but did not document those reductions (RAQC, 2016a).

The "***Every Trip Counts***" program has operated for seven years in Jefferson County. In 2016, this was augmented by a non-Jeffco area in the Smart Commute Metro North TMO. In 2016, the reported participation included 3,504 Jeffco residents and 311 non-Jeffco residents, for a total of roughly 3,800 participants. The program's annual report for 2016 estimated a total of 2 million pounds of carbon dioxide reduction. The report shows an OzoMeter indicating one pound of carbon dioxide reduced for each mile of travel reduced. By inference, 2 million VMT were reduced by the "Every Trip Counts" program.

The ***Boulder Clean Air Challenge*** reportedly attracted 100 participants in 2016.

The Groundwork Denver marketing campaign noted in Chapter 3 reported a total of 1,168 participants responded to their CMAQ-funded "***Strive Not to Drive***" campaign, together with another 515 from a similar campaign in adjacent neighborhoods. They estimated reducing 188,000 single-occupant vehicle trips over a two-year period, reducing 1,787,000 vehicle miles of travel. Dividing the trips by 240 weekdays per year and then by 2 years yields an estimated 390 trips reduced per workday. At an average trip length of 9.5 miles, this is 3,700 VMT per day. CDOT is committed to keeping all road users safe on Colorado roadways. To address this, CDOT developed a statewide public awareness campaign, "***Share the Road, Friend***", to encourage everybody to uphold their mutual responsibility to share the road. The campaign speaks to all road users—motorists, bicyclists, and pedestrians—reminding them that life has enough problems, sharing the road shouldn't be one of them. The campaign elements can be downloaded, and include print ads, posters, bus shelter and billboard displays.

Market-Based Strategies - Participation

Three market-based strategies for supporting alternative mode use were discussed in **Section III**. These were variable pricing on Express Lanes, employee transportation allowances, and a road user charge. Express Lanes are discussed later in this chapter. Data on employee travel allowances is not readily available. Colorado recently conducted a pilot program to test roadway user charges, with a pool of 100 volunteers.

Intelligent Transportation Systems and Traveler Information Strategies - Participation

Under the topic of Intelligent Transportation Systems, Chapter 3 discusses transit smart cards, transit information systems, highway traveler information systems, travel information radio and travel information online. Many of these technologies have come into normal, widespread use. For most of these technologies, "participation" cannot readily be quantified. It was noted early that over 100,000 Denver area residents use EcoPasses, Neighborhood EcoPasses, or other transit smart cards. This includes tens of thousands of college students as well as 4,100 employees at Denver international Airport.

TDM-Friendly Design Considerations - Participation

RTD's 2013 Transit-Oriented Development Status Report indicated that its TOD efforts had resulted in over 27,000 residential dwelling units (mostly apartments) completed or under construction near light rail stations, in addition to 6,800 hotel rooms, 5.5 million square feet of retail space, 6.8 million square feet of office space, plus medical, education, government and cultural facilities (RTD, 2013). To put this into statewide perspective, assume that each apartment accommodates an average of almost two occupants, for a total of 50,000 new residents near light rail stations. This is comparable to the entire population of some of Colorado's multi-county Transportation Regions.

One example of TOD is RTD's Alameda Station Pilot Project, officially named Denizen, completed in August 2014, specifically designed for residents who want to use transit. Every unit has access to shared car and bike parking, and there are dedicated bike lanes built around the area. The project includes 275 residential units near the Alameda Station (RTD, 2015).

The Boulder Junction TOD development will create up to 300 residential units, with perhaps another 600 persons living near a light rail station.

VI.2 Participation in Emerging Technologies and Programs

Carhailing (Uber, Lyft) - Participation

Data regarding Uber and Lyft usage in Colorado is difficult to obtain, according to a Colorado Springs journalist's recent report (Colorado Springs Independent, 2016). It was learned that Lyft has a total of 315,000 U.S. drivers. If evenly divided in 200 cities, this would be 1,575 drivers per city, as a crude estimate. The number for Uber is likely somewhat higher. Note that larger cities likely have more drivers and smaller cities likely have fewer.

According to Colorado Public Utilities Commission data, ridership for Yellow Cab in Colorado Springs fell by about 87,000 rides annually in 2015 after carhailing began in 2014. This was about a 16 percent reduction in cab rides, presumably replaced by carhailing (Colorado Springs Business Journal, 2016). This equated to just an average of 238 carhailing rides per day for 365 days in a year. With time, carhailing is likely increasing in use as it grows in public awareness and acceptance.

The Denver region has 4.3 times the population as the Pikes Peak Region. If it has 4.3 times the amount of carhailing as Colorado Springs, this would be 374,100 annual uses, or over 1,000 per day. This number seems too low.

Carsharing (rental) - Participation

About 500 carshare vehicles are currently available to the general public in the metro Denver area. As these are short-term car rentals, it is possible for them to be used more than one time daily. Not all of them are used daily, and some are occasionally out of commission for cleaning or repair. With widespread adoption of carsharing, it has been estimated that one carshare vehicle potentially eliminate the need for up to 11 private vehicles (Martin et al., 2010).

Car2Go's website suggests that it has 40,000 members in the Denver region (Car2Go, 2017). A member presumably is anyone who has paid the one-time $5 fee to join.

When rented, the vehicles are of course driven, which creates vehicle miles of travel. But the availability of carsharing allows some people to choose not to own a vehicle. A person who owns a vehicle is more likely to use it, since the ownership, taxes and insurance are fixed, sunk costs. Carsharing also reduces the need for parking spaces.

Bikesharing (rental) - Participation

It was reported in **Section IV** of this report that there are roughly 700 bikes in Denver, 300 in Boulder, 90 in Fort Collins, 25 in Castle Rock, and 190 in the Aspen SH 82 corridor available for bikesharing by the general public. This is a total of approximately 1,300 bicycles, a number which will likely increase over time. Additional bikes are available at colleges and universities, not necessarily to the general public. These bikes are intended to be used for short trips, with typically a 30-minute use restriction, so that they can be used multiple times daily.

Boulder B-Cycle's 2016-2018 Master Plan indicated it had achieved 0.55 average rides per bike per day or less for the years 2012 through 2014 (Boulder B-Cycle, 2015). However, the program reported that its bikes were used for 85,000 trips in 2015. Dividing this by 300 bikes yields average usage of 283 annual trips per bike, or (dividing by 365 days) 0.77 use per bike per day.

The Denver B Cycle annual report for 2015 reported a total of 363,000 trips, which is approximately 1,000 per day. Given a fleet of 700 bikes, this is about 1.5 uses per bike per day. The report estimated that 67,000 users covered an estimated 773,000 miles in 2015 (Denver B Cycle, 2016). This means there were an average of 5.4 trips per user during the year, and an estimated trip length of 2.13 miles per rental.

As a simplifying assumption, the weighted average daily use per bike for Denver and Boulder could be applied to all 1,300 known public (non-university) bikeshare vehicles in Colorado. Multiplying 1.3 uses per day by 1,300 bikes yields about 1,700 bikeshare uses per day, statewide. Multiplying this number by 2.13 miles per use yields a statewide daily reduction of 3,650 vehicle miles of travel (VMT), if every bikeshare use actually replaced a vehicle trip. In fact, some rentals likely were for recreational purposes. Denver B-Cycle recently reported survey results indicating that 47 percent of its trips in 2016 replaced motor vehicle trips (Denver Post, 2017d). This means actual travel reduction from bikesharing is about 1,700 VMT per day. However, bikesharing is a support strategy that allows commuters to take an alternative mode of travel to work and then use a rental bike for daytime errands. Bikesharing is expanding rapidly in Colorado, so the daily VMT reduction will increase with additional users.

Express Lanes - Participation

Managed express lanes provide to CDOT the ability to add roadway capacity financed with toll revenues in cases where the needed capacity could not be provided with traditional highway funding. A map of planned and existing managed lane projects was provided earlier in **Figure IV.5.** For toll-paying solo drivers, Express Lanes do not reduce vehicle miles of travel, but do offer a travel time savings, as well as a reliable trip time that cannot be assured in the adjacent congested general purpose lanes. A second aspect of Express Lanes is how they accommodate high-occupancy vehicle (HOV) traffic.

On its Express Lanes, CDOT has the capability of managing toll rates by time of day so that the express lane does not become congested and slow down. Tolls can be adjusted to limit lane use (fewer vehicles operating) to ensure a reliable trip time at a minimum speed. With a few exceptions (I-70 and C-470), CDOT allows HOVs to use the Express Lanes for free, and adjusts tolls to limit the number of toll-paying single-occupant drivers.

Express lanes are operated by CDOT's High Performance Transportation Enterprise (HTPE). As of November 2017, HTPE had sold about 153,000 switchable transponders which enable HOVs to identify themselves to roadway sensors and thus use most express lanes for free. About 30,000 people in the Denver region currently participate in carpools of three or more people, according to 2015 data from the American Community Survey, a Census Bureau product. If all of them carpooled on any given day in a three-person carpool, then up to 10,000 vehicles could use CDOT's Express Lanes on a toll-exempt basis. Existing two-person carpools could add an occupant to also take advantage of the toll exemption.

Automated and Connected Vehicles/RoadX – Participation

A number of CDOT RoadX-sponsored high-tech roadway innovations are in initial phases of development and pilot project implementation as was discussed earlier in **Section III** of this report. Taken together, they have potential to benefit all Colorado roadway traffic. However, to date, no quantifiable participation or impact numbers can be determined. A near-term project affecting I-25 near RidgeGate will occur in a location that carries 139,000 vehicles per day. Future improvements on I-70 from Golden to Vail will affect a roadway carrying 30,000 (Vail end) to 100,000 (Golden end) vehicles per day.

> *"In the next 10 to 15 years, we will see upward of three million connected vehicles on the roads. And the Feds just issued rules mandating all car manufacturers to install dedicated short-range radio that allows vehicle-to-vehicle communication."*
>
> *- Amy Ford, CDOT Communications Director, Quoted in Engineering News Record, January 2017*

VI.3 Participation in TDM for Specific Markets

Schools and Universities - Participation

The DRCOG Way to Go Schoolpool program enrolled nearly 17,000 families in 2014 and reported that about 6,400 families actually formed school carpools. Schoolpools are also promoted in Colorado Springs and Fort Collins. If Schoolpool participation in those communities were assumed to be proportional to MPO regional population (i.e., same participation rate per capita as the Denver region), then those communities could have roughly 1,500 and 1,100 participating families, respectively.

Since the program was created by Congress in 2005, 130 Safe Routes to School (SRTS) grants administered by CDOT have benefitted over 500 schools. In 2016, grants totaling $2 million were awarded for seven infrastructure projects and an additional $500,000 was awarded for 14 non-infrastructure programs in Colorado. The SRTS program focuses on improving safety for walking and bicycling to school. Safer routes can encourage increased use of these active transportation modes. Educating people to walk or bike safely when they are young can carry over to their older years by keeping them healthier and being less accustomed to going everywhere by automobile.

As noted earlier, there are an estimated 100,000 college students in the Denver metro area and another 40,000 in the North Front Range region. Colleges and universities in these regions have fairly robust alternative transportation programs including mandatory bus passes and free on-campus shuttles, as well as access to highly rated bicycle-friendly infrastructure. There are a total of about 160,000 college students in other regions where there is generally less congestion and less emphasis on alternative transportation modes. Here is RTD's list of schools using CollegePass:

- Anschutz Medical Campus (University of Colorado Medical School)
- Community College of Denver
- Metropolitan State College of Denver
- University of Colorado at Denver
- Colorado School of Mines
- Naropa University at Boulder
- Rocky Mountain College of Art and Design (Lakewood)
- University of Colorado at Boulder
- University of Denver
- Escoffier Schools of Culinary Arts (Boulder)
- University of the Rockies (RTD, 2017b)

Special Events - Participation

In **Section III**, special transit services were discussed as the primary TDM measure used at special events. RTD SportsRides routes serve approximately 100 special events annually.

Special SportsRides transit service is provided by RTD for a number of sporting events including ten Denver Broncos games annually. Buses pick up passengers at 23 different Park-n-Ride lots around the region. Users of this service for one game are likely to be repeat users for other games.

RTD RockiesRide service picks up baseball fans from 11 Park-n-Rides for each of 81 Colorado Rockies home games annually. Special service is also provided from 12 Park-n-Rides to a half dozen University of Colorado football games.

RTD takes passengers to the BolderBoulder running race from 14 park-n-Ride lots, with frequent service for about two hours, totaling about 300 busloads. RTD takes approximately 40 busloads from four Park-n-Rides to the Susan G. Komen Race for the Cure that begins at the Pepsi Center arena near downtown Denver.

If most of these SportsRides buses are full with 40 passengers, the total ridership for these events is many thousands of passengers during the course of the year. These figures are already included in the 99 million boardings reported earlier for the RTD bus system.

In 2016, CDOT's Bustang service operated on five Sundays for the purpose of taking riders from Fort Collins and Colorado Springs to Denver Bronco games, carrying about 90 passengers per game.

Recreation and Tourism Destinations - Participation

Interstate 70 between the Denver region and mountain communities is the state's busiest recreation corridor. This corridor carries heavy traffic on both winter ski weekends and summer weekends and holidays. Addition of the 13-mile I-70 Mountain Express Peak Period Shoulder Lane has significantly improved traffic flow for these trips. The lanes allow more traffic throughput at higher speeds and have reduced the number of crashes. Note that crashes cause congestion, increasing travel time and lowering throughput.

A 2016 CDOT assessment of Mountain Express Peak Period Shoulder Lane impact for summertime stated the following: The I-70 Mountain Express Lane was open 29 days during the 2016 summer, capturing 8 percent of the traffic. Eight percent of the busiest traffic day (Labor Day) was nearly 4,000 toll-paying vehicles. The report compared conditions before and after express lane implementation with the following Labor Day traffic data:

- 2012: 40,500 vehicles per day with speeds consistently below 20 miles per hour (mph)
- 2016: 46,300 vehicles per day with speeds that were predominantly above 45 mph and occasionally dipped to 30 mph (CDOT, 2016c).

Busy winter ski weekends would have traffic volumes comparable to Labor Day but with the added challenges of weather-impaired visibility and possibly icy roads.

The I-70 Coalition, under contract to CDOT to undertake TDM outreach to I-70 travelers, reported in 2016 that they had recorded a peak volume of 6,000 hits to their website during the ski season. The most page provided a forecast of travel conditions. A page regarding transit options had accumulated 34,000 hits during the winter ski season by the end of February.

The Coalition's "Change Your Peak Time" outreach campaign in 2013-2014 reportedly achieved 15.3 million potential advertising impressions (Communication Infrastructure Group, 2015).

CDOT Snowstang buses provided roundtrip service to six mountain ski areas on two weekends in 2017. It may be assumed that each bus used carried 40 passengers plus their ski equipment, thus removing some traffic off of the busy I-70 recreation corridor each weekend.

RTD offers seven trips daily between Boulder and the Eldora Ski Resort (a 21-mile trip) every day of the skiing season. These buses have accommodations for transporting ski equipment, which would be a challenge using normal commuter buses. If each bus carries 40 passengers, this would total 280 passengers per day.

Regarding RFTA summertime service to Maroon Bells near Aspen, scheduled service calls for 24 roundtrips daily. If each bus were to carry an average of 30 people, this would be daily participation by roughly 750 riders.

Regarding casino shuttles, the Ramblin' Express private bus service offers 35 daily round trips to Cripple Creek from Colorado Springs, 10 from Pueblo, and 17 from Woodland Park. These 56-passenger coaches run close to capacity on weekends and at less than half capacity on weekdays. If each of these 62 buses were to carry an average of 50 people, the total would be over 3,000 riders per weekday. The same company has 20 daily round trips between Aurora (Denver region) and Black Hawk/Central City, representing an estimated 400 passengers daily (Ramblin' Express, 2017). In addition, one of the Cripple Creek casinos operates its own bus service with five roundtrips daily from Colorado Springs, possibly carrying another 200 passengers.

Transportation Corridors and Construction Management - Participation

The T-REX project team developed the TransOptions Plan to minimize traffic disruption on I-25 during the five-year construction period, 2001 to 2006. About 50% of commuters took action, with work schedule flexibility ranking number one. Transit subsidies and telecommuting were among the most effective strategies at reducing travel (Harrington, 2007).

The TDM mitigation plan for the US 36 corridor Express Lanes project exceeded expectations, reducing vehicle miles traveled by an estimated 12,500 per day. During 2015 to 2017, the program distributed 1,653 EcoPasses, 738 transit passes (e.g., 10-ticket ride book), and provided incentive payments to 58 vanpoolers and 188 carpoolers (36 Commuting Solutions, 2017).

Employer-Based Commute Programs - Participation

The Transportation Solutions Foundation, a TMA serving south central Denver area, reports as success stories two Smart Moves campaigns focusing on employers in targeted corridors. During 2008-2010, they estimate reducing VMT by a cumulative total of 2.5 million miles along Colorado Boulevard. During 2012 to 2014, they estimate a reduction of 230,000 vehicle trips and 2.2 million VMT (Transportation Solutions Foundation, 2016).

More recently, a 2014-2016 CMAQ-funded effort targeting six employers targeted the Parker/Leetsdale vicinity in Denver. Transportation Solutions estimates that approximately 600 employees changed their transportation mode for two days per week for 60 weeks, reducing VMT by approximately 1.05 million (Transportation Solutions Foundation, 2016). Dividing the total by 120 days is 8,750 VMT per day. Diving this by 600 employees yields a VMT reduction of 14.6 miles per person per day round trip, or 7.3 miles reduced one way.

