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DENVER REGIONAL COUNCIL OF GOVERNMENTS

2017 ANNUAL REPORT ON ROADWAY TRAFFIC CONGESTION IN THE DENVER REGION

October 2018

1. Introduction

On an average weekday in the Denver region in 2017, people made 15 million total trips, traveling 110 million miles:

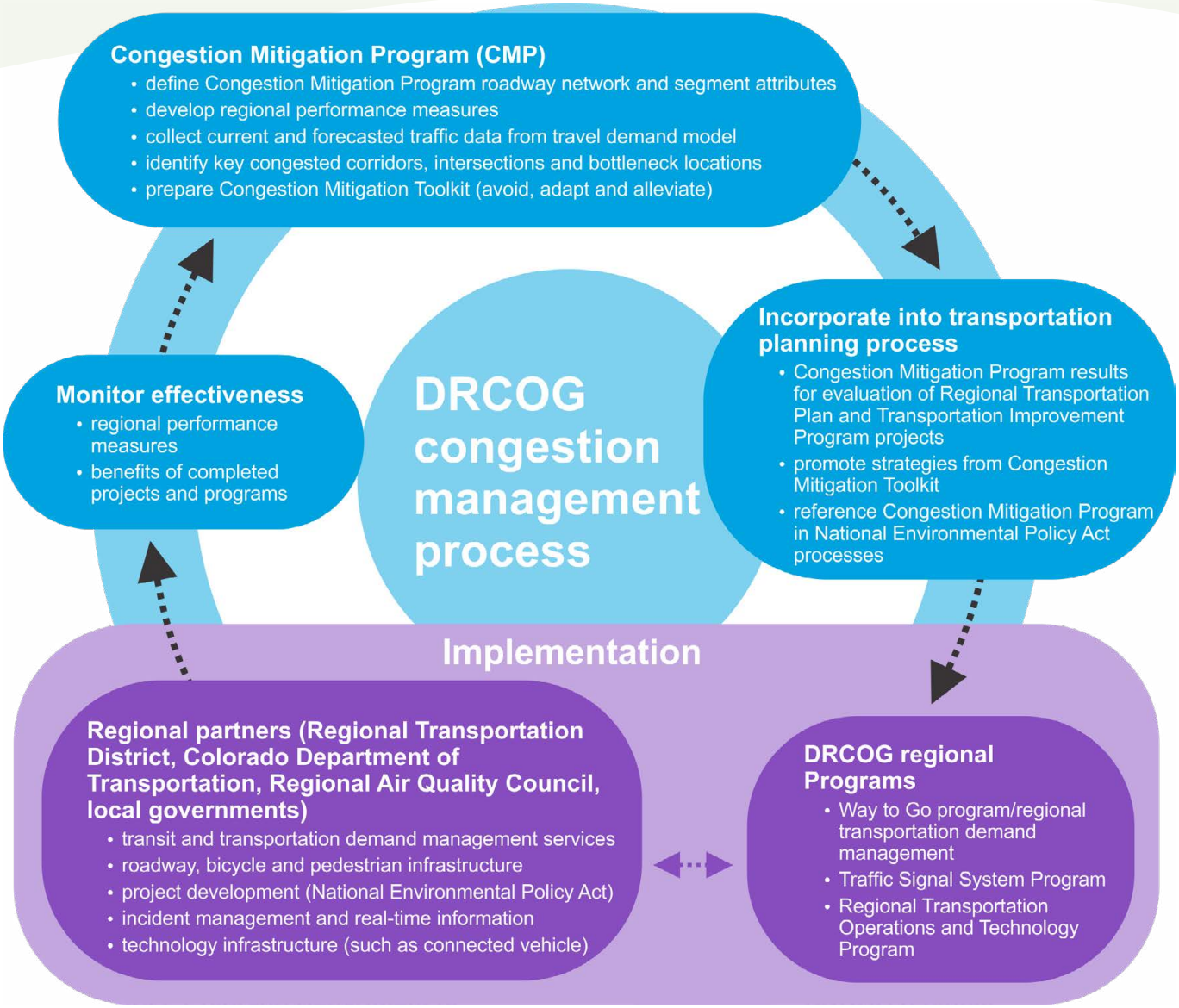
- 2 million trips were made by pedestrian and bicycling modes
- 13 million trips were made in motor vehicles (cars, trucks, buses).
    - 9 million motor vehicle trips were made (9 million drivers and 4 million passengers), traveling 83 million miles on the region's streets and highways.
    - More than 250,000 hours of extra congestion delay affected drivers, passengers and goods.

As population and employment grows, each of these measures is expected to increase significantly by 2040. The Denver Regional Council of Governments will continue to work with its partners to improve travel time reliability and **provide multiple mobility choices** within the region.

DRCOG administers a federally required congestion management process depicted in **Figure 1** with three key themes for improving mobility for people and businesses in the region:

- help people **adapt** to congestion
- help people **avoid** congestion
- **alleviate** congestion with capacity and operational projects, crash reduction efforts and improved incident management

Figure 1: DRCOG Congestion Management Process



The congestion management process includes the following activities to enable the effective management and operation of the region's transportation system:

- Maintain and update a database containing traffic volumes, capacity information, and congestion measures for the DRCOG designated Regional Roadway System.
- Coordinate the acquisition of traffic count, vehicle miles traveled (VMT) and multimodal facility use data.
- Identify measures used to evaluate proposed and completed roadway and multimodal projects.
- Report regional performance measure results for congestion, travel delay and travel time reliability.
- Identify key congested locations including roadway corridors, intersections and freeway bottlenecks.
- Monitor and compile privately provided congestion, delay and reliability measures (such as INRIX data).
- Use the congestion management process as a basis for defining a congestion-related purpose and need for corridor and project studies evaluated through the National Environmental Policy Act process.

- Establish a toolkit of construction, demand management, real-time information and operational strategies to address congestion, to be implemented by state, regional and local agencies.
- Monitor Transportation Improvement Program-funded projects to evaluate and summarize effectiveness in reducing congestion or providing travel options.

The congestion management process toolkit contains three categories of congestion mitigation strategies to address recurring and non-recurring congestion: active roadway management, transportation demand management and physical roadway capacity strategies. Each category contains eight types of strategies (see **Figure 2**). Some specific types of projects within each strategy have evolved since the toolkit was published in 2008, especially in relation to new technology projects and services. DRCOG and its planning partners closely monitor technological advances and legislative actions related to connected vehicles, infrastructure and automated vehicles.