36 Commuter Solutions, a TMA serving the U.S. 36 corridor between Denver and Boulder, reports the following results for 2016 (36 Commuter Solutions, 2017):

- provided incentives to over 190 solo drivers who opted to car/vanpool or take transit
- motivated 65 individuals to try biking
- provided over 700 employees with RTD Master EcoPasses for the second year in a row

DRCOG's third annual Go-Tober employer challenge signed recorded 41,204 "smart commutes" totaling 399,712 miles (DRCOG, 2017b). DRCOG's Employer Outreach budget for 2016 was about $250,000. The program attracted 1,719 participants in 2017.

Airports - Participation

As noted in Chapter 3, a number of private sector airport shuttle services exist, along with RTD SkyRide buses and a new A-Line commuter rail line to serve Denver International Airport. As of 2014, 4,100 persons employed at this airport held RTD EcoPasses.

Incidents and Emergencies - Participation

The times and places that incidents and emergencies will occur cannot be known, but statistics demonstrate that some locations are likely to experience certain major problems. For example, the Interstate 70 Mountain Corridor between Denver and the mountain ski resorts has snow and icy conditions every winter. Any crash on I-70 results in traffic backups, but the crash of a heavy truck is particularly problematic.

In 2008, CDOT implemented a Heavy Vehicle Relocation Pilot Program that stationed tow trucks capable of removing heavy trucks along the I-70 corridor. This reduced the average clearance time for a heavy tow incident by half, from an average of 52 minutes to 26 minutes. The first year pilot program was a big success and the I-70 Heavy Tow program has been continued since that time. In its first four years, the program cleared 109, 184, 212 and 193 incidents, respectively (CDOT, 2012). Each rapid clearance reduces thousands of hours of traveler delay. This is a traffic operations strategy, rather than TDM, but it clearly results in more efficient roadway use.

Based on the success of the I-70 program, CDOT is in the process of expanding Heavy Tow operations to Interstate 25 in CDOT Region 2 (Pikes Peak Region) and Region 4 (NFRMPO).

All CDOT regions have Incident Management Plans to assure orderly and expeditious incident response and detour routes if necessary. CDOT has two fulltime corridor managers respectively coordinating incident management for I-70 and I-25. CDOT also provides Motorist Safety Patrol service on the I-70 Mountain Corridor and on I-25 in the Denver area.

Freight Transportation - Participation

It is widely known that Sunday afternoon eastbound traffic toward Denver is the most congested time to travel on the I-70 Mountain Corridor, as winter skiers and summer recreationalists return home from their weekends. Weather and crashes greatly exacerbate the resulting traffic delays. A Colorado Motor Carriers Association survey found that 9 of 36 surveyed carriers, or 36 percent, avoid these peak hour times completely. Shipments that do occur on Sunday afternoons are mostly non-discretionary loads of essential services such as bulk, mail, bulk fuel, and food services (CMCA, 2012). This equates to a self-imposed alternative works schedule strategy for freight shipments due to the high delay cost of peak period travel.

VI.4 Colorado TDM Participation Recap

The participation information presented in this chapter is summarized in **Table IV.9** to **Table IV.12**.

Table VI.9: Summary of Colorado Participation in TDM Core Strategies

Summary of Colorado Participation in TDM Core Strategies	
TDM Type	***Statewide Participation***
Transit (Local/Regional)	82,400 commuters; Two non-commute transit trips for every commute transit trip
Intercity Transit	550 CDOT Bustang riders per day; 3,500 private carrier trips not feasible for commuting
Vanpools to Work (HOV 5+)	9,700 commuters (1,000 via public matching services; others private) Vanpools not common for non-work
Carpools to Work (HOV 2 to 4)	233,000 commuters statewide; Carpools common for non-work trips – note that any two people (e.g., a parent and child) make a carpool.
Walking to Work	76,100 commuters; Ubiquitous non-work walk trips; Everybody is a pedestrian.
Bicycling to Work	34,200 commuters; more common for recreation
Variable Work Hours	Not quantified
Telecommuting	172,200 workers at home
Park-and-Ride Lots	Total of 100 lots with 36,000 spaces; users already counted above as carpool, vanpool, transit

Table VI.10: Summary of Colorado Participation in TDM Support Strategies

Colorado Participation in TDM Support Strategies	
TDM Type	***Statewide Participation***
Rideshare Matching	18,000 persons registered in four public programs
Guaranteed Ride Home	2,500 uses annually; Over 100,000 people covered
Parking Management	10,000 spaces in three cities that actively manage to support TDM
Incentives	Many public programs; assume fewer than 5,000 recipients, all DRCOG and NFRMPO; Private incentives not quantifiable.
Marketing and Education	Not quantifiable. Active programs primarily in Denver and North Front Range. 600 RAQC Ozone Aware; 3,800 Every Trip Counts; 100 Boulder Clean Air Challenge; 1,700 Groundwork Colorado; 800 Durango Way to Go!
Market-Based Strategies	100 volunteers in CDOT Road User Charge Plot Program
Intelligent Transportation Systems	Ubiquitous ITS hardware systems are in place on urban freeways; CDOT has a statewide Traffic Operations Center; Colorado Springs has a TOC also. Over 100,000 transit users have smart card passes instead of paying with cash.
TDM-Friendly Design Considerations	An estimated 50,000 people in the Denver Metro Area live in high-density Transit-Oriented Developments. A TOD site in Boulder will soon house 600.

Table VI.11: Summary of Colorado Participation in Emerging Technologies

Colorado Participation in Emerging Technologies	
TDM Type	***Statewide Participation***
Carhailing (Uber, Lyft)	About 240 estimated uses per day in Colorado Springs and at least 1,000 daily uses in the Denver metro area.
Carsharing (rental)	About 500 carshare vehicles are available in the Denver metro area. Not all of them are used daily, but they have the potential to be used by several persons over the course of each day.
Bikesharing (rental)	363,000 trips in Denver for 2015, or 1,000 per day. 85,000 trips in Boulder for 2105, or 238 per day. Statewide total roughly 2,000 uses per day.
Express Lanes	As of late 2017, CDOT has sold about 153,000 switchable transponders sold that allow free use of most Express Lanes by vehicles with three or more occupants.
Automated and Connected Vehicles/RoadX	New technologies are under development and implementation. Will soon benefit 140,000 daily users of I-25 near RidgeGate.

Table VI.12: Summary of Colorado Participation in TDM for Specific Markets

Colorado Participation in TDM for Specific Markets	
TDM Type	***Statewide Participation***
Schools and Universities	6,400 families in the Denver region and perhaps 9,000 statewide participate in SchoolPool carpooling. 140,000 college students in the Denver region and North Front Range region attend schools with robust TDM programs including transit passes.
Special Events	RTD provides tailored service to about 100 special events per year, carrying thousands of passengers per event. Biggest effort is 300 busloads (possibly 10,000 passengers) carried to the annual BolderBoulder running race. CDOT Bustang buses carried 90 people per game to two Denver Bronco games in 2015.
Recreation and Tourism Destinations	I-70 Mountain Express Lane carrying 8 percent of peak day traffic (nearly 50,000 vehicles), therefore 4,000 toll payers. I-70 Coalition website has had as many as 34,000 hits in a day. RTD buses to Eldora can carry about 300 passengers per day. CDOT Snowstang buses on two days in 2017 will carry 240 riders daily. RFTA Maroon Bells bus carries up to 750 riders per day. Private shuttles carry 1,300 riders daily to Cripple Creek and at least 400 riders daily to Black Hawk/Central City.
Transportation Corridors and Construction Management	Half of I-25 commuters in Denver changed their behavior in response to T-REX construction in 2011-2006. During 2015 to 2017, the program distributed 1,653 EcoPasses, 738 transit passes (e.g., 10-ticket ride book), and provided incentive payments to 58 vanpoolers and 188 carpoolers.

Colorado Participation in TDM for Specific Markets (continued)	
TDM Type	***Statewide Participation***
Employer-Based Commute Programs	Several TMO/TMA outreach efforts report achieving two-year reductions of one to two million VMT among participant groups of hundreds to one thousand people. These participants are already included in the Core TDM strategy participation reported earlier. Colorado has at least four firms that have been designated by EPA as Best Workplaces for Commuters, meaning they have extremely aggressive TDM programs for their employees
Airports	Denver International Airport has light rail service, SkyRide RTD Bus service, numerous private shuttles, and allows carhailing. 4,100 employees at the airport have RTD EcoPasses.
Incidents and Emergencies	All CDOT Regions have incident management plans. The CDOT Heavy Tow program on I-70 responds to 200 incidents per year, greatly reducing response time and resulting traffic delays. This program is being expanded to I-25 north and south of Denver.


Walk
Bike
Carpool
Vanpool
Transit
Telework

COLORADO
Department of Transportation

VII. COST OF COLORADO TDM PROGRAMS

Numerous State, local and private sector TDM efforts have been discussed in the preceding chapters of this report. Cost information is not readily available for many of them. Available cost information is presented in this chapter, especially for current CDOT programs. Costs for specific projects come from the CDOT Statewide Transportation Improvement Program (STIP) for Fiscal Years 2017-2020 (CDOT, 2016d). In some cases, typical cost data are available from programs elsewhere. Program costs may include both capital and operating costs.

VII.1. Cost of TDM Core Strategies

Transit (Local/Regional) - Cost

Table II.2 in **Section II** reported that about $455 million was spent in operating costs for urban transit systems in 2014, and another $80 million was spent on rural transit systems. These numbers do not include capital costs. Capital costs include the purchase of buses, rail vehicles and facilities, transit stations, and bus stops, among other things.

RTD capital costs fluctuate from year to year in accordance with FasTracks construction activity. RTD's capital budget for 2016 was about $373 million for light rail and another $111 million for the rest of its system (RTD, 2015), and the $484 million total exceeds the total operating costs for all Colorado transit providers combined. The RTD FasTracks light rail system represents a public investment of roughly $7 billion, with additional expansion envisioned for the future (Denver Business Journal, 2010).

CDOT's Division of Transit and Rail administered about $40 million of Federal and state funds annually for transit projects in 2014, including $8 million in carry-over funds. The division awarded 61 grants of Colorado FASTER (Colorado's Funding Advancements for Surface Transportation and Economic Recovery Act of 2009) funds at $16.8 million and 141 Federal Transit Administration (FTA) grants at $20.6 million, for a total of $37.5 million. Funds were allocated to transit facilities, vehicles, local transit admin/operating projects, transit equipment, intercity bus operation, mobility management and planning projects that provide better transit service and connect Colorado residents, employees, and visitors to major activity centers (CDOT, 2014d). It can be seen that this $40 million is a small fraction, less than ten percent, of the $455 million statewide operating costs in 2014 as reported above.

FTA grant programs administered by CDOT include the following, identified as Sections of Title 49 of the United States Code:

5303 – Metropolitan transportation planning (for areas with MPOs)
5304 – Statewide and nonmetropolitan transportation planning (CDOT and TPRs)
5311 – Formula grants for rural areas (i.e., areas with TPRs)
5310 - Formula grants for special needs of elderly individuals/individuals with disabilities
5339 – Grants for buses and bus facilities

Each of these grant programs has matching fund requirements, which may vary from program to program. Most projects are federally funded, with local match, but in some cases CDOT provides the match. Since 1992, CDOT has administered about 90 CMAQ-funded transit projects costing about $90 million (including local match).

Funding from the Federal Transit Administration is reported in CDOT's Federally-mandated STIP.
See **Appendix B** for a list of upcoming local transit projects from the current STIP.

Mountain Metro Transit in Colorado Springs provides the following cost information regarding typical transit costs (Mountain Metro Transit, 2017):

- A new, full-size urban bus costs approximately $450,000.
- On average, fixed-route bus service costs $75 per hour per route. This translates to roughly $245,000 per year per route (for 3,267 route-hours) without factoring the cost of supplementary ADA para-transit service.
- On average, ADA para-transit service costs $65 per hour per route.

Intercity Transit - Cost

Annual costs for Amtrak rail service and private sector intercity bus services are not estimated in this report. Amtrak offers special SkiTrain service between Denver Union Station and the Winter Park ski resort from January to March. CDOT in 2017 provided $1.5 million for a $3.2 million Winter Park Express platform and related railroad improvements project, in partnership with Amtrak, the Union Pacific Railroad, and the ski resort (CDOT, 2017b).

Currently (FY 2017), CDOT is spending about $5.1 million annually for intercity bus services, as follows, in rounded figures:

- $1.6 million from FTA Section 5311(f) federal grants for rural areas to subsidize private provider routes operated by Greyhound, Arrow/Black Hills Stage, Burlington Trailways
- $3.0 million Colorado FASTER funds for Bustang service
- $200,000 for RFTA Grand Hogback Service, Glenwood – Rifle
- $200,000 for TransFort FLEX Service, Fort Collins – Boulder
- $100,000 for Steamboat - Craig Service (CDOT, 2017l)

The cost of 13 purchasing Bustang buses in 2015 for the three current routes (North, South and West) was reported to be $7.3 million, or an average of over $500,000 per bus. Additional buses will be need for upcoming Bustang service expansion.

In addition to the three main Bustang routes, CDOT provided service to five 2016 Broncos football games and operated the Rams Route (Colorado State University to Denver) Friday/Sunday service on five weekends in 2017. Both of these services achieved farebox recovery in excess of 100 percent, meaning that they more than recovered their operating costs. In January 2017, CDOT will operate weekend to six Colorado ski areas as a pilot project.

In 2017, CDOT is spending $2.5 million to acquire buses for new rural regional service called "Outrider" routes (CDOT, 2017b). The capital and operating cost structure for this new service is likely to be similar to that of Bustang. The CDOT FY 2017-2020 STIP includes a line item of $105,000 for Outrider outreach activity.

In 2017, CDOT also is spending $2.5 million for rehabilitation and expansion of the Frisco Transit Center along the I-70 Mountain Corridor. This intermodal facility serves local transit, Bustang, Greyhound and private car rental businesses. Construction is expected to begin in 2018 (CDOT, 2017l).

Vanpooling - Cost

Organized public vanpool programs at DRCOG (Denver), NFRMPO (Fort Collins) and Mountain Metro Rides (Colorado Springs) account for about ten percent of Colorado's ridesharing with five or more vehicle occupants. Whether publicly or privately operated, the cost of vanpooling boils down to the basic costs of vehicle ownership and operation. Thus it includes vehicle purchase and maintenance, insurance, and fuel, plus administration.

The 2016 DRCOG Way to Go Program budget includes $910,000 in vanpool subsidies funded by RTD. It includes additional funding for administration of DRCOG's contract with the company that operates the vanpools.

The Fiscal Year 2017 NFRMPO VanGo program budget is $1.7 million, consisting of one million for vanpool services, $416,000 for vehicle acquisition, $228,000 for marketing, and $70,000 for grant management and reporting. Fare collection is projected to be $841,000. Fort Collins sales tax revenues will pay $419,000. NFRMPO vanpool fares are not subsidized with federal funds (NFRMPO, 2016b).

The *CDOT FY 2017-2020 STIP* includes funding to replace vanpool vehicles for NFRMPO VanGo ($300,000, number of vans not specified) and Mountain Metro (Colorado Springs) Metro Rides programs. Replacement of four Mountain Metro vans is budgeted at a cost of $128,000, which is an average of $32,000 per van.

True Confessions of a Former Vanpooler

"I and other state employees used to take the FREX bus from Colorado Springs to downtown Denver. When that was discontinued, we looked into vanpools with Mountain Metro and DRCOG. DRCOG's deal was cheaper - because they are subsidized, I think – and they were very helpful, so we picked them. The cost varied by month, in the range of $250 to $300 ($12 to $15 per day, roundtrip). Our van could hold seven people but we usually had four or five. The head of the vanpool calculated the cost each month. The cost varied with the number of people and the price of gas. Parking was $100 per month, included in our cost, which is a bargain in downtown Denver, where parking is getting harder to find and more expensive. The maintenance was covered by the vanpool company. We paid the vanpool company online."

[Remainder is paraphrased]

My relative here just got a job in the same building, so now I am carpooling. What's next for me? The 60-mile commute takes too much time – it's brutal. I have taken the bus, the vanpool and the carpool. It's a hands-on job, so telecommuting is not an option.

I'm going to retire this year and they can replace me with someone who only has to drive 20 miles.

(Interview, 2017)

Carpooling - Cost

Carpooling is a largely private activity that, like vanpooling, boils down to vehicle capital and operating costs, including fuel, maintenance, repairs and insurance. Carpooling can save money for the user by allowing these costs to be shared among multiple people. No further discussion is provided here. In this chapter, please see the separate discussion of:

- Rideshare Matching Programs
- Express Lanes
- Parking Management

Pedestrian Facilities - Cost

Sidewalks are commonly provided as part of development in urban areas, along with recreational or multi-purpose trails. Their cost is generally passed along to residents and businesses through development costs or local taxes. Some state highways in urban areas have adjacent sidewalks which CDOT built and maintains. CDOT also has built some pedestrian overpasses or underpasses across state highways, as well as a few trails (e.g., 26-mile route along C-470 and the 18-mile U.S. 36 Bikeway). As noted earlier, CDOT has an ADA Transition Plan that focuses on reconstructing sidewalks or building new sidewalks to ensure pedestrian mobility in accordance with the Americans with Disabilities Act. CDOT also funds infrastructure improvements under the Safe Routes to Schools Program, discussed separately in this section.

The current CDOT STIP (CDOT, 2016d) lists 35 upcoming bike/ped/trail/multimodal projects (standalone facilities not part of a highway project). Of these, four are specifically underpasses or overpasses, and the average cost for these is $3.3 million. The remaining 31 projects have an average cost of $1.1 million. The total cost, including Federal funds and local match, was about $51 million. In most cases, the project name suggests that the facilities will accommodate both bicycles and pedestrians. Only one project was

specifically a bikeway and only one project was specifically a sidewalk. The report indicated that in the past year, 15 projects costing a total of $15 million had been completed, which included only one grade separation, an underpass costing $2 million.