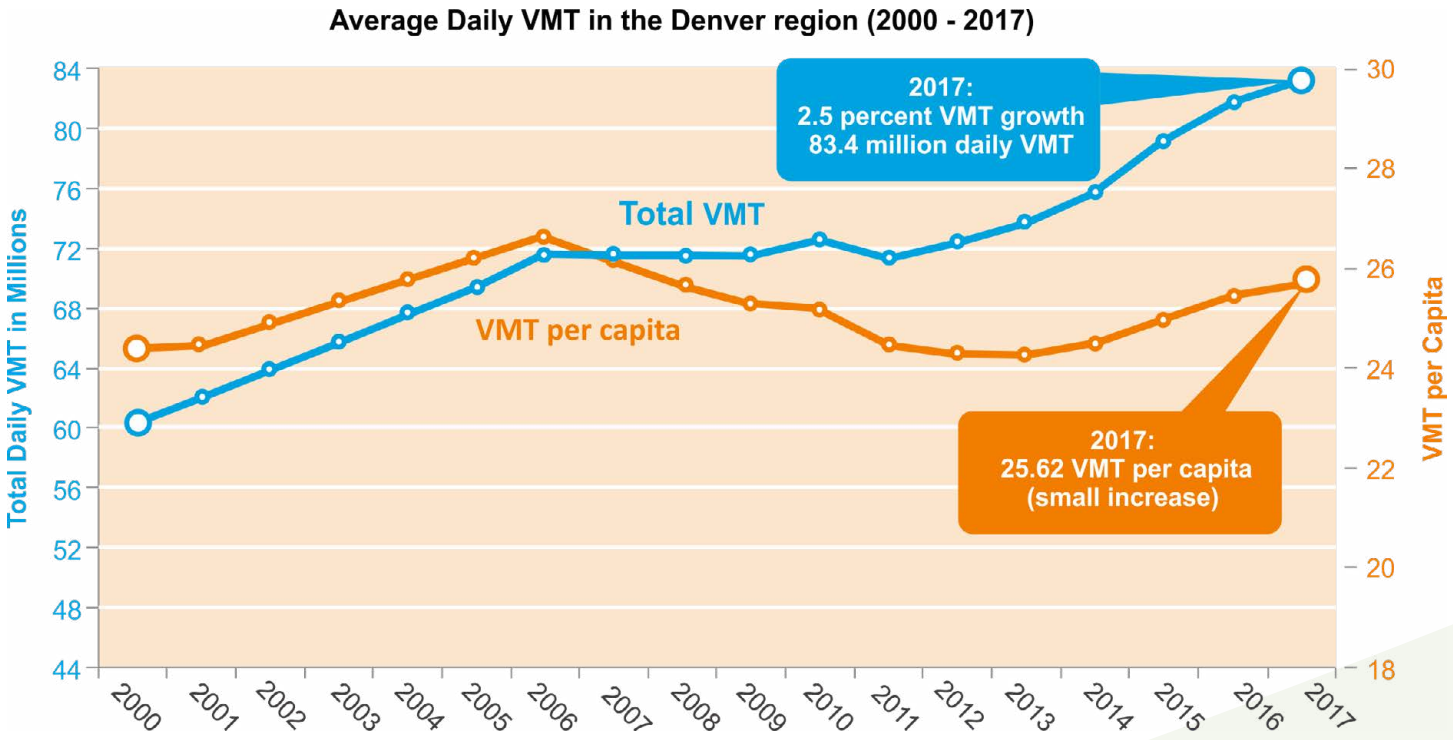
Figure 2: Congestion mitigation toolkit summary

2. Travel and VMT on a typical weekday

Quality of life in the Denver region depends greatly on mobility, the ease with which people and goods move from place to place. Reliable access to jobs, services, education and recreation by a variety of travel options is frequently cited as important by people throughout the region. Rapid household and economic growth poses a challenge to providing adequate mobility.

Every year, DRCOG staff estimates the annual change in the total VMT per day on all Denver region roadways to gain a better understanding of vehicle travel and congestion. Staff consolidates data from Federal Highway Administration annual reports, automated traffic recorders, the Colorado Department of Transportation's Highway Performance Monitoring System and local agency and toll highway traffic counts. **Figure 3** depicts average weekday VMT by all types of motor vehicles for the Denver region during the past 17 years.

Figure 3: Average daily VMT in the Denver Region (2000-2017)

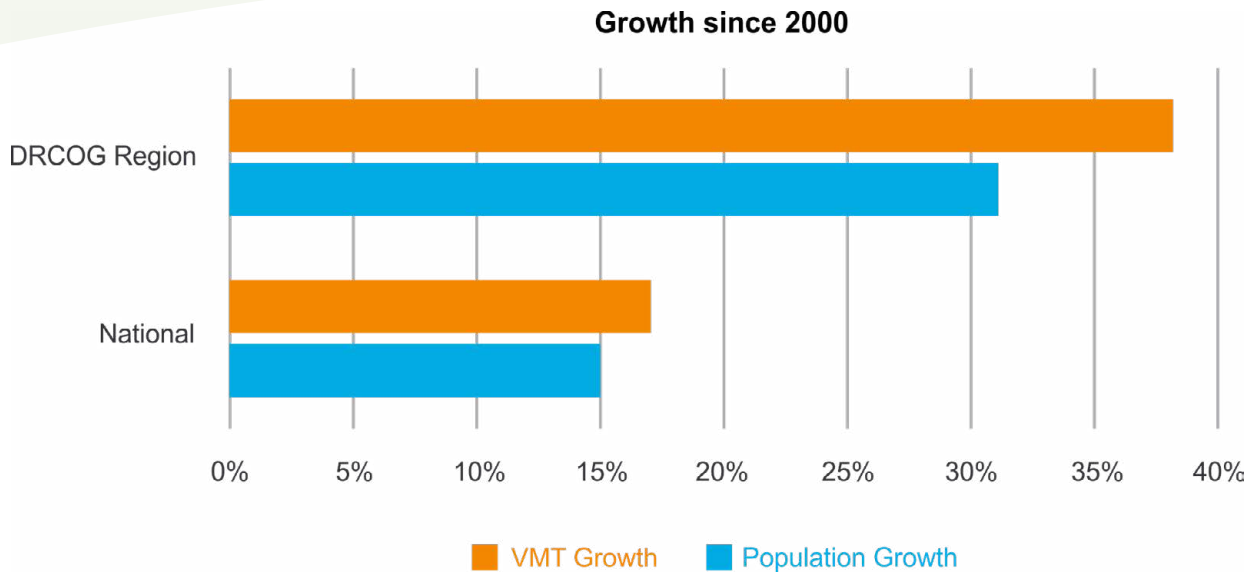


VMT increased by an estimated 2.5 percent in 2017, the fifth year in a row with substantial VMT growth. In 2017, the Denver region's roadways carried about 2 million more vehicle miles every day than in 2016. 2017 also represented the third year in a row in which VMT outpaced population growth, leading to an increase in VMT per capita. In 2017, the average resident of the Denver region drove about as much as they did in 2008, or about 1 mile less per day than in 2006. Much of the increase in VMT in the Denver region is related to economic growth. VMT implications of economic growth include:

- more people working
- skyrocketing housing prices which force more people to live further from workplaces
- more package deliveries
- construction activity (moving workers, equipment and materials to job sites)

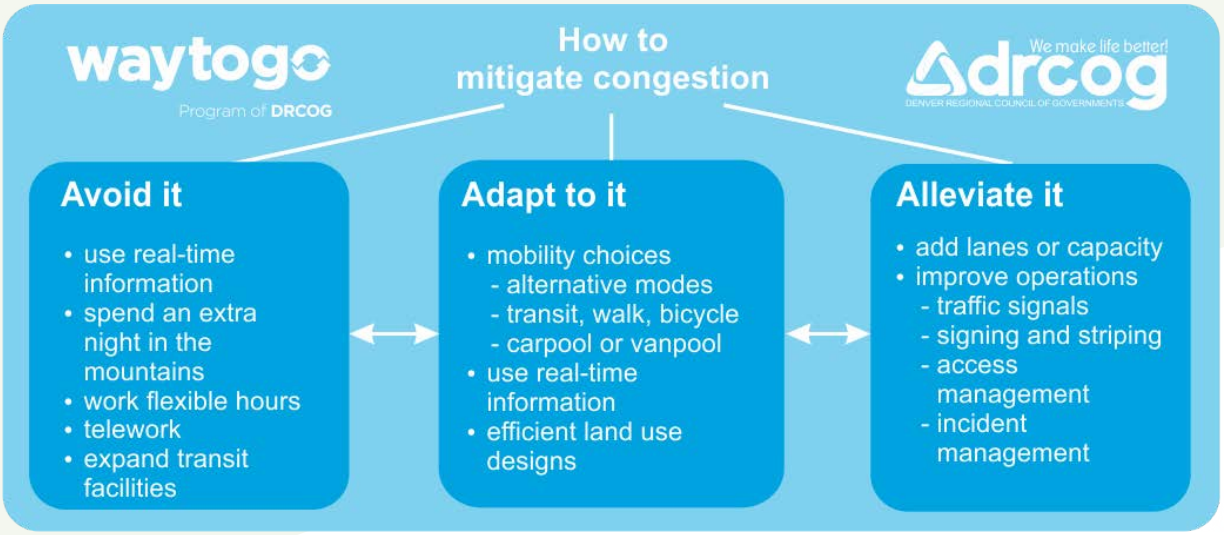
A similar trend has occurred nationwide, with VMT growth stalling through the late-2000s followed by a return to historical growth levels. The Denver region's historic population and VMT growth rates, however, have far exceeded the national average (see **Figure 4**).

Figure 4: VMT and population growth since 2000



The thriving economy makes the Denver region attractive to new residents and employers, but also presents a challenge to curbing VMT growth and its corresponding congestion. DRCOG's travel model forecasts VMT will increase to 111 million per day by 2040, 33 percent more than in 2017. However, to meet the shared regional goal, set in DRCOG's Metro Vision plan, of a 10 percent reduction in VMT per capita, the 2040 VMT should not exceed 99 million. Technological, economic and demographic traits have unpredictable implications for the future of vehicle travel and congestion. Progress toward meeting the Metro Vision goal depends on DRCOG and its partners helping people avoid and adapt to congestion by:

- providing and encouraging viable **mobility choices** (transit, walk, bicycle)
- creating opportunities for **shorter trips** (such as via mixed land use patterns)
- facilitating **carpool and vanpool** options (pre-organized and real time)
- encouraging **teleworking** and flexible work hours
- supporting and using the Way to Go (waytogo.org) **transportation demand management services** (a program of DRCOG and its partner transportation management associations)
- implementing projects and strategies to **reduce crashes** and associated congestion
- improving **real-time traveler information** regarding major incidents on roadways or rail transit, and regarding optional travel modes



3. Traffic congestion on major roadways

DRCOG maintains a database to monitor traffic congestion and performance measures for the 2,400-mile designated Regional Roadway System. The Regional Roadway System includes **major** streets, highways, freeways and tollways. It does not represent the entire roadway system. The congestion database identifies key attributes associated with roadway capacity, traffic volume and person volume (number of individuals) for each segment of the system.

Table 1 displays several measures for the Regional Roadway System, with 2040 estimates based on forecasts from the DRCOG regional travel demand model. The model assumes that an additional 1 million people will live in the Denver region by 2040, a 32 percent increase from 2017. The model incorporates the future demographic makeup of the population and future transportation facilities, transit lines and employment concentrations. However, it does not include speculative factors related to emerging technologies related to vehicles, roadways, fixed guideways and mobility services. See "Section 6. What will transportation be like in 2040?" for further consideration of emerging factors affecting congestion.

Figure 5 (pages 10-11) shows key severely congested locations in the Denver region and highlights congested corridors in 2017 and 2040. The data come from DRCOG's congestion database which integrates travel speeds from INRIX, hundreds of new traffic counts, crash data and updated roadway attributes to estimate congestion on the Regional Roadway System. The diverse types of roadways on the Regional Roadway System have daily traffic counts ranging from over 250,000 vehicles (350,000 people) on segments of freeways such as Interstate 25 to fewer than 3,000 vehicles per day (4,200 people) on rural connecting highways such as state Highway 79 north of Bennett and the Peak to Peak Highway (state Highway 119).

DRCOG staff used a congestion mobility score for each segment to determine which corridors were most congested. The score includes four metrics:

- **severity:** How bad does congestion get on the roadway during rush hour?
- **duration:** How many hours per day is the roadway congested?
- **magnitude:** How many people (traffic volume) are affected by congestion on the roadway?
- **reliability:** How often do crashes or incidents occur on the roadway?

DRCOG staff tallies scores from the four categories into a final total. Roads with a total congestion mobility score of 11 or higher in 2017 or 2040 are highlighted in Figure 5.

Table 1: Current and future congestion on the Regional Roadway System (freeways and arterials)

	2017		2040 (RTP)		Percent Change Between 2017 and 2040
	Average Weekday	Annual Total Estimate (1)	Average Weekday	Annual Total Estimate (1)	
Vehicle measures:					
Vehicle miles of travel	64,394,000	21,765,052,000	86,546,000	29,252,653,000	34%
Vehicle hours of travel	1,448,000	489,414,000	2,084,000	704,494,000	44%
Vehicle hours of delay	236,000	79,736,000	483,000	163,261,000	105%
Travel delay per driven registered vehicle (2)	7 minutes	42 hours	11 minutes	62 hours	48%
Travel delay per household	11 minutes	61 hours	16 minutes	89 hours	45%
Person measures:					
Person miles of travel	88,490,000	29,909,740,000	119,598,000	40,423,963,000	35%
Person hours of travel	1,994,000	673,928,000	2,831,000	956,815,000	42%
Person hours of delay	326000	110053000	663000	224003000	104%
Travel delay per resident	6 minutes	34 hours	9.2 minutes	52 hours	54%
Other:					
Percent of travel time in delayed conditions	16%	N/A	23%	N/A	43%
Travel time variation (peak vs. off-peak)	1.22	N/A	1.37	N/A	12%
Lane-miles of roads congested for three-plus hours	1547	N/A	2,820	N/A	82%
(percent of total lane miles)	22%	N/A	38%	N/A	N/A
Economic travel delay costs:					
Commercial vehicles (3)	$1,600,000	$541,100,000	$2,700,000	$909,900,000	68%
Passenger vehicle persons (3)	$3,300,000	$1,099,400,000	$5,600,000	$1,900,800,000	73%
Total cost of delay	$4,800,000	$1,640,500,000	$8,300,000	$2,810,700,000	71%
Transit and other regionwide measures:					
Total RTD transit boardings	337,000	N/A	603,000	N/A	79%
Rail transit boardings	101,500	N/A	218,000	N/A	115%
RTD Park-n-Ride parking space use (out of 31,225 spaces)	65%	N/A	N/A	N/A	N/A
Modeled bicycle and pedestrian trips	1,182,000	N/A	1,642,000	N/A	39%
Population	3,255,000	N/A	4,304,000	N/A	32%
Employment	1,769,000	N/A	2,384,000	N/A	35%
Traffic crashes (2015)	223	75,214	N/A	N/A	N/A

Sources: DRCOG Congestion Management Program Database, RTD Ridership Statistics, 2040 Regional Transportation Plan

Technical notes:

(1) Annual total estimate is "Average weekday" total multiplied by 338.

(2) Assumption of 1,895,700 driven registered vehicles in 2017 and 2,616,100 in 2040.

(3) Cost calculations incoporate $12 per hour per adult in car, $48.30 per hour per light commercial vehicle operator, and $71 per hour for heavy commercial.

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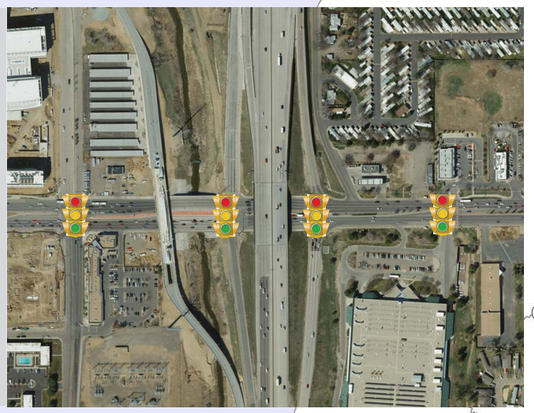
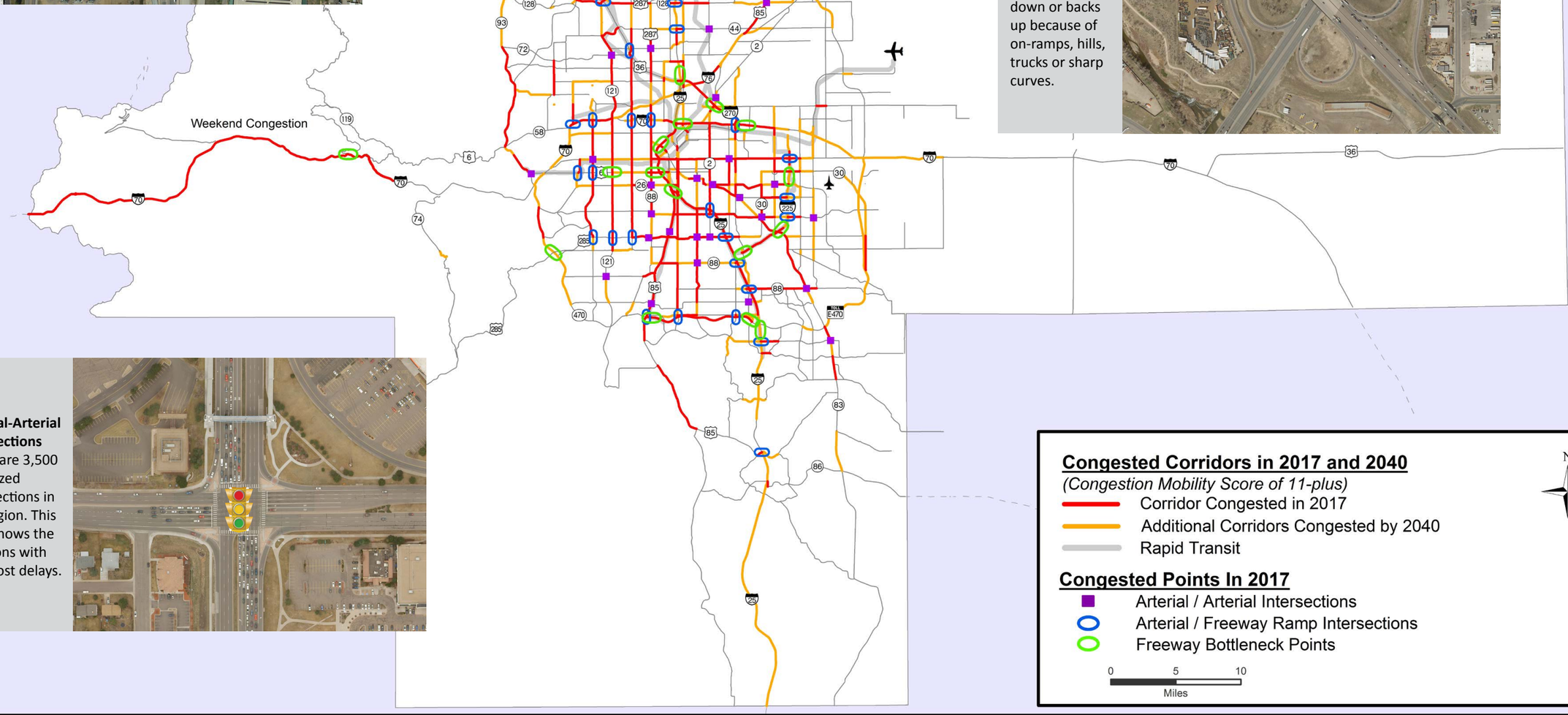
Figure 5: Key Congested Locations in 2017 and 2040