It was noted earlier in this *Colorado Transportation Options Report* that CDOT recently awarded seven infrastructure grants totaling $2 million under the Safe Routes to Schools program. This is an average of $285,000 per local bicycle/pedestrian improvement project.

Bicycle Facilities and Programs - Cost

As noted immediately above, CDOT's *Statewide Transportation Improvement Plan* anticipates expenditures of $51 million statewide for 35 federally-funded bike and pedestrian projects, and most of the projects will accommodate both of these transportation modes.

CDOT has bicycle accommodations on some state highways and has built some multi-purpose trails as noted immediately above. CDOT's 2009 Bicycle and Pedestrian Policy Directive, quoted earlier in this report, is repeated here for emphasis:

> "It is the policy of the Colorado Transportation Commission to provide transportation infrastructure that accommodates bicycle and pedestrian use of the highways in a manner that is safe and reliable for all highway users. The needs of bicyclists and pedestrians shall be included in the planning, design, and operation of transportation facilities, as a matter of routine."

Thus, it is now routine for CDOT roadway construction projects to include the costs of bicycle accommodations.

Section II of this report noted the 2015 kickoff of the public-private Colorado Pedals Project, calling for developing more bike and pedestrian infrastructure, using CDOT and federal Transportation Alternatives Program and Congestion Mitigation and Air Quality Improvement Program funds. Additional funds will come from Great Outdoors Colorado. This initiative promises to focus many additional millions of dollars to make Colorado the nation's number one state for bicycling.

In addition to these infrastructure projects, CDOT annually promotes the national Bike to Work Month and Bike to Work Day initiatives to encourage people to try bicycle commuting. DRCOG's Way to Go budget for 2016 includes $30,750 in private donations that sponsor Bike to Work Day in the Denver region. Staff time is spent by CDOT and many government jurisdictions to plan, promote and execute Bike to Work Day activities. CDOT also has developed a "Share the Road, Friend" marketing campaign.

Variable Work Hours - Cost

Variable Work Hours are a strategy that is promoted by regional ridesharing agencies as part of their employer outreach efforts. The cost of altered work schedules is usually minimal for the employer and is internalized there. No further information is provided here regarding costs for this strategy.

Telecommuting - Cost

Telecommuting is a strategy that is promoted by regional ridesharing agencies as part of their employer outreach efforts. The cost of altered work schedules is internalized by employers. Working at home may necessitate the use of a mobile phone or an employer-provided laptop computer, which may or may already be available for in-office use. Working at home can save money for employers through office sharing, as well as by improving employee morale and retention. No further information is provided here regarding costs for this strategy.

Park–and-Ride Lots - Cost

This report has documented the existence of about 100 park-ride-lots providing 36,000 parking spaces for use by carpools, vanpools and transit. Of these, 27 lots and 3,500 spaces are CDOT's, while the majority of facilities belong to RTD in the Denver region. Park-and-ride lots are expensive because they require land, construction and maintenance. CDOT's facilities are surface lots, not parking structures. Using a typical cost of $6,000 per parking space cited earlier in this report suggests that CDOT's cumulative investment may be $21 million. However, many of CDOT's lots are in highway right-of-way so likely had lower land costs.

The current STIP lists four recently completed park-and-ride lot expansion or modification projects that ranged in cost from $70,000 to $284,000 and had an average cost of $175,000. The STIP lists one upcoming project to expand the Falcon Park-and-Ride lot east of Colorado Springs by 150 spaces for $859,000. This is an average cost of $5,700 per space.

In 2017, CDOT is undertaking several further park-and-ride improvements:

- $5.0 million for a new park-and-ride with slip ramps for Bustang at I-25 and Kendall Parkway, near Loveland. This is part of the I-25 Express Lanes Project.
- $3.0 million for replacement of the existing Woodmen Road park-and-ride lot at I-25 in Colorado Springs, because the lot is at full capacity and a much larger adjacent facility has become available.
- $1.5 million for a new park-and-ride outside of Telluride in San Miguel County to serve local and regional transit service.
- $2.0 million for relocation and expansion of the Rifle park-and-ride in western Colorado, to better serve existing transit and future Bustang service (CDOT, 2017b).

VII.2. Cost of TDM Support Strategies

Rideshare Matching - Cost

Colorado has four public rideshare matching agencies – three operated by MPOs (in Denver, Fort Collins, Colorado Springs) and one by the City of Aspen. The overall $3.2 million DRCOG Way to Go program budget for 2016 was broken down as shown in **Table VII.1**. The basic ridesharing services cost was about $400,000, but note the interrelationship among program tasks.

Table VII.1: DRCOG Way to Go Budget for 2016

DRCOG Way to Go Budget for 2016	
Activity	***Amount***
Ridesharing Services – includes carpooling, SchoolPool and Administration of VRide (now Rideshare by Enterprise) vanpool contract	$389,076
Advertising and Promotion, including Bike to Work Day	$928,358
Employer Outreach	$247,426
Partnerships and Training, including coordination with TMAs and TMOs	$220,399
Overall Administration in support of all above programs	$163,257
Subtotal for above, publicly funded	***$1,948,516***
Bike to Work Day Sponsorships – private donations – no public finds used	$30,750
Regional Vanpool Fare Subsidies within RTD boundaries. RTD-funded only.	$910,000
Guaranteed Ride Home – entirely funded by employers who buy EcoPasses	$328,575
Grand total for both types of funding	***$3,217,841***

The PPACG Transportation Improvement Program reflects funding of $487,000 in FY 2017 and 2018 for the Metro Rides Travel Demand Management Program, which includes carpool, vanpool and SchoolPool matching services.

The NFRMPO rideshare and carpool programs are one and the same. The NFRMPO website (www.vangovanpools.org) was recently overhauled at a cost of $42,400. The annual maintenance for the website for the first year (FY 2017) is $12,630 (NFRMPO, 2017).

Guaranteed Ride Home - Cost

Three rideshare matching agencies (DRCOG, NFRMPO and the City of Aspen) offer a guaranteed ride home for transit pass holders and carpool or vanpool participants. This program benefit consists of a taxicab ride in case of emergency. About 2,500 "free" taxicabs rides are provided annually by these agencies. As was shown in
Table VII.1, DRCOG budgeted $328,575 for this program in 2016.

Parking Management - Cost

A total of about 10,000 parking spaces are actively managed to promote alternative transportation modes in Denver, Boulder and Aspen. Parking administration and enforcement cost money, but parking fees and fines are set at levels that more than compensate for the costs, making the parking spaces a money-generating asset. Aspen uses its parking proceeds to help pay for its free public transit service.

Since parking spaces cost money (previously cited estimate of $6,000 per surface space, more in structures), employers can save money on parking infrastructure by encouraging carpooling. Some examples of preferred carpool parking have been noted in this report. The cost of posting a carpool parking sign (e.g., assume $100) can be more than made up in savings by reducing the number of spaces need by one ($6,000). Some employees may be carpooling already, without special parking benefits, and they would be allowed to use the reserved spaces. To induce additional carpooling, more reserved spaces would be necessary. Employers can track the need by requiring users to register and obtain a sticker or placard needed to use the spaces.

Incentives - Cost

Various incentives for alternative transportation use are offered by public agencies, TMAs, and private employers. Many of these public sector incentives are relatively modest in comparison to total commuting cost. As detailed earlier in this report, these included a free RTD ten-ride regional bus ticket book, currently costing $40.50 per month (RTD, 2017b), or a $40 gift card, or in some cases a $75 cash award. Some of these incentives are monthly, but are limited to a fixed time duration, such as six months. Ideally, incentives should encourage solo drivers to try an alternative mode, but once they have tried it, the inherent costs savings of the alternative mode should be adequate to encourage continued non-driving.

EcoPass prices are based on four geographic areas in the Denver metro area. In much of the Denver metro area, a company with 15 employees can pay $1,470 total for EcoPasses for all their employees (an average of $98 per employee). A company with 100 employees would pay $8,500 or $85 per employee per year for a transit pass. In the high transit use downtown area, a firm with ten employees pays $2,873 (an average of $283 per employee) [Denver Post, 2015c]. Distribution of free RTD EcoPasses was a TDM strategy used by several TMOs that have recently received CMAQ grants from DRCOG. One of the incentives reported for the U.S. 36 corridor was a 70 percent discount on employer-purchased EcoPasses.

Marketing and Education - Cost

Many of the marketing programs cited in this report have been funded through funds set aside by DRCOG in their Regional TDM Pool. Agencies are invited to apply for these funds with a minimum funding request of $80,000 and a maximum request of $300,000, both over a two-year period. For FY 2016-2017, a total of $2.08 million was available (DRCOG, 2017c). Past projects awarded include (DRCOG, 2015d):

FY 2012-13 DRCOG Regional TDM Pool Projects
US 36 Transit Incentive Program
B-Cycle Marketing Campaign
Bike Denver Special Event Bike Parking
Boulder County Nederland Monthly Transit Pass Program
Boulder County Diagonal Highway Vehicle Trip Reduction Program
Boulder County Connections (TMO) Community Investment (incentives) Program
Boulder Community Cycles Employee Bike Ambassadors
Denver South TMA Million Mile Challenge
eGo Carshare 15-Vehicle Purchase and Marketing Program
Groundwork Denver NW Denver Community-based Social Marketing VMT Reduction
Regional Transportation District Regionwide Marketing of RTD FlexPass
Stapleton Area TMA Building an Active Stapleton Try Transit Campaign
Transportation Solutions TMO Parker-Leetsdale Corridor Campaign

FY2014-15 DRCOG Regional TDM Pool Projects
36 Commuting Solutions US 36 Bus Rapid Transit/ Transit Incentive Program
Bike Denver Ride On Auraria marketing campaign
Boulder Bike Sharing B-Cycle first-mile/last-mile bike sharing campaign
Boulder County Trip Tracker Program for two school districts
Boulder Community Cycles Bike Shelter and Bike Station promotion
eGo Carshare Affordable Housing Multi-modal Toolkit for Boulder and Denver
Groundwork Denver West Line SOV and VMT Reduction marketing program
RAQC Every Trip Counts Program – incentives for ozone-season trip tracking
Stapleton Foundation TMO Northeast Connect neighborhood outreach

FY2016-17 DRCOG Regional TDM Pool Projects (DRCOG, 2015e)

Infrastructure:	Cost
City of Aurora - 3 Light Rail Bike-n-Ride Storage Facilities	$300,000
36 Commuting Solutions 2 light rail Bike-n-Ride Storage Facilities	$258,623
Boulder County Transit Real-Time Arrival Signage (five)	$257,935
City of Golden Bike Library purchase 60 bikes and parking	$164,144
City of Englewood Shared Bike/Parking Lanes	$100,000
Non-infrastructure:	
Groundwork Denver West/NW Denver community TDM marketing	$238,493
eGo Carshare 3 new vehicles plus marketing of multi-modal passes	$111,767
Bike Denver Ambassador Program bike encouragement marketing	$248,369
Walk Denver Wayfinder Academy marketing of car-lite lifestyles	$144,550
Transportation Solutions TMO Cherry Creek/Colorado employee outreach	$200,000
RAQC/Smart Commute Metro North Every Day Counts Program	$286,364
Community Cycle Multi-Modal Transportation Center at Boulder Junction TOD	$124,235

This TDM pool includes $0.98 million for infrastructure projects and $1.35 million for non-infrastructure, for a total of $2.33 million.

Market-Based Strategies - Cost

The Road User Charge concept currently being explored in a CDOT pilot project is not in operation and does not have quantifiable costs. Ultimately, road user charges could replace fuel taxes. Newspaper accounts have suggested that a cost of 1.2 cents per mile is under consideration, but ultimately any such rate would be determined by the State Assembly.

Intelligent Transportation Systems, Intelligence, and Traveler Information Strategies - Cost

CDOT in 2014 estimated that it had spent $150 million over the past two decades deploying ITS devices and infrastructure statewide.

Currently, the CDOT TSMO ITS Branch work plan denotes funding in the amount of $45.6 million in FY18 for
ITS capital investment, ITS replacement and signal replacement programs.

As an example of what some of these expenditures are for, the 2017-2020 Statewide Transportation Improvement Program indicated that CDOT had recently completed implementation of the following 18 projects costing a total of $24 million:

REPLACEMENT OF VARIABLE MESSAGE SIGNS
ITS EQUIPMENT: I-25 (DENVER TO MONUMENT)
ITS ON I-25 (PUEBLO TO WALSENBURG)
ENHANCED TRAFFIC MANAGEMENT SYSTEM PH2
I-70 ITS FIBER AND ETHERNET EQUIPMENT
STATEWIDE TSMP FY15 SGN
ITS FRICTION SENSORS
I70 AND I25 ITS ETHERNET UPGRADE
ITS RWIS TOWER UPGRADE
ITS INNOVATIVE TECHNOLOGIES
ITS EQUIPMENT ON I-76 (I-25 TO I-70)
ITS WIM SCALE APPROACH UPGRADE
DEPLOYMENT OF NODE BUILDINGS
VMS STRUCTURE AND WALKWAYUPGRADES
TRAVEL INFORMATION SYSTEM UPGRADE
ITS LIVEVIEW CAMERAS PHASE 4
MAINTENANCE DECISION SUPPORT SYSTEM
ADVANCED VEHICLE LOCATION TECHNOLOGY

TDM-Friendly Design Considerations - Cost

This report has earlier documented Transit-Oriented Development efforts in the Denver and Boulder areas, which are both within the DRCOG planning region. In 2011, as part of a coordinated effort with 86 partner organizations, DRCOG secured a $4.5-million, three-year grant from the Sustainable Communities Partnership,
a federal collaboration of the U.S. Department of Housing and Urban Development, the U.S. Department of Transportation and the U.S. Environmental Protection Agency, supported regional, corridor, and site-level planning and implementation activities (DRCOG, 2017d). These funds were used to support Transit-Oriented Development.

In 2007, CDOT-administered CMAQ grants totaling $1.6 million funded 14 Station Area Master Plans (STAMP), many of which involved TOD planning. Additionally, a number of CDOT grants have funded aspects of Boulder's Transit Village/Boulder Junction TOD project.

The most recent major Federal transportation bill, Fixing America's Surface Transportation (FAST) Act, signed into law in December 2015, makes TOD expenses eligible for funding under highway and rail credit programs (FHWA, 2017).

VII.3. Cost of TDM Emerging Technologies

This section discusses cost information pertaining to carhailing, carsharing, bikesharing, Express Lanes, and automated and connected vehicles/RoadX.

Carhailing (Uber, Lyft) - Cost

Uber and Lyft are private, for-profit companies that match customers with drivers, like a taxicab dispatching operation. The drivers provide the vehicles. Neither firm receives funding from the State of Colorado. However, Lyft provided transportation to transit stations in Centennial as part of a $400,000 pilot program for six months that ended in February 2017.

Carsharing (rental) - Cost

Boulder-based eGo CarShare was awarded a $100,000 Congestion Mitigation and Air Quality (CMAQ) grant in 2014-2015 to create "Multi-modal Toolkits" for residents in various affordable housing neighborhoods in Boulder and Denver. This effort provided low-income households with significantly subsidized monthly transit passes, easy access to carsharing at a 50 percent discount, free or discounted B-cycle memberships and/or access to pool bikes, and education about the multi-modal transportation options available to them (Mobility Lab, 2014; carshare.org, 2017).

The eGo Carshare program received a grant in 2012-13 for the purchase of 15 vehicles.

Aspen's Car to Go program is operated without State or Federal funds. However, a $124,000 CMAQ grant funded four carshare vehicles in 2009.

The other carsharing operations in Colorado are private sector operations affiliated with major vehicle manufacturers and/or national car rental firms.

Bikesharing - Cost

Boulder B-Cycle and Denver B-Cycle are non-profit organizations. In addition to bike rental income, much of their revenue comes from corporate sponsors and private donations. B-Cycle received DRCOG Regional TDM Pool grants for the 2012-2013 and 2014-2015 grant cycles.

It is reported that Denver B-Cycle spent $2.1 million in 2014, and had a net loss of $270,000 (Denver Post, 2015d).

The Golden Bike Library was funded with a $164,000 CDOT grant and $34,000 local match from the city. The initial program has 40 bikes with plans to add 20 bikes at a second location in 2017 (Denver Post, 2016e).

The Castle Rock FreeCycle program, which is in its fifth year, reportedly cost about $20,000 to launch by purchasing bicycles, bike racks, and a website, and costs $2,500/year to maintain (HealthLeaders Media, 2017; Denver Post, 2016f).

Express Lanes - Cost

A map of existing and planned managed lane projects in Colorado was presented in **Figure IV-5**. It is difficult to assess the costs of Express Lanes by themselves because the existing facilities have been developed over time, in some cases, for example transforming from an HOV lane (buses and carpools only) to a HOT lane (HOVs plus anyone willing to pay a toll). Recent major projects U.S. 36, I-25 North, and C-470

also include other elements that are not specifically Express Lanes. For example, CDOT's 2014 TIGER grant application to FHWA for C-470 funding indicated that about one-third of the estimated project costs was attributable to reconstruction of the existing lanes, and two-thirds was for new facilities. HPTE indicates that the project is expected to cost $276 million, including $110.6 million in state and federal funding and $10 million from Douglas County. The remainder will be funded via loans repaid by toll revenues (CDOT, 2016e).

Similarly, the U.S. 36 Express Lanes project also included significant reconstruction, as well as one buffer-separated managed lane in each direction, bus rapid transit ramp stations, auxiliary lanes between most interchanges, and a bikeway, at a total cost of $307 million for just the first phase, to 88th Street (CDOT, 2017j; USDOT, 2017d). Once again, it is difficult to identify the cost solely attributable to the Express Lanes.