Segments with a Congestion Mobility Score 11 or higher

Arterial-Freeway Ramp Intersections
Extensive congestion occurs where arterial streets intersect with freeway ramps in a series of signalized intersections.



Freeway Bottleneck Points
Locations where traffic often slows down or backs up because of on-ramps, hills, trucks or sharp curves.



Arterial-Arterial Intersections
There are 3,500 signalized intersections in the region. This map shows the locations with the most delays.

Congested Corridors in 2017 and 2040
(Congestion Mobility Score of 11-plus)
- Corridor Congested in 2017
- Additional Corridors Congested by 2040
- Rapid Transit

Congested Points In 2017
- Arterial / Arterial Intersections
- Arterial / Freeway Ramp Intersections
- Freeway Bottleneck Points

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4. Performance of recently completed projects

During the past 10 years, more than 200 individual projects to address the effects of traffic congestion and provide mobility options have been completed through the DRCOG Transportation Improvement Program. **Table 2** presents a summary of **specific** projects and programs (which contained many subprojects) completed from 2008 through 2017 and their associated benefit levels. All projects align with strategies identified in the Congestion Mitigation Toolkit. The table does not include every project, nor the extremely important day-to-day operation and maintenance efforts of the transportation system throughout the region by CDOT, Regional Transportation District, local governments and first responders.

Traffic congestion measurements from national sources indicate minor worsening of the Denver region's overall congestion since 2008. Conditions are much less severe than if the projects referenced in Table 2 were not completed. Of course, in localized areas, at certain times of the day and key bottleneck locations, traffic congestion has worsened significantly, largely due to the population, employment and VMT of the booming Denver region increasing by nearly 20 percent over the last decade.

DRCOG's regional travel demand model was used specifically to evaluate the cumulative effect of roadway projects listed in Table 2. Results indicate the projects provide a total benefit reduction of about 18,500 hours of delay experienced by people every day, with people spending 6 percent less of their travel mileage in severely congested conditions.

Table 2: DRCOG region Transportation Improvement Program projects completed: 2008-2017

1. Active roadway management projects (more than $50 million)				
	Years	**Sponsor**	**Project description**	**Outcomes**
DRCOG Traffic Signal System Improvement Program	2008-ongoing	Multiple	• traffic signal system improvements for 20-plus communities and CDOT • implemented traffic signal coordination timing plans along 150 arterial street corridors (2,000-plus intersections)	• for a typical weekday, saved an average of 700 hours of person travel delay and 260 gallons of fuel per corridor • reduced air pollutant emissions due to less stop-and-go traffic
Regional intelligent transportation system "pool"	2008-2015	Multiple	• major expansion of communication infrastructure (fiber, dedicated short-range communications) • traffic and transportation control centers; cameras and monitors; message signs; travel time, bicycle and bus detection	• timely information provided from traffic centers via multiple methods to public to make decisions about when and where to travel • core efficient traffic signal operation • communication infrastructure will provide backbone for future connected vehicle implementation
Regional transportation operations "pool"	2016-ongoing	Multiple		
2. Transportation demand management/non-SOV travel choice projects				
Transit (more than $3 billion)**:**	**Years**	**Sponsor**	**Project description**	**Outcomes**
FasTracks rail and bus rapid transit corridors; Union Station	2008-ongoing	RTD	W Line; B Line; University of Colorado A Line; and U.S. Route 36 bus rapid transit operating; G Line, N Line, and Souteast Rail Extension nearing completion	• new FasTracks services provide a significant increase in reliable transit service, attracting former single-occupant vehicle drivers and stimulating higher density mixed-use developments adjacent to rapid transit stations • approximately 50,000 boardings per day
DRCOG "first commitment" to FasTracks		RTD	funding to RTD for FasTracks	
DRCOG "second commitment" to FasTracks	2010-ongoing	Multiple	approximately 20 local government and partner agency projects to support FasTracks in all corridors	
Bolt and Stampede bus service expansion in Boulder County	2012-ongoing	Boulder County	provided more service (shorter headways) and extended Stampede route length	• significant increase in ridership. • approximately 3,050 boardings per day.
Enhanced bus service (Lyons)	2012-ongoing	Boulder County	provided enhanced weekday and weekend service between Lyons and Boulder/Longmont	• significant increase in ridership on Boulder-Lyons leg • canceled the Lyons to Longmont service due to low ridership
South Thornton, West Adams County, Broomfield and Belleview Station Call-n-Rides	2008-ongoing	Multiple	new Call-n-Ride RTD service for the three communities and around Belleview Station	• moderate to significant increase in ridership • RTD continuing service • approximately 250 boardings per day
Golden circulator bus to W Line	2013-ongoing	Golden	new bus service between the West Corridor end-of-line station and central Golden	• significant increase in ridership • approximately 280 boardings per day
MetroRide service expansion	2016-ongoing	RTD	expanded the service hours and bus frequency for the MetroRide route	• significant increase in ridership. • 2,150 boardings per day

Table 2: DRCOG region Transportation Improvement Program projects completed: 2008-2017 (continued)

Transportation demand management (approximately $40 million)**:**				
RideArrangers transportation demand management program	2008-2011	DRCOG	programs: carpool, Schoolpool, vanpool, Bike to Work Day, Guaranteed Ride Home, Go-Tober, other events	• encourage and support commuting using non-SOVs • healthy and active transportation modes of travel
Way to Go transportation demand management program	2012-ongoing			
Regional transportation management program "pool"	2008-ongoing	Multiple	50-plus marketing or program projects, support for seven partner transportation management agencies, four small infrastructure projects	• encourage and support travel by non-SOVs • healthy and active transportation modes of travel
Bicycle and pedestrian (approximately $75 million)**:**				
Bicycle and pedestrian travelway facilities	2008-ongoing	Multiple	40-plus projects: off-street multiuse trails, bike lanes and sidewalks	• more than 20,000 non-SOV trips per day • healthy and active transportation modes of travel
Bicycle and pedestrian underpasses and overpasses	2008-ongoing	Multiple	seven projects: bridges over highways, tunnels under streets and access to transit stations	• more than 5,000 non-SOV trips per day; transit station bridges enabled additional transit trips • provide safer or more comfortable alternatives to crossing busy streets or railroad tracks
3. Roadway lanes and interchanges				
Freeways/ managed lanes (more than $800 million)**:**	**Year opened**	**Sponsor**	**Project description**	**Outcomes**
U.S. Route 36 toll express/bus rapid transit	2015	CDOT	added managed express lanes, auxiliary lanes and bus rapid transit stations in each direction	• major reduction in peak travel times (10-15 percent, source: INRIX); less stop-and-go traffic; greater reliability for express lane users and bus riders • significant increase in transit use. • constructed 17-mile U.S. 36 Bikeway
North I-25 interim managed lanes, U.S. Route 36 to 120th Avenue	2016	CDOT	added interim managed express lanes in each direction	• minor reduction in peak travel times (approximately 5 percent, source: INRIX) • less stop-and-go traffic; greater reliability for express lane users and bus riders
I-25, RidgeGate Parkway to County Line Road	2015	CDOT	added travel lane in each direction to balance lanes end-to-end	• moderate reduction in peak travel times (5-10 percent, source: INRIX); less stop-and-go traffic; included new multiuse trail
I-225, Parker Road to Second Avenue	2014	CDOT	widened the remaining four-lane section to six lanes	• major reductions in peak travel times (30-40 percent, source: INRIX), less stop-and-go traffic
I-70 mountain eastbound peak period shoulder lane	2015	CDOT	added eastbound shoulder managed lane that operates in limited peak periods	• major reduction in peak and weekend travel times (30-40 percent, source: INRIX); less stop-and-go traffic; greater reliability for express lane users
I-225 westbound approach to I-25 reconfiguration	2017	CDOT	installed barrier to prevent traffic from weaving from Tamarac Street ramp to southbound I-25	• major reduction in peak and off-peak travel times (15-20 percent, source: INRIX); less turbulence
I-70, Kipling Street to Wadsworth Boulevard reconfiguration	2017	CDOT	restriped to add eastbound auxiliary lane	• moderate reduction in peak travel times (5-10 percent, source: INRIX); less turbulence

Table 2: DRCOG region Transportation Improvement Program projects completed: 2008-2017 (continued)

Arterial streets (more than $200 million)**:**				
Arapahoe Road at I-25 (and at Yosemite Street)	2017	Arapahoe County	reconstructed interchange, added turn lanes and through-lanes	• post-project results not yet available. • reduced off-ramp queue backups onto southbound I-25
Colfax/17th avenues at I-225	2011	Aurora	added 17th Street ramps and access to/from Anschutz/Fitzsimons campus	• reduced average peak period delay by approximately 20 percent. • reduced off-ramp queue backups onto southbound I-225
Federal Boulevard at 92nd Avenue	2016	Westminster	turn lane and operational improvements	• reduced average peak period delay by approximately 20 percent
Foothills Parkway (State Highway 157), Valmont Road to State Highway 119	2015	Boulder	turn lane and operational improvements	• reduced average peak period delay by approximately 20 percent
Belleview Avenue at Quebec Street intersection	2015	Greenwood Village	turn lane and operational improvements	• reduced average peak period delay by approximately 20 percent • included new multiuse sidewalk
120th Avenue at Federal Boulevard intersection	2015	Westminster	turn lane and operational improvements	• reduced average peak period delay by approximately 20 percent • included several new multi-use trail connections
19th Street at U.S. Route 6 interchange	2017	Golden	constructed grade-separated bridge/interchange, added turn lanes	• eliminated stops and congestion delay for vehicles on U.S. Route 6 • included pedestrian and bicycle facilities and park space on the bridge structure/cover
Parker Road at Arapahoe Road interchange	2011	Arapahoe County	constructed grade-separated bridge/interchange, added turn lanes	• eliminated stops and congestion delay for vehicles on Parker Road (state Highway 83) • reduced overall delays on Arapahoe Road
32nd Avenue at Youngfield Road intersection area	2015	Wheat Ridge	turn lane and operational improvements	• reduced average peak period delay by approximately 30 percent • included new multiuse sidewalks
University Avenue at Arapahoe Road intersection	2008	Centennial	turn lane and operational improvements	• reduced average peak period delay by approximately 40 percent
Railroad crossings ($120 million)**:**				
Pecos Street grade separation over railroad	2011	Adams County	constructed roadway bridge and sidewalks over BNSF, Union Pacific and G Line and B Line railroad tracks	• eliminated railroad crossing crashes and approximately 15 freight railroad traffic stoppages per day on Pecos Street • will eliminate railroad crossing closures from G Line and B Line trains; included new multiuse sidewalk
Peoria Street grade separation over railroad/Smith Road	2015	Denver	constructed roadway bridge and sidewalks over Union Pacific and A Line railroad tracks	• eliminated railroad crossing crashes and approximately five freight railroad traffic stoppages on Peoria Street per day; eliminates more than 140 A Line railroad traffic stoppages per day • included new multiuse sidewalk
Wadsworth Boulevard grade separation under railroad/Grandview Avenue	2008	Arvada	constructed roadway bridge and sidewalks under Grandview Avenue and BNSF and G Line railroad tracks	• eliminated railroad crossing crashes and approximately six freight railroad traffic stoppages on Wadsworth Boulevard per day • will eliminate railroad crossing closures from G Line trains • included new multiuse sidewalk

5. Future regional performance targets

DRCOG's Metro Vision plan, adopted in 2017, identifies several regionwide foundational measures and long-range targets. Several targets are directly related to traffic congestion and mobility. Recently completed and future projects (Table 1) will help the region make progress toward the targets below.