Constructing Express Lanes does not necessarily fit the definition of TDM which is to find low-cost ways to get more efficient use of existing infrastructure. However, allowing use of toll lanes by HOVs provides a time savings advantage over use of the general purpose lanes. Thus, the TDM cost of Express Lanes is primarily the amount of revenue that is not collected from HOVs if they had to pay for the lane use, plus any added HOV enforcement cost not covered by fines. As noted earlier, the change from HOV2+ to HOV3+ required vehicle occupancy on Express Lanes will reduce the number of HOVs in toll lanes and thus reduce the lost-revenue cost of this strategy. Express Lanes also have time-based fare differences that encourage travel during lower-fare off-peak hours.

Express lanes may benefit other TDM projects in an indirect way. In 2009, the General Assembly enacted Senate Bill 09-108, the Funding Advancements for Surface Transportation and Economic Recovery Act of 2009 (FASTER). FASTER established provisions for multi-modal transit projects (Colorado Revised Statutes, Section 43-4-812). This legislation allows for fees collected by the High Performance Transportation Enterprise, a Public Highway Authority, or a Regional Transportation Authority to be used for transit-related projects that relate to the maintenance and supervision of the highway segment or highway lanes on which the user fee or toll is imposed.

Automated and Connected Vehicles/RoadX - Cost

*In 2016, CDOT committed **$20 million** to kick-start RoadX, and another $12 million for fiscal year 2017.*

Billions of dollars are being invested at this time by private industry in the race to develop automated and connected vehicles and connected vehicle technology. This is being done based on the assumption that the resulting technologies will be affordable to consumers so that industry can mass-produce and find a market for such vehicles.

Additional investment is being made by the public sector for the purpose of improving mobility and safety. In 2016, CDOT committed $20 million to kick-start RoadX, with the primary goals of technology-enabled congestion relief and safety improvements. The program's budget in fiscal year 2017 is $12 million. Each year, as proven project benefits are seen, CDOT will continue to dedicate funds to technology to keep Colorado moving forward (CDOT, 2016b). One of the RoadX efforts currently underway is the Bicycle and Pedestrian Challenge, which will pay $50,000 for innovative safety technology ideas and follow up with an additional $50,000 for prototype development and testing.

Many of CDOT's RoadX efforts involve public-private partnerships, whereby CDOT is able to leverage its limited public funds and obtain additional private sector funding participation.

VII.4. Cost of TDM for Specific Markets

Schools and Universities - Cost

The costs of SchoolPool programs in the Denver, Fort Collins and Colorado Springs areas are included as part of their carpool matching programs.

CDOT recently awarded seven infrastructure grants totaling $2 million under the Safe Routes to Schools program. This is an average of $285,000 per local bicycle/pedestrian improvement project. An additional $500,000 was awarded for 14 non-infrastructure programs, yielding an average of about $36,000 per grant.

The RTD CollegePasses and Transfort passes held by perhaps 140,000 students in the Denver and Fort Collins areas are paid for by those students as mandatory fees. If each pass were valued at $400, this represents a total investment of $56 million by these students and their families.

Special Events - Cost

The largest example of special event bus service noted earlier was the total of 300 busloads of passengers delivered to and returning from the annual Bolder Boulder running race. Assuming one hour per busload and two busloads per round trip, using a reported operating cost of $75 per hour per route (from Mountain Metro, not RTD), this event incurs a minimum of $45,000 in operating costs. However, these loads likely have a high passenger load factor which would greatly reduce the net cost.

Recreation and Tourism Destinations - Cost

For the past several years, CDOT has annually contracted with the I-70 Coalition to provide TDM services at shifting traffic away from peak travel times especially on winter season ski weekends. The amount of the three-year contract is $100,000, for an average of $33,000 per year.

A CMAQ grant in the amount of $329,000 was awarded in 2014 to help create a parking garage and shuttle system in the Town of Estes Park. Estes Park is an extremely popular visitor destination during summertime as it is situated at the eastern edge of Rocky Mountain National Park. It is highly congested with pedestrians, through traffic, and traffic looking for a place to park.

Transportation Corridors and Construction Management - Cost

CDOT committed $3 million for TDM efforts as mitigation for the T-REX I-25 construction project through central and southern Denver.

CDOT's construction mitigation plan for the U.S. 36 Express Lanes project was $943,000, including $325,000 in subsidies for RTD EcoPass transit passes, and about $600,000 for localized marketing.

Employer-Based Commute Programs - Cost

DRCOG's 2016 budget for in-house employer outreach efforts was $247,426, as shown earlier in **Table VII.1**. Additionally, a DRCOG TDM Pool award of $200,000 is funding employer outreach in the Cherry Creek area of Denver via the Transportation Solutions TMO.

The cost of CDOT's purchase of EcoPasses is $83,891 per year for 1,245 passes is based on the number of eligible employees and the respective fare zones of their places of employment.

Airports - Cost

At Denver International Airport, 4,100 employees have EcoPasses. If each pass is worth $500, this is a cost of roughly $2 million per year.

Incidents and Emergencies - Cost

CDOT's Winter Driving Assistance efforts, including the I-70 Heavy Tow program, cost about $500,000 a year, but provide a very high benefit return on investment. Studies have shown that for every hour the I-70 West Corridor is closed to traffic, it can have an adverse economic impact of up to $800,000, with a majority of those revenues affecting surrounding communities (CDOT, 2016c). Due to the high rate of return, the program is being expanded significantly at this time.

Freight TDM – Cost

The current STIP includes a listing of $13,874 for I-70 Chain Law Enforcement, as part of Region 3 Congestion Relief efforts. It also lists a planned $1 million expenditure for I-70/US6 Chain Station Lighting Improvements. A completed $600,000 project for a weigh-in-motion scale approach upgrade was listed previously above as an ITS expenditure.

VII.5. Recap of TDM Costs

The information discussed above in this chapter is summarized in **Table VII.2** to **Table VII.5**.

Figure VII.2: Summary of Costs for Colorado TDM Core Strategies

Summary of Costs for Colorado TDM Core Strategies	
TDM Type	***Cost Information***
Transit (Local/Regional)	Statewide operating costs $654 million in 2016 RTD Light Rail Capital cost $373 million in 2014 RTD other capital costs $11 million Mountain Metro Transit: cost of a bus is about $500,000 MMT bus operating cost $75 per hour MMT para-transit operating cost $65 per hour CDOT transit funds administered about $30 million per year, of which part is listed below for Intercity Transit Past CMAQ costs include about $90 million for 90 transit projects
Intercity Transit	Amtrak and Private Carrier service costs are not estimated. CDOT spending $5.1 million for operations: • Bustang $3.0 million • Routes operated by Greyhound, etc. $1.6 million • Three public agency routes $0.5 million 13 Bustang buses cost $7.3 million, or $500,000 apiece CDOT spending $2.5 million for Outrider rural transit buses CDOT spending $105,000 for Outrider outreach efforts CDOT: $1.5 million for $3.2 million SkiTrain platform CDOT: $2.5 million for Frisco Multimodal Transportation Center Past CMAQ provided $4.8 million for FREX (pre-Bustang)
Vanpools to Work (HOV 5+)	Fares paid by riders cover most vanpool cost DRCOG Way to Go budgets $910k NFRMPO budget $1.7M includes $841k fare income NFRMPO $300k or $426k for vanpool replacement MMT buying 4 vans for $128,000. Average cost is $32k Various subsidies available via Incentive programs Past CMAQ grants to buy vans totaled $820k and included 2 vans for Telluride/Mountain Village

Table VII.2: Summary of Costs for Colorado TDM Core Strategies (continued)

Summary of Costs for Colorado TDM Core Strategies	
TDM Type	***Cost Information***
Carpools to Work (HOV 2 to 4)	Carpooling largely a private activity with vehicle ownership, fuel, maintenance and insurance costs. Also see Rideshare Matching discussion.
Walking to Work	Unquantified expenditures for sidewalks by cities, towns and private developers. CDOT's 2017-2020 STIP has $51 million in bike/ped improvements, most of which will accommodate both modes. Four upcoming grade-separations cost an average $3.3 million. 31 other upcoming projects average $1.1 million. 15 just completed projects averaged $1 million. 7 Safe Routes to School infrastructure projects: avg. $285k About 40 CMAQ grants for bike/ped since 1992 = $14 million
Bicycling to Work	See Walking to Work discussion above. Colorado Pedals (state) project likely to commit many more millions for bike improvements in near future. CDOT and many government agencies promote Bike to Work Day, at unquantified cost. DRCOG Bike to Work budget has $30k in private sponsor donations. DRCOG TDM grants of $300k and $259k went to Aurora and 36 Commuting Solutions for bike storage lockers at 5 light rail stations. About 40 CMAQ grants for bike/ped since 1992 = $14 million
Variable Work Hours	Any costs (minimal) absorbed by workers and their employers; strategy reduces employee travel time and fuel cost; strategy is promoted through public rideshare programs
Telecommuting	Any costs (laptops, modems, Internet, mobile phones) absorbed by workers and their employers; strategy reduces employee travel time and fuel cost; strategy is promoted through public rideshare programs. Telecommuting is a transportation alternative promoted by ridesharing agencies and public outreach campaigns. In 2000, DRCOG received an $83k CMAQ grant specifically for telecommuting.
Park-and-Ride Lots	Costs vary by lot size and new versus modification. Four upcoming CDOT park-and-ride projects total $11.5 million 150-space Falcon Park-and-Ride project to cost $859k 4 recent CDOT park-and-ride projects averaged $175k CDOT's 3,500 spaces at (assume) $6k/space = $21M invested RTD has 30,000 spaces and some of them are parking garages Past CMAQ grants have paid for other park-and-ride lots.

Figure VII.3: Summary of Costs for Colorado TDM Support Strategies

Summary of Costs for Colorado TDM Support Strategies	
TDM Type	***Cost Information***
Rideshare Matching	DRCOG's Way to Go budget for 2016 was approximately $2M, which included carpool, vanpool, SchoolPool, employer outreach and marketing. The PPACG Metro Rides TDM program is funded at $487k per year in FY2017 and 2018. This budget includes carpooling, vanpooling and SchoolPool. NFRMPO's rideshare matching efforts are part of its overall TDM program including vanpool operations. NFRMPO's rideshare matching software cost about $42k and has an annual maintenance cost of $13k. 40 past CMAQ grants have provided $26 million for regional rideshare programs, including assistance to the City of Aspen.
Guaranteed Ride Home	DRCOG Way to Go budgeted $328k for this program in 2016.
Parking Management	Denver, Boulder and Aspen manage parking for the purpose of encouraging alternate mode use. Denver spent $18 million on parking administration in 2008 but collected $26 million in parking charges and fines. A parking space may cost $6,000 in a surface lot and $30,000 in a parking structure. Signage to designate preferred parking for carpools is very inexpensive.
Incentives	Cash incentives for alternate commuting are offered by several TMAs and TMOs in the Denver metro area, including for trips from the NFRMPO area. These organizations receive grants of $80k to $300k from DRCOG's Regional TDM Pool Program. Incentives were also included in CDOT's construction TDM programs for T-REX and the U.S. 36 Express Lanes Projects.
Marketing and Education	Grants of $80k to $300k from DRCOG's Regional TDM Pool Program are awarded for marketing efforts. More than $1.3M was awarded for 2016-2017 to seven organizations, including RAQC's Every Trip Counts program. DRCOG's Way to Go budget includes $928k for advertising and promotion of Way to Go, including Bike to Work Day. Since 1992, over 150 CMAQ grants totaling $47 million have gone to various TDM outreach programs.
Market-Based Strategies	Pilot program is exploring Road Usage Charge. No costs available.
Intelligent Transportation Systems, Intelligence, and Traveler Information Strategies	CDOT estimates that $150 million was spent on ITS through 2014. The CDOT TSMO ITS Branch work plan budgets $45.6 million in FY18 for ITS capital investment, ITS replacement and signal replacement programs.
TDM-Friendly Design Considerations	DRCOG received a $4.5 million grant to advance Transit-Oriented Development projects.

Figure VII.4: Summary of Costs for Colorado Emerging Technologies

Summary of Costs for Colorado Emerging Technologies	
TDM Type	***Cost Information***
Carhailing (Uber, Lyft)	Carhailing services are private for-profit operations similar to taxicabs. In general, they receive no public funding. However, the City of Centennial contracted with Lyft to provide a $400k first mile/last mile pilot program in early 2017.
Carsharing (rental)	Non-profit eGo Carshare received a $100k CMAQ grant for outreach program with subsidies for low income. eGo Carshare received a grant for $112k in 2016-17 that will purchase 3 new vehicles and market multimodal passes. Most carsharing companies are for-profit, not receiving public funds. A 2009 CMAQ grant to the City of Aspen paid for carshare vehicles.
Bikesharing (rental)	Colorado's largest bikeshare operator, Denver B-Cycle, spent $2.1 million in 2014. B-Cycle previously received two grants for marketing from DRCOG's Regional TDM Pool Program. Castle Rock's FreeCycle program cost $20k to launch with 25 bikes and costs $2,500 annually to operate.
Express Lanes	Express Lanes are expensive infrastructure. The C-470 Express Lanes project $268M cost is two-thirds for new lanes, one third for reconstruction. Facility will not have HOV toll exemption. HPTE has sold about 153,000 switchable Express Lane transponders as of November 2017. Transponder owners have free access to most Express Lanes if they have at least three occupants in the vehicle.
Automated and Connected Vehicles/RoadX	CDOT started its RoadX initiative with $20 million in 2016, then $12 million in fiscal year 2017. The CDOT RoadX Bicycle and Pedestrian Challenge is funded to the tune of $500,000. Major private sector firms around the world are investing billions in research and development in the race to produce, sell and deploy automated and connected vehicles.

Figure VII.5: Summary of Costs for Colorado TDM for Specific Travel Markets

Summary of Costs for Colorado TDM for Specific Travel Markets	
TDM Type	***Cost Information***
Schools and Universities	All students at the major colleges and universities in the Denver and NFRMPO area have transit passes, for which they are charged along with their tuition. Many of these schools have robust TDM programs. CDOT operated Rams Route Bustang service on five weekends for the fall 2016 semester. With high load factors, fare revenue for these trips covered CDOT's operating costs.
Special Events	RTD provides special service for about 100 events per year, included in their annual operating budget. CDOT operated intercity Bustang service to five Denver Bronco football games in 2016, included in Bustang operating budget.
Recreation and Tourism Destinations	CDOT has a three-year contract for $100,000 (i.e., $33,000 per year) with the I-70 Coalition to engage mountain communities in encouraging TDM for winter ski weekend traffic.
Transportation Corridors and Construction Management	CDOT had a $3 million TDM program to mitigate construction impacts of the 6-year T-Rex I-25 expansion in central Denver CDOT had a $925k budget for TDM during construction of the U.S. 36 Express Lanes project.
Employer-Based Commute Programs	DRCOG's Way to Go budget for employer outreach was $247k in 2016. Regional TDM pool grants from DRCOG go to TMOs and TMAs. A $220k grant in 2017 is going to Transportation Solutions TMO, which previously received a similar grant. Other grants have gone to 36 Commuting Solutions for U.S. 36 Express Lane project mitigation, also geared to employers.
Airports	At Denver International Airport, 4,100 employees have EcoPasses. If each pass is worth $500, this cost a total of over $2 million. CDOT provided CMAQ grants for bus service to DIA in 1995 and 1996.
Incidents and Emergencies	CDOT's Winter Driving Assistance program, including I-70 Heavy Tow, reportedly cost $500,000 annually but save many times that in travel time. The program is now being expended to I-25 between Colorado Springs and Fort Collins.

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VIII. COST EFFECTIVENESS OF CURRENT TDM PROGRAMS

The previous sections in this report have identified recent and ongoing TDM efforts in Colorado, together with available information regarding program participation and costs. This section examines the general cost effectiveness of TDM strategies. The purpose of this effort is assess effectiveness by strategy type, not to grade individual programs.

VIII.1. Previous Studies

Two previous national studies may be of interest to this topic. Both endeavored to assess the relative cost-effectiveness of a range of TDM strategies. Both focused on strategies typically funded with Federal Congestion Mitigation and Air Quality (CMAQ) funds. Therefore both expressed cost effectiveness in terms of dollars per amount of vehicular emissions reduced. The older study, from 2002, used as its pollutant emissions two vehicle exhaust gases that contribute to the formation of ozone, volatile organic compounds (VOC) and oxides of nitrogen (NO_x). The much newer study from 2016 used as its pollutant emissions only one of these two exhausts, the VOC.

Because vehicles emit much less pollution now than they did in the late 1990s, the reported values from the 2002 study are completely outdated now. Therefore, the **Table VIII.1** does not include the numbers, but only reports the order in which the strategies ranked at that time, from best to worst. There was a huge difference in the cost-effectiveness of the least-cost and highest-cost strategies, so those numbers are noted.

Table VIII.1: 2002 Emission Reduction Cost Effectiveness of TDM Strategies

2002* Emission Reduction Cost Effectiveness of TDM Strategies	
Cost Effectiveness	***TDM Strategies***
Least cost per ton of VOC + NO_x Reduction (best value)	Regional rideshare programs ($18,500 per ton)
	Vanpool programs
	Employer trip reduction
	Transit service upgrades
	Incentives
	Park-and-rides
More costly	Bicycle/pedestrian programs
	New transit capital systems/vehicles
	Shuttles and para-transit
	Incident management
	HOV lanes
Highest cost per ton (worst value)	Telecommuting ($743,000 per ton)
Source: TRB Committee for the Evaluation of the Congestion Mitigation and Air Quality Program, as reported in TRB Traveler Response to Transportation System Changes Handbook, Third Edition: Chapter 19, Employer and Institutional TDM Strategies (Transportation Research Board, 2010).	
Note: * The supporting data is dated (2002) and should be used only to provide relative understanding of the cost-effectiveness of alternative TDM strategies relative to emissions reduction.	

Note that at that time (15 to 20 years ago), computers were comparatively much more expensive. Telecommuting today is certainly a much-improved value.

Newer values from FHWA's 2016 CMAQ Cost Effectiveness Summary Figures are presented in **Table VII.2**. Since these values are still relatively current, they are reported in the Figure.

Table VIII.2: 2016 Emission Reduction Cost Effectiveness of TDM Strategies

2016* Emission Reduction Cost Effectiveness of TDM Strategies		
	TDM Type	***Cost per Pollutant Unit Reduced***
Least cost per ton of VOC Reduction (best value)	Incident management	$172 K
	Park-and-ride lots	$464 K
	Transit service expansion	$495 K
	Bicycle and pedestrian projects	$685 K
	Transit amenity improvements	$1.3 M
More costly	Employee Transit Incentives	$1.4 M
	Carsharing	$1.7 M
	Regional rideshare programs	$2.1 M
	Intermodal freight	$2.6 M
Highest cost per ton (worst value)	Bikesharing	$5.4 M
Source: FHWA, 2016b. Note: * Newer data and different pollutant from previous Figure, therefore not comparable.		

VIII.2. Colorado Projects in CMAQ Database

A key funding source for TDM efforts is the federal Congestion Mitigation and Air Quality program. These funds are available only in areas which have had difficulty meeting national ambient air quality standards. Past carbon monoxide problems and current ozone issues have focused most of this funding to the congested DRCOG, NFRMPO and PPACG regions. Additionally, however, some past CMAQ funding went to mountain communities that had problems with particulate matter (road dust) due to use of sand for dealing with snow and ice on the roads.

The Federal Highway Administration maintains a national database of projects funded with CMAQ grants. The Air Quality CMAQ Public Access System contains information on project costs and estimated emission reductions (FHWA, 2016c). The entire database lists over 500 Colorado CMAQ projects totaling over $400 million since 1993. The most recent year of projects listed in this database is 2014. **Table VIII.3** lists all Colorado CMAQ projects funded in 2014.

The pollution metric used in the above calculations was kilograms of carbon monoxide, which is a vehicle exhaust component different from what was used in **Table VIII.1** and **Table VIII.2**. Like NOx and VOC, this pollutant also correlates reasonable well with VMT. For this sample of CMAQ projects, a regional ridesharing program was most cost-effective, followed by ITS, Marketing/Employer Outreach, then pedestrian improvements, transit and bikesharing. The $84 million U.S. 36 Express Lanes project did not have an emissions reduction reflected in the FHWA database.

Table VIII.3: Costs and Cost Effectiveness of 2014 Colorado CMAQ Projects

Costs and Cost Effectiveness of 2014 Projects from the FHWA CMAQ Database			
Project	***Cost in $1,000s***	***Units of Pollution Reduction***	***Cost per Pollution Reduction Unit***
PPACG METRO RIDES TDM PROGRAM	$412	194	$2
THORNTON SIGNAL IMPROVEMENTS	$271	230	$1
SH 177 ITS IMPROVEMENTS	$646	47	14
LOVELAND FIBER OPTIC PROJECT	$998	31	32
ITS TOTALS AND AVERAGE	**$1,915**	**308**	**$6**
TRANSPORTATION SOLUTIONS PILOT	$175	122	$1.4
STAPLETON FOUNDATION	$193	64	$3
RAQC TRANS OUTREACH AND EDUCATION	$302	38	$8
TRANSPORTATION SOLUTIONS	$193	24	$8
BOULDER TRANSPORTATION CONNECTIONS	$193	19	$10
DRCOG CMAQ UNMATCHED TDM PROGRAM	$3,118	215	$15
SMART COMMUTE METRO NORTH	$242	14	$17
STAPLETON FOUNDATION N.E. CONNECTIONS	$214	10	$21
36 COMMUTER SOL. MARKETING/INCENTIVES	$241	7	$34
DRCOG CMAQ MATCHED TDM PROGRAM	$582	10	$58
BOULDER COUNTY TRIP TRACKER	$266	2	$133
TDM MARKETING TOTALS AND AVERAGE	**$5,719**	**525**	**$11**
QUEBEC OVER C-470 PEDESTRIAN BRIDGE	$1,311	16	$82
ESTES PARK VISITOR CENTER TRANSIT	$329	8	$41
FASTRACKS LIGHT RAIL STATION IMPROVEMENTS	$5,500	10 (N/A)	$550
FASTRACKS LIGHT RAIL – NEW TRACK EAGLE P-3	$3,600	10 (N/A)	$360
GOLDEN CIRCULATOR BUS SERVICE	$446	3	$249
COMMERCE CITY TO DENVER CBD REGIONAL BUS	$148	7	$21
SEVEN STATION AREA MASTER PLANS	$750	28	N/A
TRANSIT PROJECTS TOTALS AND AVERAGE	**$10,773**	**66**	**$163**
BOULDER BIKE SHARING	$146	2	$73
FORT COLLINS FC BIKES CMAQ FY12 AND FY13	$850	2	$425
BIKESHARING TOTALS AND AVERAGE	**$996**	**4**	**$249**
HPTE US 36 PHASE II EXPRESS LANES/BIKEWAY	$83,650	N/A	N/A
Source: FHWA, 2016c.			

VIII.3. Calculating Vehicle-Miles of Travel

To calculate vehicle emissions, the studies and database discussed above must have first calculated reductions in the number of vehicle-miles traveled (VMT). Emissions also depend on the assumed travel speed. Travel speeds may or may not have been taken into account in the two above Figures, as they are difficult to estimate. Another relevant metric is called vehicle hours of traffic (VHT), which combines traffic volumes and speeds, but this is also difficult to estimate as it again requires speed assumptions. Therefore, most TDM program evaluations are based primarily on VMT changes.

One vehicle mile of travel (VMT), or vehicle-mile traveled, means that one vehicle travels one mile. If one vehicle travels two miles, or if two vehicles each travel one mile, that total is two VMT, and so forth. **Figure I.7** presented in **Section I** estimated that 48.1 billion VMT occurred on Colorado state highways and local roads in 2014. With all the zeroes, the annual 48.1 billion figure is 48,100,000,000 VMT.

To meet Federal transportation planning requirements, CDOT estimates the average amount of ***daily*** VMT on its roadway system, not including traffic on county or municipal streets. For context, the estimates for 2015 are provided in **Table VIII.4**.

Table VIII.4: 2015 Average Daily VMT on State Highway System by MPO and TPR

	Estimated 2015 Average Daily VMT on State Highway System by MPO and TPR[1]			
	Planning Organization	***Largest City***	***2015 ADVMT***	***Interstates***
MPOs	DRCOG	Denver	43.6	25,70,76,225, 270
	PPACG	Colorado Springs	6.2	25
	NFRMPO	Fort Collins	4.9	25
	PACOG	Pueblo	2.6	25
	GVMPO	Grand Junction	2.0	70
TPRs	Intermountain	Glenwood Springs	5.7	70
	Upper Front Range	Fort Morgan	3.7	25,76
	Eastern	Sterling	3.5	70,76
	Southwest	Durango	2.3	none
	Gunnison Valley	Montrose	2.0	none
	San Luis Valley	Alamosa	1.8	none
	Central Front Range	Cañon City	1.8	none
	Northwest	Steamboat Springs	1.7	none
	Southeast	Lamar	1.2	none
	South Central	Trinidad	1.1	25

Source: *CDOT Online Transportation Information* System (CDOT, 2017m).
Note: 1) Average Daily Vehicles Miles of Travel (millions).Does not include County and municipal roads.

The Figure identifies which Interstate Highways traverse the various planning regions because these are relatively high volume roadways affecting the VMT on the State Highway System.

As indicated, the Figure above does not include traffic on County and municipal roads. DRCOG has estimated ADVMT for its modeled roadway system including these local facilities for the years 2010 (70

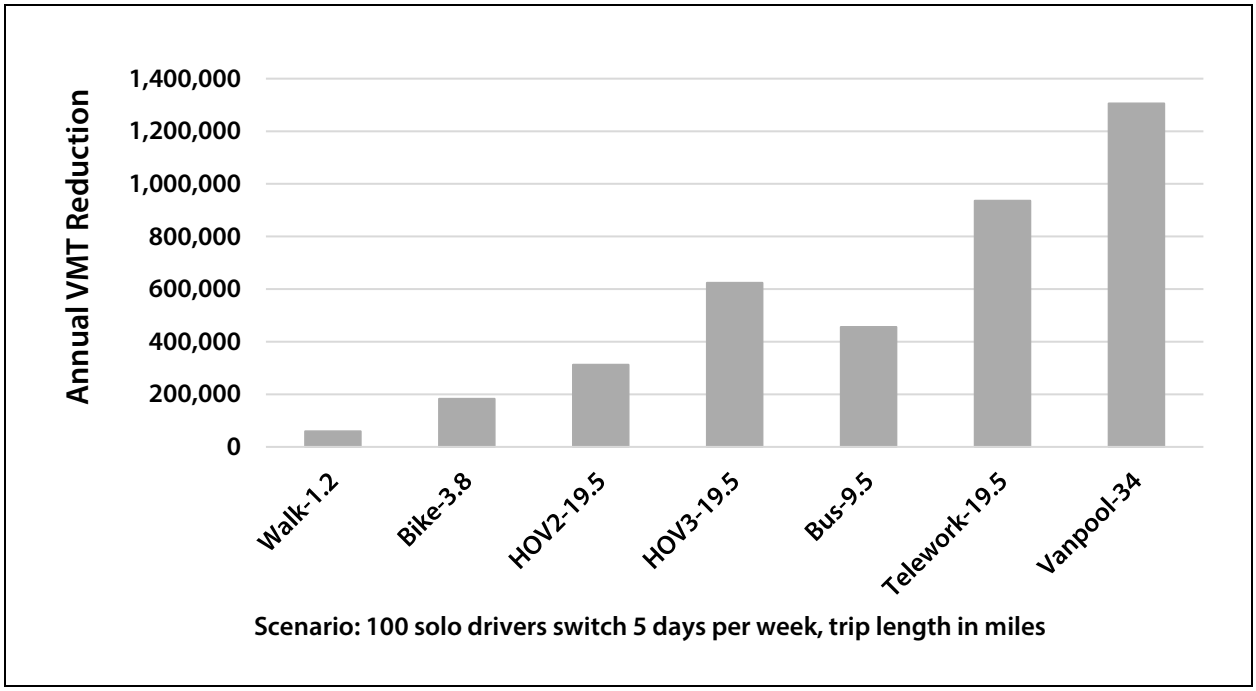
million) and 2020 (85 million). By straight-line interpolation, a reasonable estimate of DRCOG regional VMT for 2015, comparable to the figures in **Table VIII.5**, would be 77.5 million VMT per day. So in the Denver region, in addition to 43.6 million VMT on State roads, there are another 34 million VMT on local roads. For each region listed in **Figure VIII.5**, the State roads VMT number shown represents only part of the total VMT in that region.

Calculation tools have been developed for the purpose of estimating VMT reductions from TDM programs. CDOT and DRCOG both have such systems. CDOT's "CMAQ Reporter Formulas" have been used to report project impacts to the State Transportation Commission (CDOT, 2010). DRCOG's "VMT and Trip Reduction Calculation Packet" (DRCOG, 2015f) provides a consistent methodology available to potential grantees seeking funds from the Regional TDM Pool. Both methodologies contain formulas developed for various types of TDM strategies. Although the equations may look complicated, they basically multiply together the answers to the following questions:

- How many people switched from one mode (e.g., solo driving) to another, and how many vehicles did that take off the road?
- What was the average trip distance for the vehicle travel that was reduced?
- How many days per year did this modal change occur?

For commuter-based strategies, most of the formulas assume there are effectively 48 five-day work weeks in the year, a total of 240 days, which eliminates weekends and holidays. **Figure VIII.1** shows examples of the annual impact of 100 people changing their travel mode from driving alone to taking a bus, walking, bicycling, or telecommuting. The typical trip distance has been varied for each scenario based on how the mode is normally used. For example, walking is not supported (time-wise) for long trips and vanpooling is not financially supported for short trips.

Figure VIII.1: Annual VMT Reduction for 100 Solo Drivers Switching to Other Modes



The DRCOG VMT reduction formulas provide default values for use if project-specific data are not available. These were used in creating **Figure VIII.1**. From survey data and from the 2012 DRCOG regional transportation model, the average trip length for a transit trip is 9.5 miles one way. For carpool and telework trips, it is 19.5 miles one way. For vanpool trips it is 34 miles one way. Walk work trips are 1.24 miles and bike trips 3.8 miles (DRCOG, 2014).

It was noted earlier that the DRCOG region has approximately 1.6 million workers and about 77.5 million daily VMT (all trip types). Changing the behavior of 100 workers reduces vehicle use by a couple of thousand VMT per day: 250 VMT per day for switching to walking, and 5,400 daily VMT for switching to vanpooling.

Average work trip differences for the Denver metro region may not be appropriate elsewhere, in smaller metro areas and smaller rural communities, especially for ordinary carpool trips. Walking and bicycle trips would still be short, and vanpool trips would still be long, but the assumed Denver metro 19.5 miles one-way for carpooling and telework is likely shorter elsewhere because the communities are smaller. However, trip length is a factor that compels people to use the modes instead of driving alone, so the difference may not be major.

Benefit Years

Another factor entering into TDM effectiveness calculations is the expected duration ("lifetime benefit years") of the trip reduction effect. This is similar to the depreciation of assets in corporate or personal tax accounting. CDOT assumes one year of benefit for a transit or carpooling incentive – once the payment to the commuter stops, the carpool or transit use might stop as well. For most rideshare inducing programs, a two-year benefit is assumed, because most carpools last about two years (CDOT, 2010).

Physical equipment and improvements are assumed to last longer. A bicycle purchased for bike sharing is expected to last four years. A vanpool vehicle might last seven years. Many ITS elements are assumed to last seven years. A park-and-ride lot is assigned a ten-year lifespan, as it will eventually need maintenance. A newly purchased bus is also assigned ten years. A bike/pedestrian overpass is assigned a 24 year life span.

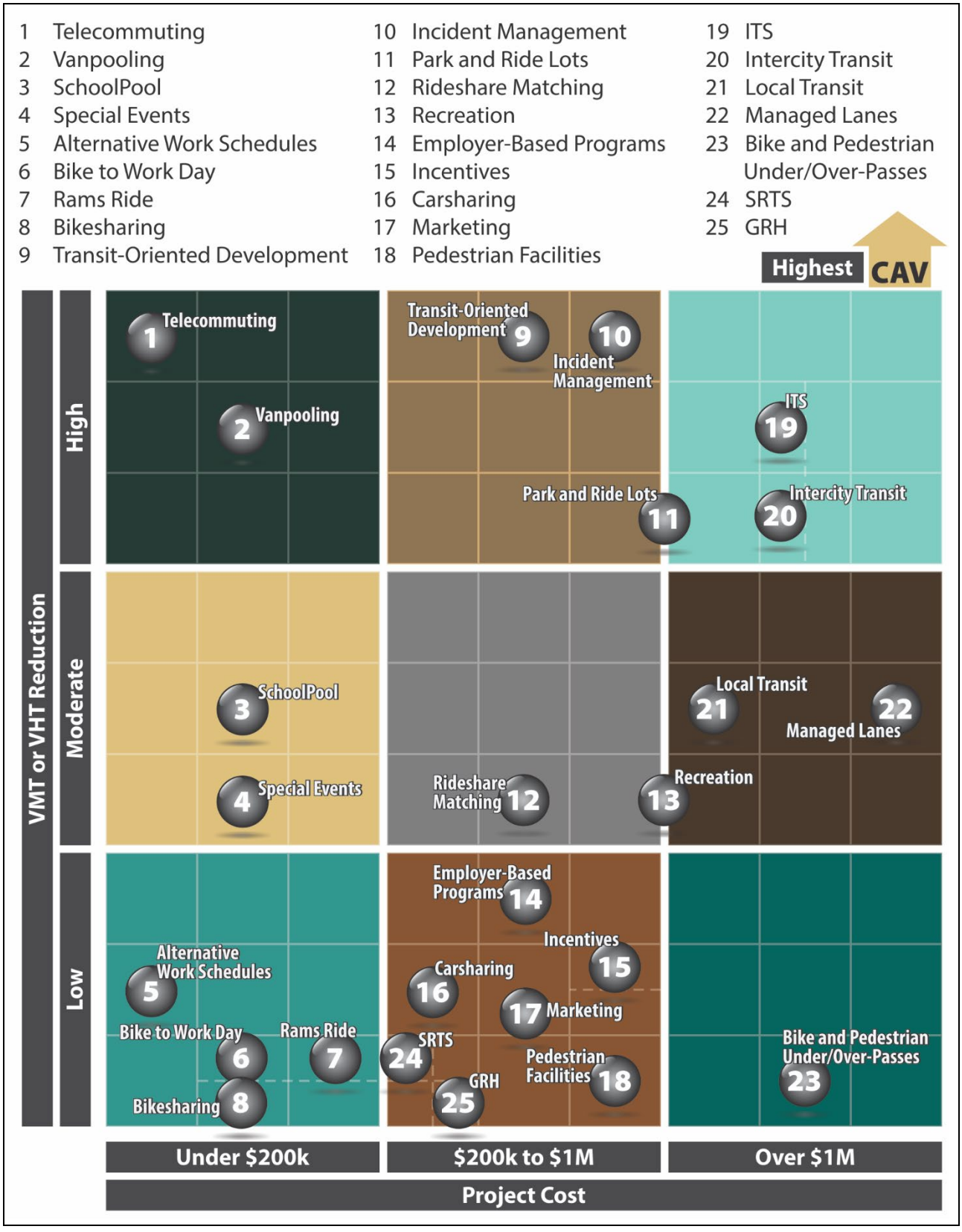
Asset lifespan does not alter the amount of VMT reduction that an investment will produce in one year, but does factor into cost effectiveness for the investment. If two TDM projects would each yield the same amount of annual VMT reduction for the same cost, but one will have benefits for twice as long as the other, the longer-lasting effects would yield a lower lifetime cost per VMT for that investment.