Metro Vision targets (horizon year: 2040):

- number of annual traffic fatalities: fewer than 100 (272 in 2017)
- daily VMT per capita (on the Regional Roadway System): approximately 23 miles (10 percent decrease from 25.5)
- percent non-single-occupant vehicle mode share (to work per the U.S. Census Bureau): 35 percent (24 percent in 2018)
- daily person travel delay per capita (on the Regional Roadway System): fewer than 10 minutes (6 minutes in 2017)
- average peak versus off-peak travel time variation (on the Regional Roadway System): less than 1.30 (1.22 in 2017)

The federal Fixing America's Surface Transportation (FAST) Act also requires short-range targets for several performance measures related to traffic congestion. DRCOG must periodically report progress toward achievement of the targets.

Key congestion-related Federal Highway Administration target values approved by DRCOG: Transportation management area 2018 targets:

Transportation management area 2018 targets:

- number of fatalities: 259 (was 267 in 2017)
- number of serious injuries: 1,931 (was 1,932 in 2017)
- number of pedestrian and bicyclist fatalities and serious injuries: 339 (was 342 in 2017)

Denver-Aurora urbanized area 2020 targets:

- percent of non-SOV travel mode share to work: 24 percent (was 23.8 percent in 2016)
- annual hours of peak hour of excessive delay per capita on designated National Highway System: 52 (was 47.7 in 2016)

Transportation management area 2022 targets:

- interstate system travel time reliability: 81 percent (was 81.7 percent in 2016)
- non-interstate National Highway System travel time reliability: 64 percent (was 63.5 percent in 2016)
- interstate system truck travel time reliability index: 1.5 (was 1.45 in 2016)

Photo courtesy of the Colorado Department of Transportation.

6. What will transportation be like in 2040?

Whether 2040 seems far off or just around the corner, the pace of innovation guarantees that the region's overall transportation system will operate much differently in just 22 years. The future will bring additional travel modes, mobility services and safety systems influenced by technological advancement. Metro Vision alludes to the role of technology and innovation as essential to the connected multimodal region of the future:

> **Metro Vision:** Embrace new technologies and innovations. Car-sharing, ride-sharing and bike-sharing programs are already significant travel options within the region. Emerging transportation innovations, such as connected and driverless cars, have the potential to dramatically influence future personal mobility. Broader use of technology and other innovations (such as broadband, smartphones and trip-planning tools) has the potential to connect multimodal transportation system users to the information they need to manage travel, avoid and reduce congestion; optimizing available capacity.

Technology-based strategies have the potential to reduce traffic congestion and increase personal mobility in the region. Private, public and nonprofit organizations are developing applications to make choosing an efficient mode of travel more feasible. As a result, travelers and freight shippers can make better decisions with real-time information about how they travel (mode), when they travel (time), where and whether they travel (location), and which route they choose (path).

Beyond these applications, emerging technologies associated with connected and automated vehicles will change the way people and freight move around the region. Companies are developing and testing concepts for automated circulating vans or shuttles that could move people throughout the region efficiently. Although it is difficult to predict which technologies or providers will prevail, there is significant interest and momentum to capitalize on these opportunities. DRCOG will support and facilitate deployment of technology-related infrastructure and services that benefit the region.

Connected vehicles and automated vehicles are similar, but distinct, technologies with differing potential benefits and considerations. A key aspect of how they work together, however, is that more advanced automated vehicles will require most of the infrastructure components related to connected vehicle implementation.

Connected vehicles (CVs) include a set of technologies that allow a host of applications based on sharing data:

- Information shared among vehicles is known as **vehicle-to-vehicle** (V2V). For example, if a vehicle far ahead of you has turned on its wipers or fog lights, started skidding or deployed its airbag in a crash, it can send a message to your vehicle.

- Information shared between vehicles and roadway devices or with traffic management centers is known as **vehicle-to-infrastructure** (V2I). For example, your car can receive an alert of a tight curve, stopped traffic or bad weather conditions ahead. If a pedestrian has pushed the walk signal button, your vehicle can be alerted before you reach the crosswalk.

Federal research has demonstrated the safety, mobility and environmental benefits of connected vehicles. The prospect of fewer crashes prompted the National Highway Traffic Safety Administration to propose rules requiring vehicle-to-vehicle communications capabilities in new vehicles. Such rules will provide the foundation for applications to help drivers avoid crashes. Auto manufacturers already include many such applications in current vehicles.

Automated vehicles (AVs) include features that allow operation of a vehicle with varying levels of participation from a human, including full automation

with no in-vehicle human involvement. Facilities on which automated vehicles can operate range from typical general-purpose roadway lanes to fixed guideways which permit automated vehicles only. A key consideration for transportation planners is how to accommodate varying levels of automated vehicles in mixed traffic with non-automated vehicles. Many new vehicles already come equipped with automation assistance features such as lane-deviation steering and advanced braking.

The auto, transit and truck industries, technology companies and associated governmental entities will facilitate the advancement of connected vehicles and automated vehicles. The momentum for innovation represents an opportunity for local governments, CDOT and other transportation system operators to coordinate, fund and deploy an extensive connected vehicle environment across the region. Such an environment will include on-site field devices, communications infrastructure and back-end data collection, management and monitoring services.

DRCOG has administered a Regional Transportation Operations working group for 30-plus years. At its founding, the purpose of the group was to coordinate the implementation of connected traffic signal systems across the region. Recently, the group's activity has grown to include coordinating and prioritizing the implementation of intelligent transportation system technology projects. Such projects (including fiber installation, communication devices and transportation management centers) are implemented by CDOT, RTD, local governments and other agencies. Technological developments such as smartphone applications, car-, bicycle- and scooter-sharing services, and management of data obtained via roadside units have changed dramatically in the past few years and will continue to expand. The DRCOG Regional Transportation Operations working group will expand its efforts accordingly and with other new initiatives in the region addressing the benefits, implications, considerations and implementation of new technologies.

Both CDOT and the City and County of Denver have made commitments to develop a connected vehicle environment and implement applications that benefit the traveling public. The results of such commitments will help cars, trucks, buses, bicyclists and pedestrians talk to each other (vehicle-to-vehicle) and to roadways (vehicle-to-infrastructure). Applications will be implemented through such programs as CDOT's RoadX, and Smart Mobility Plan, as well as Denver's Advanced Transportation and Congestion Management Technologies Deployment grant from the U.S. Department of Transportation.

Mobility Choice Blueprint

In 2017 the Mobility Choice Blueprint Initiative partnership launched, with funding and participation by DRCOG, CDOT, RTD and the Denver Metro Chamber Leadership Foundation. Its mission is "to create a mobility vision for metro Denver driven by public and private sectors by developing key strategies to leverage our current assets using new technologies and provide an integrated system of the future for all."