VIII.4. Cost Effectiveness Assessment of TDM Measures

The cost-effectiveness of any specific TDM project will depend on the scope of the project and the demographics and transportation of the surrounding transportation system, but types of TDM projects can be characterized by their general costs and effectiveness. This is done for the projects discussed in this report in **Figure VIII.2**, based on the costs and participation detailed earlier. Safety benefits – difficult to quantify – are not included in this evaluation.

In the array, projects with high potential for reducing VMT or delay (VHT) appear at the top, and those with less potential appear lower down. Those with minimal costs appear toward the left and those with higher costs appear to the right.

Figure VIII.2: Summary of Colorado TDM Cost Effectiveness



Off the Chart Effectiveness: RoadX

Note that the CDOT RoadX project is shown above the array, at the right-hand corner. The $20 million kick-start funding for this initiative puts it at the high end of the cost scale, but the potential benefits of automated and connected vehicles are far above anything else in the array. Billions of dollars are being invested in automated and connected vehicles by the private sector around the world, and CDOT's investment will facilitate the new technologies in Colorado. Automated and connected vehicles have the potential to reduce most crashes, greatly eliminating non-recurrent congestion, and improve traffic flow for recurring conditions as well, affecting all trip types, not just commuters.

Highly Effective, Low-Cost Strategies

Inside the array, two strategies appear in the left top corner. These are telecommuting and vanpooling. These attractive strategies may have limited expansion potential.

Telecommuting is suitable for some information-based jobs that can be handled at home, thereby eliminating commuting trips. Colorado (and especially Boulder) already has comparatively high telecommuting rates, compared with the rest of the nation. Each day worked at home saves a commuter round trip (e.g., 9.5 miles one-way in the Denver region), and an estimated 172,000 Coloradoans do this. Most costs for computers and Internet connection are internalized (paid) by the worker or the employer. CDOT has previously funded modest telecommuting encouragement project, and MPO rideshare programs promote this strategy at low cost. Improving broadband connectivity in underserved areas could increase telecommuting in rural areas.

Vanpooling is suitable for long commute trips where five or more workers share a similar trip origin, destination and schedule. This is a fairly rare combination, so the demand for vanpooling is limited, but where there is demand, the strategy is highly effective. DRCOG estimates that its vanpools reduced annual VMT by 6.63 million in 2014. Vanpools can be publicly subsidized or not. The users pay for most of the costs. MPO rideshare programs provide matching services and administer or contract out for van ownership, maintenance, repairs, and insurance.

Highly Effective, Moderate-Cost Strategies

This group of strategies includes Transit-Oriented Development, incident management, and park-and-ride lots.

Transit-Oriented Development (TOD) was discussed in this report under the name of TDM-Friendly Design Considerations. CDOT has previously funded a number of moderate-cost station area master plans as well as some specific TDM infrastructure at TODs in the Denver region, including Boulder. This is a partnership with private developers to create high-density mixed use development near light rail stations and potentially other transit-intensive locations. As a result, large numbers of residents have excellent transit service and do not need to own an automobile in the city. This strategy works only where there is robust transit service, so will have minimal applicability in smaller communities.

Incident Management efforts by CDOT include its I-70 Heavy Tow program, Motorist Safety Patrols, and other aspects of its Winter Driving Assistance program. CDOT's moderate investment in these efforts ($500,000 in FY2016, greatly increasing soon), yield huge reductions in travel delay (VHT) on I-70 and expanding to I-25 in northern and southern (central) Colorado.

Park-and-Ride Lots, depending on their size, can cost less or more than $1 million. At a ballpark cost of $6,000 per space, a lot with 150 spaces would cost $900,000. Larger lots would cost more. Properly located after appropriate study, these lots are highly used and each space represents a fairly long solo driver trip taken off the road by carpooling, vanpooling or transit. Each lot has a useful lifespan lasting a decade or more.

Highly Effective, Higher-Cost Strategies

This group of strategies includes Intelligent Transportation Systems and Intercity Transit.

In recent years, most CDOT investments in **Intelligent Transportation Systems** have averaged over $1 million in cost, and CDOT has a $5 million ITS budget for FY2017. Various ITS technology is found on most urban freeways and on major highways. Traffic cameras around the state are monitored at the CDOT Traffic Operations Center in Golden and can be viewed online in real time by the public. ITS improves incident response for all trip types (including truck freight and recreation traffic), not just commuter trips, thereby greatly reducing traffic delays (VHT).

Intercity Transit is currently a $5 million annual expenditure by CDOT, including the $3 million Bustang intercity bus services. These buses have the capacity to carry 51 passengers apiece and generally serve trips of 50 miles or more, so the annual VMT reductions add up quickly. All Bustang routes currently start or end in Denver, where RTD has a robust local transit system available for the rest of the trip. Local transit connections are an important consideration for where intercity transit service can be successful.

Moderately Effective, Low Cost Strategies

This group includes SchoolPool matching and Special Event transit.

SchoolPool Matching is highly successful in the Denver region. DRCOG estimates that 6,400 families who formed carpools in 2014 reduced VMT by 15.7 million. Dividing this by 39 weeks, and 4.8 days per week, as they do, yields a daily reduction of 83,900 VMT per day, half of which occurs during the morning rush hours. Without SchoolPool, each parent might make two roundtrips to school each day (there and back, morning and afternoon), thus making the one-way trip four times. This VMT reduction is accomplished for a very small cost by the Way to Go rideshare matching program. This strategy is most applicable in the Denver region, where a lot of school choice decisions result in longer than necessary school trips, averaging 7.8 miles one way. The potential benefits are less for smaller communities.

Special Event Transit, offered by Bustang and RTD responds to large numbers of people going to the same place at the same time, and thus experiences very high load factors. RTD runs 400 busloads of participants to the BolderBoulder running race, for example. These services usually occur on weekends, when the buses are not needed for weekday commute trips and might otherwise sit idle. RTD serves about 100 special events annually.

Moderately Effective, Moderate Cost Strategies

Regional Rideshare Matching has time-limited benefits, since the average carpool lasts about two years. DRCOG estimated that it achieved 536,000 new VMT reduction in 2014, and probably had a comparable amount of residual reduction from prior-year matches. Typically they are able to find compatible matches for about one out of every six people who register to find a carpool.

Moderately Effective, Higher-Cost Strategies

This group of strategies includes Recreation TDM, Local Transit services, and Express Lanes.

Recreation TDM, like special event transit, focuses on a large number of people going to the same place at the same time, such as heading from Denver to the mountain ski areas on weekends. They are also similar because both types of travel have a lot of participation by couples, families or groups already in carpools, rather than solo drivers. The CDOT annual $1 million contract with the I-70 Coalition to encourage TDM and trip time changes primarily for winter ski traffic provides alternate mode information and road condition information to help motorists avoid delay. As many as 6,000 hits a day have been recorded on their GoI70.com website. Working together as the I-70 Coalition, the mountain communities share ideas and leverage resources, as reflected in the extensive TDM efforts documented in **Appendix A** of this report.

Local Transit is highly successful in the Denver region and in the Intermountain Planning Region, together accounting for an estimated 89 percent of the state's transit trips, transit commuters, and annual operating costs. The state's other local transit systems serve 2,500 or fewer commuters daily or fewer, and six of these systems have annual operating costs of $1 million or more. In smaller communities, transit is not a TDM measure for congestion reduction, but instead a critical system for basic mobility.

Express Lanes are found in the Denver metro area and the Intermountain Planning Area (I-70 and SH 82). Managed lane projects cost many millions or even hundreds of millions of dollars, much of which can be attributed to roadway costs (more infrastructure than TDM). The Census estimates that about 30,000 commuters in the Denver region carpooled in vehicles with three or more occupants in 2015, including vanpoolers but not transit users. Some of these (HOV3+) commuters are able to use Express Lanes for free in the Denver region. The Express Lanes offer a travel time advantage for these travelers. Some commuters would be HOV3+ without this perk, and thus are not reducing their VMT. Others may participate in HOV3+ carpools for the purpose of receiving the travel time savings. Regardless of VMT reductions, Express Lanes provide reliable trip times and raise revenue for added capacity that otherwise might not be available.

Less Effective, Low Cost Strategies

This category of TDM strategies includes alternative work schedules, Bike to Work Day, bikesharing and Rams Route.

Alternative Work Schedules include several variations, of which the most effective is the 4-day, 40-hour schedule that eliminates one work day out of five each week, cutting commuting by 20 percent for program participants. A 9/80 schedule provides half the VMT reduction, and a variable work hours schedule provides no VMT reduction at all. These schedules may help commuters to avoid the busiest part of peak commuter traffic, slightly reducing VHT. Alternative work schedules reduce some congestion because work trips are dispersed at different times. Regional rideshare agencies and private employers promote these strategies at minimal cost to the public.

Bike to Work Day efforts including newly emerging Winter Bike to Work Day events, encourage non-riders to try bicycle commuting on one day of the year, hoping they will learn about the mode and decide to try biking to work more often. DRCOG reported about 32,000 participants in 2016 (and 25,300 in 2018), but about three quarters had participated previously (not new converts to biking), and a survey (in 2014) reported that only 60 percent of these would have been solo drivers if not biking. Despite the large turnout on Bike to Work Day, residual biking throughout the rest of the year resulting from the event is fairly minimal. Of the estimated 2.5 annual VMT reduction, most of it occurred on just the one day. Bike to Work Day is a fun event in cities and towns throughout Colorado. It will serve a useful educational role as the state strives for increased bicycling under the Colorado Pedals initiative that was announced in 2015.

Bikesharing (short-term bike rental) typically limits trips to 30 minutes or less and requires that the bike be picked up from and returned to designated stations, so it has minimal usefulness for ordinary commuter trips. Bikesharing offers particular relevance in transit-oriented developments, found mostly in the Denver area. Bikesharing is underway in a number of Colorado cities. CDOT has provided several modest grants to support Bikesharing programs. Denver B-Cycle reported about 1,000 uses per day, and 1,000 short trips adds up to minimal daily VMT. Any of these trips that are recreational, or just for exercise, may not reduce VMT at all. Nevertheless, Bikesharing can be a useful piece of the multimodal puzzle of choices that together facilitate people who do not own a car.

Rams Route is a CDOT Bustang service transporting mostly Colorado State University students to Denver on Friday, for weekend activities and events, and returning them to Fort Collins late on Sunday. The trip is fairly long and the bus occupancy is fairly high, making the service financially successful, but the amount of ridership is small and does not reduce peak period congestion. The service may actually induce travel, because without it the trips would not be made at all. The fact that it is used, for a given price, means that

it is meeting a market demand. This is an application discussed earlier under the topic of Schools and Universities.

Less Effective, Moderate Cost Strategies

This group of strategies includes Safe Routes to Schools, carsharing, guaranteed ride home, employer-based programs, incentives, marketing and pedestrian facilities.

The federal **Safe Routes to Schools** program pays for infrastructure improvements and educational programs that encouraging the use of active transportation (walking or bicycling) to school. About 130 recipients and over 500 schools across Colorado have benefitted from this program, both through improved safety and through increased physical exercise. The most recent program year, infrastructure grants averaged about $285,000. This program targets not the long school trips addressed by SchoolPool in Denver, but much shorter neighborhood trips generally less than a mile. It results in improved health and safety, with lessons that can be retained through adulthood, but minimal VMT reduction at the time of implementation.

Carsharing (short-term car rental) is similar to Bikesharing, except that it is more flexible with regard to vehicle pickup and drop-off locations, and it is more expensive than renting a bicycle. Carsharing is another piece of the multimodal puzzle facilitating city dwellers who do not own a vehicle, and is again useful in supporting
transit-oriented development, or for college students. It also helps reduce the number of parking spaces needed in urban areas. There are an estimated 500 carshare vehicles available to rent in Colorado. CDOT has awarded a few small grants to start non-profit carshare operations, but most carshare operators in Colorado now are for-profit rental car companies.

Guaranteed Ride Home is a perk offered to registered carpoolers, vanpoolers and RTD EcoPass holders as a safety net to assure them they will not be stranded in case of unforeseen circumstances. DRCOG reports that this effort is funded largely by employers who buy the transit passes. There were about 2,500 emergency rides paid for in 2014 and these taxicabs did not reduce any VMT. However, they helped encourage carpoolers, vanpoolers or transit riders to avoid solo driving.

Employer-based Programs are in some cases funded by DRCOG with CMAQ funds and are implemented by Transportation Management Associations or Transportation Management Organizations serving portions of the Denver metro area. Additionally, DRCOG has its own ongoing program for regionwide outreach including non-TMA areas. A number of these grant-funded programs have reported VMT reductions of one to two million over a two-year grant period. The effect of the programs may be similar to rideshare matching, where carpools last for an average of two years before dissolving, so continuing effort is needed to maintain ongoing trip reduction.

Incentives for carpooling, vanpooling and transit use are available from NFRMPO and the DRCOG Way to Go Program in the form of cash, gift cards and free or discounted transit passes. These types of incentives are also distributed by TMAs through employer-based programs as described above. Incentives are offered for a limited time period to encourage solo drivers to try alternate modes. The mode change may or may not continue after the incentives end. Recent TMA grant report indicate typical VMT reduction of about 1.5 million annual VMT, which equates to 240 days of 20-mile roundtrips by 300 employees.

Marketing Programs have been common in the Denver and Boulder areas for years, also undertaken in Fort Collins, Durango and Aspen. The Regional Air Quality Council for the Denver metro area has undertaken a number of clean air campaigns, especially targeting the summer ozone season. A number of these programs encourage participants to track and report their VMT reduction for a chance to win rewards (sometimes donated by local businesses).

Bicycle and Pedestrian Facilities often serve both modes at the same time, although some sidewalks are not meant for bikes and certainly bike lanes are not intended for pedestrians. Sidewalks, paths and bike lanes are provided by counties, cities, towns and private developers, and some improvements are funded by CDOYT, especially for State highways. Official CDOT policy calls for consideration of accommodating bikes and pedestrians whenever safely possible as part of roadway projects. CDOT funded bike and pedestrian facilities in recent years have averaged about $1 million for those without grade separations. These tend to be larger in scale than the SRTS safety projects that cost an average of $285,000. Again, walking and bicycling are suited for shorter trips (than auto, transit, carpools, etc.) so the potential VMT reduction from pedestrian and bicycle improvements can be somewhat limited. Denver-region bike trips average over three miles in length and walk trips average under a mile, so bike-oriented projects have a larger impact. These facilities offer important recreational opportunities as well, which is beneficial for quality of life.

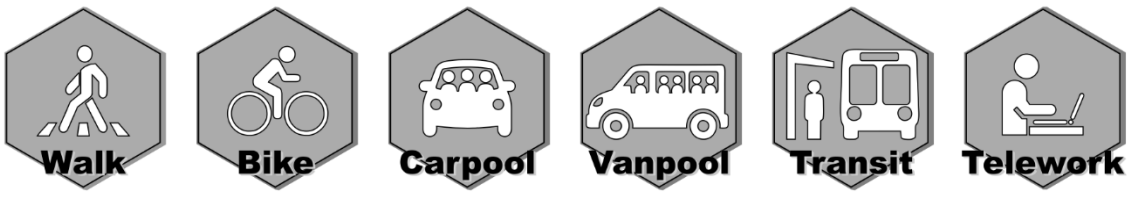
Less Effective, Higher-Cost Strategies

This category is comprised of **Bicycle and Pedestrian Overpasses and Underpasses**. These are typically provided where there is substantial non-motorized traffic demand in conflict with substantial traffic volume, resulting in a clear safety need. Recent bike/ped grade separations funded by CDOT have had an average cost of $3.3 million, making them clearly more expensive that projects without grade separations.

TDM Programs Not Shown in the Cost Effectiveness Array

Figure VIII.2 does not include several TDM approaches discussed earlier in this report. These include ***Market-Based Strategies***, for which the focus was the ***Road User Charge*** pilot program, ***Freight*** and ***Airports***. Not enough representative data were available for these strategies to make any meaningful conclusions about them as categories.

Additionally, ***carhailing*** (Uber, Lyft) is not evaluated for TDM cost effectiveness as this is a private endeavor and the needed cost and participation data are not readily available. Carhailing is like taxicab use, as it does not directly reduce any VMT from the trip being made. However, having this option available makes it more possible to have mobility without owning a vehicle, thus indirectly reducing other trips. CDOT is exploring potential partnerships with carhailing entities and so may be able to develop and analyze a pilot program within the next several years.



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- Intermountain TPR
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- Northwest TPR
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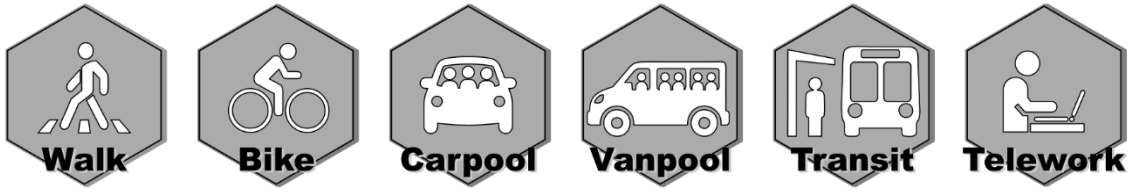


I-70 Coalition County and Municipal TDM Efforts for I-70 Mountain Corridor

I-70 Coalition Catalog of County and Municipal TDM Efforts for I-70 Mountain Corridor, January 2017	
Locality	**TDM Efforts**
Avon	Pedestrian improvements including improved street lighting, path lighting, flashing signalization at key intersections - 2014-2017 Added bike sharrows on key streets - 2014 Expanded free transit services - 2015 Began Free Spaces to Explore marketing to showcase Avon's free parking and that the Town is walkable and bikeable – 2016 Town will prepare a multi-modal and parking transportation plan in 2017 Expanding free transit service hours and area of service in 2017 Beaver Creek Blvd Redesign to improve walkability, safe bike lanes, reduced vehicle lanes to slow traffic, improve parking in 2017 ECO Transit conducting comprehensive review of transit services – 2017
Black Hawk	City website links to GoI70.com. Business Improvement District website links to GoI70.com. Operates the free, city-wide shuttle service Casino shuttles are available from the metro area for customers and employees at discounted rates.
Breckenridge	Offering expanded Breckenridge Free Ride transit service – 2015 & 2016 New service at Free Skier lot – 6am to 8am and 5pm to 11pm – 2016 Additional bus added to Airport Road bed base to serve employees – 2015 Additional bus added to the Warriors Mark area for employees/guests – 2015 Contracted service with Peak One Express to provide shuttle service to the Upper Warriors Mark bed base to serve residents and guests Additional bus added to Wellington neighborhood bed base to serve employees – 2016 Added a Trolley in the core of town to serve employees and guests (option for guests to leave their cars at home) – 2016 ZipCar available, reducing need for a car – Vehicles located in various locations throughout town including heavily utilized parking lots -2016 Installed brighter street lights in heavily utilized pedestrian areas – 2016 Increased maintenance of sidewalks (e.g. snow removal) - 2016 Commissioned an Urban Design, Parking, and Traffic Study – 2016 Implemented in-town paid parking to reduce congestion – 2016 Variable message sign on Hwy 9 includes I70 TDM messaging & local messaging to alert skiers when parking is full and prevent congestion from circling – 2012 Police Department distributes I-70 travel info-2012 to date Town shares I-70 travel info via social media-2013 to date Support distribution of I-70 travel info at town parking lots-2014 to date TDM Messaging (GoI70.com ads) on town bus fleet – 2010

I-70 Coalition County and Municipal TDM Efforts for I-70 Mountain Corridor (continued)

I-70 Coalition Catalog of County and Municipal TDM Efforts for I-70 Mountain Corridor, January 2017	
Locality	**TDM Efforts**
Clear Creek County	Shared summer permit applicant list with I-70 Coalition who then sent permittees TDM messaging for use in event communications - 2012 to date County requests summer permit applicants to encourage event carpooling Implemented the Prospector, intra-County transit with scheduled weekday service to Idaho Springs – 2016 County staff will consider DRCOG's new ridesharing software for events in 2017 Will consider TDM messaging for County website in 2017 Loveland Ski Area provides shuttle service to their employees
Dillon	Promotes GoI70.com on Hwy 6 digital sign-2015 to date Promote alternatives to using I-70 at peak times on town's digital sign-2016 to date
Eagle County	Shares GoI70's TDM messages via Twitter and Facebook, since 2010 Eagle County TV (ecoTV 18) channel airs I-70 Coalition PSA multiple times per day, 365 days per year, since 2010 Eagle County TV (ecoTV 18) channel airs CDOT camera feeds along I-70 between scheduled programming for situational awareness Free bus tickets for Eagle County Staff Promotes Trail (Bike) connectivity throughout the County Provides flexible work schedules/work from home Eagle County continues to pursue Eagle Valley Trail System to connect Summit, Garfield, and Eagle County ECO Transit conducting comprehensive review of transit services – 2017 Planned: I-70G Edwards Interchange upgrade Phase II project
Fraser	Implemented regional bus service, in partnership with Town of Winter Park and Winter Park Resort-2016 Link to the CDOT website on town website Provide message boards (both portable and permanent) with traffic and road conditions, in cooperation with our County Emergency Management
Frisco	Distributes Go I-70.com and CDOT info at Frisco Info Center, since 2010 Town Website highlights and links to GoI70.com, since 2010 Frisco Info Center helps guests download I-70 mobile app, since 2015 "Got Gas" Program encourages town employees to utilize greener, more fuel- efficient modes of transportation including but not limited to: carpooling, the Summit Stage bus system, walking, riding a bicycle, riding a scooter or driving a motorcycle. Have two bikes available at town hall that staff can use to go to meetings or get around town.

I-70 Coalition County and Municipal TDM Efforts for I-70 Mountain Corridor (continued)

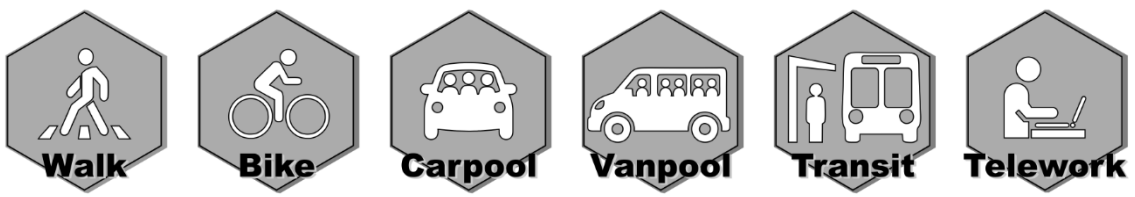
I-70 Coalition Catalog of County and Municipal TDM Efforts for I-70 Mountain Corridor, January 2017	
Locality	**TDM Efforts**
Golden	Bicycle Friendly Community designation Call and ride bus service to connect to light rail implemented jointly with RTD Street and trail construction to encourage bike use for work trips Additional bike parking provided at main bus stops and light rail Support bike education programs for school age youth Safe routes to school support Provides bike corral parking at events
Idaho Springs	Routinely posts information on city website and social media about transit, carpooling, etc. Bustang will began scheduled service to Idaho Springs starting January 2017 The City is underway with a $22 million initiative using RAMP funding that increases the walkability of the City with the reconstruction of Colorado Boulevard through the east/west length of the City. The road is being transformed from a State highway to a City street that will include sidewalks, curbs, storm water management, and lighting. This project is expected to be completed in the latter half of 2018. In partnership with the Clear Creek Greenway Authority, the City is underway with the creation of a Greenway through the length of the City. At the request of the City, CDOT has recently agreed to construct in 2017 bus slip lanes on the off-ramps of the I-70 Exit 240 interchange. City is acquiring property and doing conceptual design for a parking structure behind Tommyknockers and adjacent to I-70 exit 240. City is partnering with CDOT to plan and develop a transit center at I-70 Exit 240. City is preparing a downtown area parking study that will consider use of paid parking. In coordination with the Idaho Springs Chamber of Commerce, local businesses offer discounts to travelers during peak times on GoI70.com – since 2012 See Figure addendum for Idaho Springs planned efforts.
Jefferson County	Pre-tax commuter benefits – offers employees a pre-tax spending account up to $255/month for commuting expenses Participates in Bike to Work Day Investigating transit pass reimbursement program, possibly starting a TMO National Renewable Energy Lab reportedly has TDM efforts At least one private employer in county provides RTD EcoPasses.
Leadville	City website includes multiple links to GoI70.com to educate about I-70 congestion Strategies

I-70 Coalition County and Municipal TDM Efforts for I-70 Mountain Corridor (continued)

I-70 Coalition Catalog of County and Municipal TDM Efforts for I-70 Mountain Corridor, January 2017	
Locality	TDM Efforts
Silverthorne	Town website links to GoI70.com I-70 Coalition PSA posted on town website "Visitor's" section Town Rec Center offering Peak Time Deal on GoI70.com
Summit County	Operates the free, county-wide Summit Stage bus service New Summit Stage app provides real time bus info to travelers - 2016 SCTV runs I-70 Coalition's PSA multiple times per day, 365 days/yr. since 2009 Provision of 60 miles of paved pathway and bike lanes for bicycle commuting, recreation and travel by bike to trailheads and bus stops. Provides space at the Frisco Transportation Center for transfer to/from Greyhound, airport shuttles and other transportation providers, making it easier for visitors to choose a car-free vacation Improving rental car access at the Summit County Transportation Center making it easier for people to choose the bus or shuttles from DIA, reducing I-70 traffic See addendum to this Figure for planned future efforts.
Vail	Restricts truck traffic in Vail Village during specific weekend times. Operates an in-town bus service-2005 to present Discounted parking in Vail Parking Garage for vanpools, since 2006 Produces a "Winter Travel Information" piece-2006 to present Produces a Transportation and Parking Map that includes "Leave late" messaging Parking rate structure is built to stop charging after 4 hours in a day to encourage staying later, since 2008 CDOT Bustang service uses the Vail Transportation Center-2016 VailEventParking.com posts parking info, since 2011 Real time town parking info available at vail.gov, since 2008 Distributes TDM messaging (GoI70.com) at exit of Vail Parking Garage up to two times annually, since 2010 Distributes TDM messaging (GoI70.com) at the Vail Visitor's Center, since 2010 Shares GoI70.com social posts, since 2011 Installed two CDOT Kiosks in Vail Village -2016 Perform parking 1000/year intercept surveys to determine demographics and mode of travel The City formed a task force to reduce parking congestion
Winter Park	Implemented regional bus service, in partnership with Town of Winter Park and Winter Park Resort-2016

I-70 Coalition County and Municipal TDM Efforts for I-70 Mountain Corridor

I-70 Coalition Catalog of County and Municipal TDM Efforts for I-70 Mountain Corridor, January 2017	
Locality	TDM Efforts
Breckenridge	Under consideration: additional roundabouts, downtown parking structure, and Sidewalk improvements (possibly heated)
Idaho Springs	City plans to rebuild Miner Street between the Historic District and the Visitor Center/east commercial area that will improve the pedestrian connection between these areas – 2018 The City's first, full-time Community Development Planner hired in 2016 is kicking-off the process to update the City's Comprehensive Plan that will significantly increase the focus on mobility in the community and on I-70. City is partnering with DRCOG to kick-off in 2017 the Boomer Bond initiative that will include addressing the mobility needs of a growing older adult population in the community. City is working to develop street standards that will comprehensively address mobility. City is considering the option of a rubber-tired trolley or other type of shuttle to transport visitors between the downtown and remote parking areas, particularly during peak periods. City is in conversation with the Argo Mine and Mill regarding its conceptual plans for mixed use development of the site that may include a gondola connection through the City's open space to Central City. City is exploring with Central City the possibilities of other multi-modal connections with Idaho Springs along Central City Parkway, such as transit service or bike lanes.
Summit County	Plans to enhance the Summit County Transportation Center in Frisco into a true multi-modal facility with dedicated space for Bustang, Greyhound, airport shuttle pickup/drop off protected bike storage, easier access to local destinations from the site, traveler info and other amenities. Pursuing a regional bike connection to Lake County in partnership with Lake County, City of Leadville and Climax Mine owners to improve access for longer distance bike trips with development of the Fremont Pass extension of the Ten Mile multi-use trail.


Walk
Bike
Carpool
Vanpool
Transit
Telework

Transit Projects from the Statewide Transportation Improvement Program

NOT NECESSARILY CURRENT: The purpose of this appendix is to demonstrate the extent of Federal and State involvement in transit projects around Colorado. With so many projects in the list, plus the passage of time, the latest actual funding for transit projects has almost certainly changed since this list was compiled. For more recent information, please see:

https://www.codot.gov/business/budget/statewide-transportation-improvement-program-stip-reports-information

All costs include both federal funds and any state or local matching funds. The abbreviation $k means thousands of dollars.

104th Ave Park and Ride at Colorado - $680k
RTD Light Rail Track Replacement 19th & California - $2 million
I-25/US36 Bus on Shoulder Study - $348k
RFTA Glenwood Maintenance Facility Expansion - $600k
Bus Stop Improvements Boulder County - $106k
Greeley Evans Transit Regional Transfer Facility - $1.67 million
Estes Park CVB Visitor Center Transit Hub - $400k
San Miguel Lawson Hill Park-and-Ride - $1.5 million
NFRMPO - Johnstown Senior Center Vehicle Replacement - $80k

Statewide Metro Planning Program - $1.9 million annually
Section 5304 Pool Statewide and nonmetropolitan transportation planning - $400k annually

Section 5311 Pool Formula grants for rural areas - $11 million annually
SRC – Operating Section 5311 - $353k
Via Mobility Operating Section 5311 - $616k

Section 5316, Job Access Reverse Commute (JARC)
Mesa County JARC - $290k
Pueblo JARC - $30k
PPACG – JARC Pool - $233k
NFRMPO - JARC Pool - $165k

Section 5310 Formula grants for special needs of elderly and disabled - $550k annually
Large UZA Section 5310 $1.3 million annually
SRC - Operating Section 5310 - $813k
Douglas County - Operating Section 5310 - $472k
Douglas County - Mobility Management Section 5320 - $311k
Via Mobility - Mobility Management Section 5310 - $250k
SRC- Brokerage/Mobility Mgmt - $413k
CNDC - DRMAC Regional Mobility Mgmt - $250k
Easter Seals - Replace 1 Body on Chassis (BOC) Bus - $250k
SRC - Figurets - $46k
SRC - 1 Sedan - $45k
SRC - 5 Sedans - $140k
SRC - 2 replacement BOCs - $160k
SRC - Mobility Management - $288k
Broomfield - Support Software Dispatch - $30k
Easter Seals - Replacement Paratransit Bus - $56k
Developmental Pathways – Purchase BOC - $65k

CNDC - Brokerage - $41k
CNDC - Mobility Management - $250k
SRC - Replacement Vehicle - $58k
SRC - BOC Replacement - $41k
Broomfield - Two BOC Replacements - $99k
NFR Operation of Larimer County Mobility Program - $34k
NFR Access A Cab Para-transit Service $191k
SRC - 3 BOC Replacements and 1 Sedan $206k
SST6731.026 City of Lakewood - Operating - $46k

Section 5310 Small UZA – Approximately $1 million annually
Via Mobility - Call Center/Brokerage $878k
Via Mobility - Mobility Management - $563k
Via Mobility - Replace 3 BOC Para-transit Buses $168k
GVMPO Mesa County Bus - $406k

Section 5309 Statewide Pool – Capital investment grants, major projects - $150 million annually
Mesa County - 5309 Capital - $3 million
RTD Fixed Guideway Improvements, Upgrades and Maintenance - $13.5 million annually
Transit Vehicles: Purchase Vehicles - $160k annually
Pueblo - Transit Bus Purchase and Related Equipment - $325k
Pueblo – Para-transit Vehicle Purchase - $120k
Loveland Replacement Vehicles - $600k

Section 5307 Pool – Urbanized area formula grants – Approximately $74 million annually
PPACG-5307 Formula - $10.2 million
Mesa County - 5307 - Capital - $238k
Mesa County - 5307 - Operating - $3.8 million
RTD Preventative Maintenance: Transit – approx. $68 million annually
RTD Enhancements-ADA/PED/Bus Shelter – approx. $675k annually
Pueblo - Transit Operating Assistance - $3.6 million
Fort Collins: 3rd Party Contracting (Para-transit) - $1.05 million
NFR - Fort Collins, Loveland, Berthoud TMA - $3.95 million
NFR - Greeley Urbanized Areas - $2.69 million
NFR - Transfort Fixed Route Bus Service Including FLEX - $3.49 million
NFR Transfort Preventative Maintenance - $2.25 million
Greeley - GET Operating Assistance - $3.56 million
Greeley - GET ADA Operations - $400k
Greeley - GET Preventative Maintenance - $231k
Greeley - GET ADA Bus Purchase - $96k
Greeley - GET Demand Response Ops -$70k
Greeley - GET Fixed Route Ops - $1.56 million

Statewide Transit USC Section 5317 Pool
Pueblo - New Freedom Initiative -$30k
RTD New Freedom Pool - $875k
PPACG - New Freedom Pool - $142k
NFR - Transit USC 5317 Pool - $79k

DTD CMAQ Pool RTD MetroRide Service Expansion - $469k
Route L Service Expansion Boulder County - $642k
Route 324 Service Improvements Longmont - $459k
Intercity Bus Purchase - $752k
Superior Call N Ride - $120k

Broomfield Call N Ride - $104k
FLEX Route Extension Longmont to Boulder - Boulder - $450k

Aurora City Ctr Train/Traffic & Transportation Network Study $234k
Main Street Corridor Plan (Longmont) - $234k
N CapHill/Cheesman/CapHill/Colfax Urban Ctr Neigh Plan (Den) -$59k
SH7 Arterial BRT Station-Design, Connectivity, ROW-Bldr Cty $188k
Route 62: Central Park Station to 60th/Dahlia (Commerce Cty) - $529k

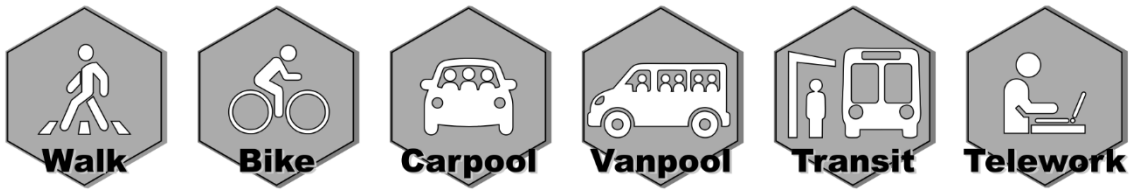
CMAQ NORTH FRONT RANGE POOL
Transfort CNG Buses Fort Collins $1.66 million
GET CNG Bus Replacement - Greeley - FY16 with FY17 - $2.16 million