Key activities for the Mobility Choice Blueprint Initiative are to:

- **Target options for connected mobility** such as transit, personal vehicles, for-profit mobility services, car-sharing, ride-sharing, bicycling and walking creating choice and moving the region to a convenient, integrated system. Maximizing the investment in the region's rail transit system is a top priority.
- **Identify public-private pilot projects**, cost estimates and joint-funding partnership opportunities.
- **Improve roadway reliability by using new technology** to support active traffic management, including express toll lanes, signal coordination, ramp metering, variable speed limits and lane control.
- **Implement public-private pilot projects,** demonstrating proof of concept, cost estimates and joint-funding partnerships.

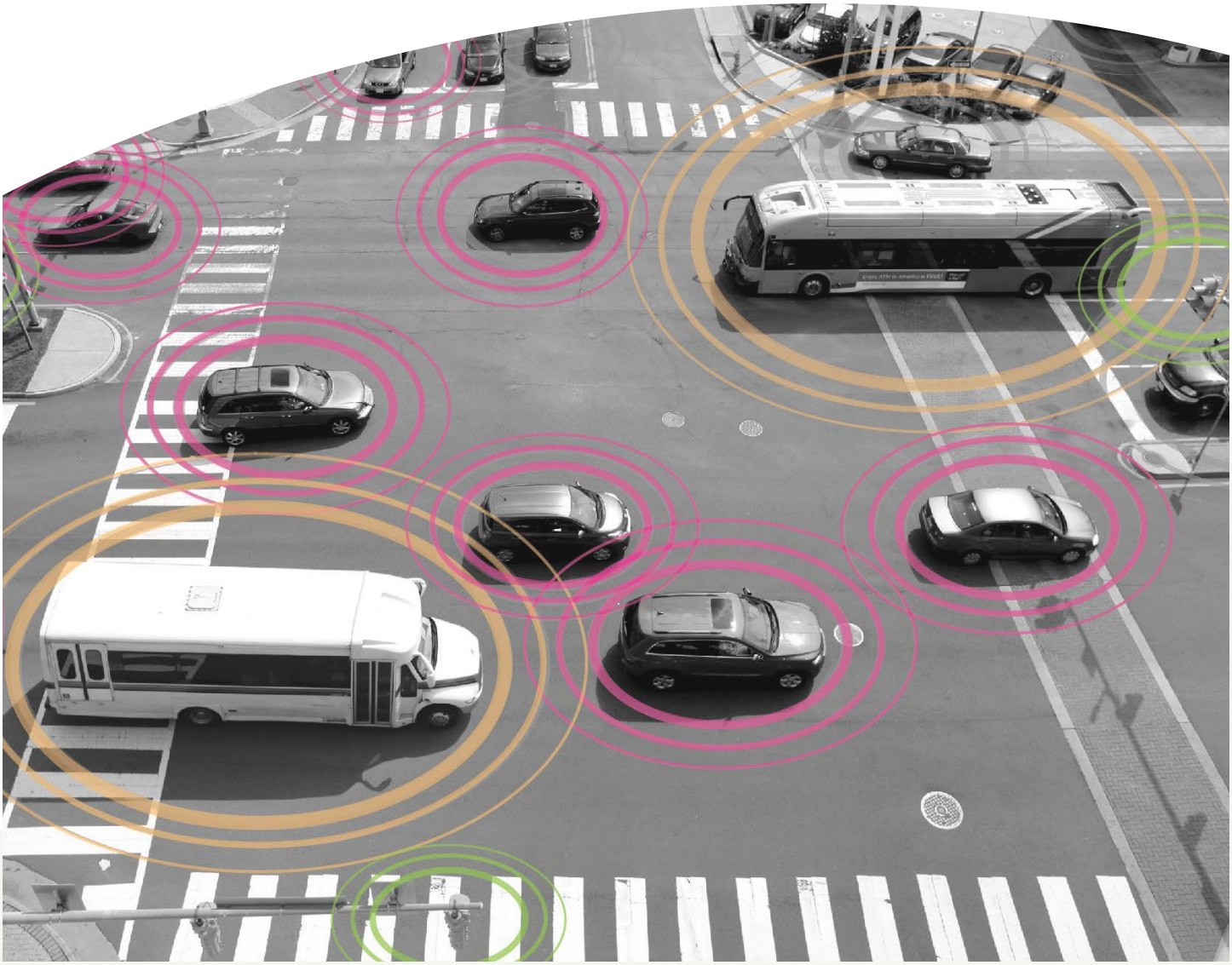
- **Hand-off implementation** of identified strategies to transportation agencies.

Connected and automated vehicles will improve personal mobility and travel options. However, much speculation surrounds their effect on reducing traffic congestion, such as:

- If the capacity for carrying more vehicles on the region's roadways increases, will such capacity result in latent or induced travel demand, increasing VMT and perpetuating vehicle congestion?
- How can drivers of connected vehicles or partially automated vehicles be discouraged from becoming less alert and overly dependent on such technology?
- Will more advanced automated vehicles within mixed travel lanes operate with shorter gaps between vehicles (increasing roadway vehicle capacity) or with longer gaps due to potential regulatory safety standards (decreasing capacity)?
- How can multipassenger travel options (such as shared rides and transit) be increased via automated vehicles?

The long-term effects, benefits, system requirements, maintenance and costs of such rapidly changing technologies requires transportation systems operators and planners to consider a range of potential outcomes and nimbly implement relevant solutions.

For more about connected and automated vehicles, see the FHWA website: its.dot.gov/cv_basics/index.htm



Visit DRCOG's partner agency websites for more information:

Colorado Department of Transportation
(codot.gov)

Regional Transportation District
(rtd-denver.com)

Colorado Department of Transportation Traveler Information
(cotrip.org)

For ways to avoid or adapt to congestion, visit Way to Go
(waytogo.org).

Preparation of this report has been financed in part through grants from the U.S. Department of Transportation, Federal Highway Administration and Federal Transit Administration. This report and others are available at DRCOG's congestion mitigation webpage (drcog.org/congestion).

Contact Robert Spotts, senior transportation/air quality planner, at rspotts@drcog.org for additional information regarding DRCOG's congestion mitigation program.

Photo courtesy of the Colorado Department of Transportation.

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TPO-RP-2017CONGESTION-18-10-18-v02