DTD STP-Metro Pool - DRCOG Area
16th Street Mall Reconstruction Arapahoe to Lawrence $2.81 million
Regional BRT Feasibility Study - $1.17 million

Faster Transit and Rail Division Funds - $10.8 million annually
Division of Transit and Rail Administration - $65k
Mountain Metro 4 - Vanpool Replace – 16-passenger Vehicles - $138k
Summit Stage (R1) - 2 Bus Replacements - $920k
VanPool Replacement Vehicles - $80k
City of Greeley/City of Evans- 3 Fxd Rt Srvc Vhcle Rplcment - $150k
Silver Key Snr Srvs - Two Replacement accessible BOC - $40k
NFR GET Regional Transfer Facility - $3.56 million
Prowers County 2 Replacement BOC Vehicles - $12k
Amblicab BOC Replacements (2) - $31k
RFTA - Regional Bus Operating - $400k
City of Steamboat - Regional Bus Operating - $266k
La Plata County - Replacement BOC - $80k
City of Fort Collins - Flex Regional Operating - $600k
NFR - Match for 3 CMAQ Buses - $250k
RFTA - GMF Renovation and expansion - $750k
FASTER FY16 NECALG 1 ADA BOC - $152k
NFRMPO - Vanpool Vehicle Replacements - $360k
Neighbor to Neighbor 2 BOC Replacements - $21k
RTD - LTR Refurb (3) - $1 million
Mountain Express - Local Vehicle Replacement - $528k
Archuleta County - Local Replacement BOC - $139k
Montezuma County - Local Vehicle Replacement - $71k
NFR - Vanpool Replacements - $232k
Aspen - Vehicle Replacement - $450k
Aspen - 4 ADA BOC Replacements - $400k
Winter Park - ADA BOC Replacement - $100k
RFTA - 1 ADA Bus Replacement - $625k
RFTA - 1 Large Bus Replacement - $563k
Summit County - Local Large Bus Replacement - $465k
Winter Park - 35' Bus Replacement (2) - $900k
DTR Bustang Outrider Outreach - $105k
Mountain Metro – Para-transit Vehicle Replacement - $875k
Mountain Metro - Fixed Route Vehicle Replacements - $875k

FTA 5339 Grant Program - $1.75 million annually
Section 5329 (e) State Safety Oversight – approximately $650k annually
FasTracks Eagle P-3 Corridors (Gold and East Line) - $389 million
FasTracks Southeast Corridor Extension: Lincoln Ave to Rdgat - $103 million
FasTracks N Metro: Denver Union Station to Eastlake 124 Ave - $161.6 million

Senate Bill 228 TRANSIT Winter Park Express Rail Platform $3.2 million
Section 5339 Small UZA – approximately $1.2 million annually
Mesa County-GVT Bus Replacement 672 425 430 300 0
L 5339 M 168 106 108 75 0
GVT - Bus and Bus Facilities - $40k annually
Via- Four Replacement BOCs - $226k
Via - Mobility Management $251
Via - Operating $504k
Via - Travel Training - $209k
Via - Two BOC Rehabs - $23k
FTA 5339 Small UZA GVT CNG Fuel Equipment - $750k
NFR - GET Transit Maintenance Lift - $294
Greeley - GET Bus Replacements - $521k
RTD - Small UZA Vehicles $1.48 million
RTD Large UZA – approximately $4.4 million annually
Fort Collins Large UZA – approximately $5.5 million annually
NFR Shop Support Equipment - $89k
NFR - Transfort Facility Repair - $400k
NFR - Transfort Hardware/Software Upgrades - $75k
CMAQ Flex to FTA Estes Park CVB Visitor Center Transit Hub $397



Mobility as a Service (MaaS)

From Wikipedia, the free encyclopedia, accessed February 16, 2019

https://en.wikipedia.org/wiki/Mobility_as_a_service

(See website for the references supporting this article)

Mobility-as-a-Service (MaaS) describes a shift away from personally-owned modes of transportation and towards mobility solutions that are consumed as a service. This is enabled by combining transportation services from public and private transportation providers through a unified gateway that creates and manages the trip, which users can pay for with a single account. Users can pay per trip or a monthly fee for a limited distance. The key concept behind MaaS is to offer travelers mobility solutions based on their travel needs.

Travel planning typically begins in a journey planner. For example, a trip planner can show that the user can get from one destination to another by using a train/bus combination. The user can then choose their preferred trip based on cost, time, and convenience. At that point, any necessary bookings (e.g. calling a taxi, reserving a seat on a long-distance train) would be performed as a unit. It is expected that this service should allow roaming, that is, the same end-user app should work in different cities, without the user needing to become familiar with a new app or to sign up to new services.

Trend towards MaaS

The movement towards MaaS is fueled by a myriad of innovative new mobility service providers such as ride-sharing and e-hailing services, bike-sharing programs, and car-sharing services as well as on-demand "pop-up" bus services. On the other hand, the trend is motivated by the anticipation of self-driving cars, which puts into question the economic benefit of owning a personal car over using on-demand car services, which are widely expected to become significantly more affordable when cars can drive autonomously.

This shift is further enabled by improvements in the integration of multiple modes of transport into seamless trip chains, with bookings and payments managed collectively for all legs of the trip. In London, commuters may use a contactless payment bank card (or a dedicated travel card called an Oyster card) to pay for their travel. Between the multiple modes, trips, and payments, data is gathered and used to help people's journeys become more efficient.

In the government space, the same data allows for informed decision-making when considering improvements in regional transit systems. Public transport scheduling and the spending of consumer dollars can be justified by obtaining and analyzing data based around modern urban mobility trends.

According to the market research company Market Research Future, MaaS market is expected to grow with a compound annual growth rate of 36% between 2017 and 2023, reaching about $253.16 billion globally in 2023.

Short-term impact

Mobility-as-a-Service may cause a decline in car ownership. It is unclear whether it would reduce overall emissions, since the number of vehicle-miles-travelled (VMT) could be higher than is the case with private cars, depending on VMT for empty MaaS vehicles and the relative extent of ride-sharing. In general, if average vehicle occupancy for on-road time decreases, total VMT will increase.

MaaS could significantly increase the efficiency and utilization of transit providers that contribute to the overall transit network in a region. The predictions were validated by the Ubigo trial in Gothenburg during which many private cars were deregistered for the duration of the trial and utilization of existing transit services increased the efficiency of the overall network. Ultimately, a more efficient network coupled with new technology such as autonomous vehicles could significantly reduce the cost of public transit.

Benefits

MaaS has many benefits that can improve ridership habits, transit network efficiency, and societies that adopt MaaS as a viable means of transportation. According to Bureau of Transportation Statistics, the average cost to own and operate a vehicle is $8858 per year assuming 15k miles. MaaS would decrease costs to the user, improve utilization of MaaS transit providers, reduce city congestion as more users adopt MaaS as a main source of transit, and reduce emissions as more users rely on public transit components or electric, autonomous vehicles in a MaaS network.

MaaS equally has many benefits for the business world - understanding the Total Cost of Business Mobility could help travel decision makers in the corporate world save hundreds of thousands. By analyzing data and costs attributed to "business mobility" (e.g. vehicle rental costs, fuel costs, parking charges, train ticket admin fees and even the time taken to book a journey) businesses can make informed decisions about travel policy, fleet management and expense claims. Business MaaS companies such as Mobilleo suggest that in journey planning alone, it can take up to 9 steps before a simple travel arrangement is booked.

Payment methods

The concept assumes use through mobile app, although the concept can also be used for any type of payment (transit card, ticket, etc.). The concept is then broken down further into 2 payment models: a monthly subscription or a pay-as-you-go approach.

The Monthly subscription model assumes that enough users consume public transit services on a monthly basis to offer bundled transit service. Users pay a monthly fee and receive bundled transit services such as unlimited travel on urban public transport in addition to a fixed number of taxi kilometers. The monthly subscription model incorporates a well-funded commercially operated "MaaS Operator" which will purchase transport services in bulk and provide guarantees to users. In Hanover, Germany, the MaaS operator can purchase bulk transit services and act as the middleman through the product, Hannovermobil. It is not necessary that the operator include all forms of transport, but just enough to be able to provide reasonable guarantees. A monthly subscription will also provide enough funding for the MaaS operator to purchase significant enough transit services that it can use market power to achieve competitive prices. In particular, a MaaS operator may improve the problems of low utilization - e.g. in Helsinki, taxi drivers spend 75% of their working time waiting for a customer, and 50% of kilometers driven without generating revenue. A MaaS operator can solve this problem by guaranteeing a base salary to taxi drivers through existing employers.

The Pay-as-you-go model operates well in environments with a high number of “one-off” riders (tourists, transit networks in areas with high car adoption, etc.). Each leg of the booked trip (each train trip, taxi trip etc.) is priced separately and is set by the transport service provider. In this model, mobile applications would operate as search engines, seeking to draw all transport service providers into a single application, enabling users to avoid having to interact with multiple gateways in an attempt to assemble the most optimal trip. Many cities have cards which pay for intermodal public transport, including Vienna and Stuttgart but none yet include taxis/on-demand buses in the service.

Both models have similar requirements, such as trip planners to construct optimal trip chains, and technical and business relationships with transport service providers, (i.e. a taxi booking/payment API and e-ticketing, QR codes on urban buses and metros, etc.).

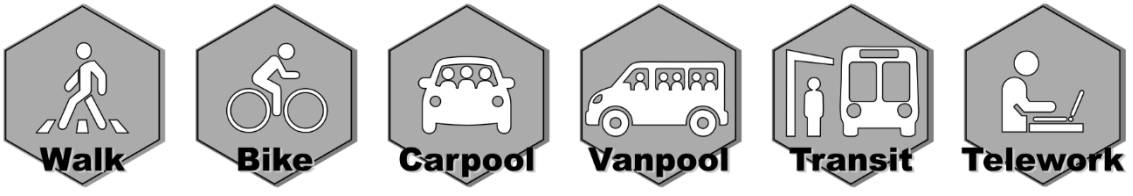
Impact of autonomous vehicles

As the development of the autonomous car accelerates, the company Uber has announced that it plans to transition its app to a fully autonomous service and aims to be cheaper than car ownership. Many automobile manufacturers and technology companies have announced plans or are rumored to develop autonomous vehicles, including Tesla, General Motors, Waymo, Apple, and Local Motors.

Autonomous vehicles could allow the public to use roads in low cost-per-mile, self-navigating vehicles to a preferred destination at a significantly lower cost than current taxi and ridesharing prices. The vehicles could have a large impact on the quality of life in urban areas and form a critical part of the future of transportation, while benefiting the traveler, the environment, and even other sectors such as healthcare.

Modelling scenarios were conducted on the deployment of shared autonomous vehicles on the city of Lisbon by PTV as part of the International Transport Forum's Corporate Partnership Board. This model shows that the positive impacts on transport networks and mobility in congested places will be realized to their greatest extent with increases in shared minibus/bus scale public transport in addition to ride-sharing; whereas autonomous taxis with individual passengers would see a large increase in vehicle kilometers and congestion.

In January 2016, the President of the United States, Barack Obama, secured funding to be used over the next ten years to support the development of autonomous vehicles.


Walk
Bike
Carpool
Vanpool
Transit
Telework

Colorado Department of Transportation Commuting Options Plan (2010)

Applicable Executive Orders

From Executive Order D0012 07:

"The DPA, in conjunction with GEO and DPHE, shall conduct a transportation efficiency audit, to be completed by December 1, 2007, to evaluate current state practices and make recommendations regarding:

a. Appropriate vehicle utilization rate and size of agency fleets;
b. Appropriate age and mileage for vehicle turnover to maximize performance and minimize maintenance costs and environmental impact;
c. Environmental costs and benefits of personal vehicle use and reimbursement policies;
d. Strategies for improving the overall efficiency of acquiring, using and maintaining all vehicles in the state fleet;
e. Cost effectiveness of car-sharing services;
f. Increasing opportunities for employee use of ride-sharing, walking and bicycling, and mass transit on business travel, and
g. Exploration of support for employee transit options."

From Executive Order D2010 006(excerpt pertaining specifically to commuting):

"Each agency shall develop a plan to improve the commuting options for its employees by December 31, 2010. The plans shall evaluate opportunities for: encouraging low fuel consumption or electric vehicles; making available electrical sources to recharge electric vehicles; encouraging use of mass transit or van/carpooling; and implementing or refining flexible work schedule or telecommuting policies."

Strategies:

- Encourage use of low-fuel consumption or electric vehicles. Make electrical sources available to recharge electric vehicles.
- Encourage employee knowledge regarding car-sharing programs that are available.
- Encourage alternative mode options, such as RTD EcoPass, FlexPass, or other programs for employee use.
- Encourage employee van/carpooling.
- Provide telecommuting (e.g., FlexPlace) or flexible work schedule options for employees to work remotely.

CDOT

Commuting Program Coordinator: Betsy Jacobsen
Size – staff: CDOT has 3,373 employees (as of December 17, 2010)
Location(s): Nearly half of CDOT employees work in the Denver Metro area (approximately 1,500).

Actions CDOT has taken:

Mass transit options: CDOT pays the cost of the Denver Regional Transportation District (RTD) EcoPass for all full-time, permanent employees in the Denver Metro area. The pass is good for all regular light rail and bus travel.

The Bicycle/Pedestrian/ Transportation Demand Management (TDM) Unit also provides education to employees regarding riding the bus, reading schedules and using the RTD trip planner.

Car-pooling: CDOT supports employee usage and participation in various van/carpool matching programs, including:

- The Denver Regional Council of Governments (DRCOG) RideArrangers program (Denver metro area). {Now called Way-to-Go]
- The Northern Front Range Metropolitan Planning Organization (NFRMPO) SmartTrips and VanGo programs (northern Colorado).
- The City of Colorado Springs Metro Rides program.

Biking to Work: CDOT sponsors and encourages statewide participation in Colorado's Bike to Work Day. In addition, CDOT's Bicycle/Pedestrian/TDM Unit provides educational opportunities for employees to learn safety and rules for riding. It also provides assistance in route selection and mapping.

Telecommuting: CDOT adopted a FlexPlace Procedural Directive (PD 1230.4) in 1995.

Single Occupant Travel Alternatives: Carpools, Video Conferencing, Telephone Meetings, and Other Alternatives to single occupant travel are encouraged in an In State Travel Procedural Directive (PD 90.1).

Flexible work schedules: CDOT adopted a FlexTime Procedural Directive (PD 1230.1) in 2006; four 10-hour days, 4.5 workdays consisting of four 9-hour days and one half-day of four hours, or 5/4 two week work period.

Microsoft Office Communicator and Live Meeting 2007: Installed on all employee computers on CDOT's servers to provide an option for employee communication via instant messaging and an online meeting venue option.

Communicating options such as car-sharing: Employees are made aware of the above options and policies via staff managers, occasional Public Announcements, and promotional flyers. CDOT also includes a section on its website regarding commuter options.

Tracking:

Employee participation numbers for RTD EcoPass program: 1,249 (as of October 14, 2010)

Employee participation numbers for van/carpools: Not currently tracked at CDOT.

Number of employees that request electrical connections for parking at work location: Not currently offered or requested.

Future/Ongoing Efforts:

Where can commuting options be enhanced?

- Use of new technology from MPO programs that provide better matching services for carpoolers.
- Better encouragement of carpooling options within CDOT.
- Enhanced encouragement benefits for van/carpoolers such as prioritized parking.
- More encouragement from management to participate in commuting options.
- Require secure, well-lighted bicycle parking at every building.
- Review the feasibility of including bicycles as part of the CDOT vehicle fleet for short trips such as going to meetings or connecting to transit stops. These could be particularly beneficial in some of the outlying areas where other options are less plentiful.

How will employees participate in this effort?

- Utilize their EcoPasses to travel more on bus and light rail.
- Track tele- and video-conferencing.
- Track FlexPlace or FlexTime employee participation numbers and determine VMT saved.
- Track trips and mileage when commuting by bike.

What employee education is / will be provided?

Increased education on commuting plan options

What are the expected results?

- An increased number of employees who use various commuting options
- A percentage of employees will incorporate commuter options into their non-working trips such as weekend errands and shopping; going to the airport, etc.

Actions the employees will take?

- Participate in mass-transit options.
- Participate in bicycle options.
- Participate in van/carpooling.
- Use or consider telecommuting and FlexPlace and/or FlexTime options.

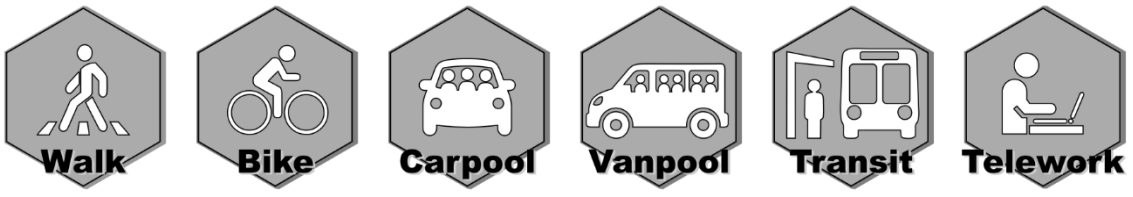
References:

Colorado Department of Transportation Procedural Directives:

- In State Travel, 90.1
- Flextime, 1230.1
- Flexplace, 1230.4
- Bike and Pedestrian, 1602.1

Colorado Department of Transportation Policy Directive:

- Bike and Pedestrian, 1602.0


Walk
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Vanpool
Transit
Telework