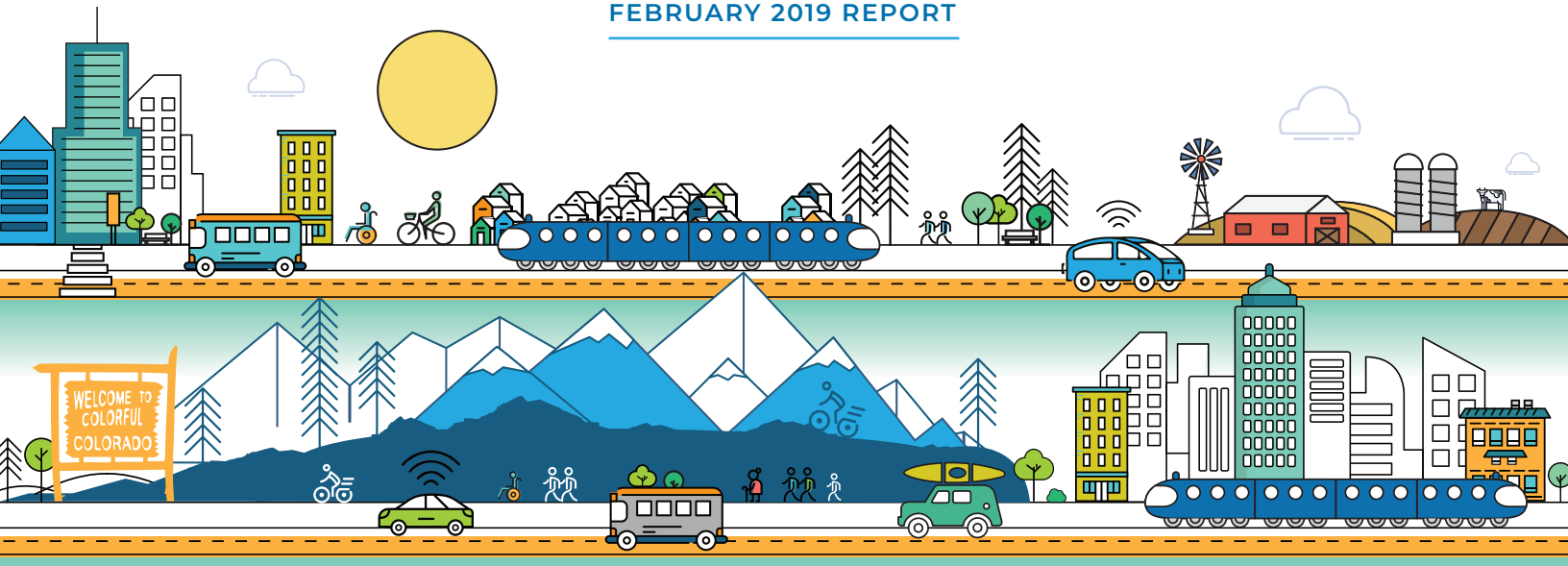
MOBILITY CHOICE BLUEPRINT

Together, we can decide how **new technologies** will **transform** the way we travel

FEBRUARY 2019 REPORT



DENVER METRO CHAMBER OF COMMERCE

drcog DENVER REGIONAL COUNCIL OF GOVERNMENTS

CDOT COLORADO Department of Transportation

RTD

The Mobility Choice Blueprint is a unique planning and funding partnership of the Denver Metro Chamber, DRCOG, CDOT, and RTD

A Message from the Mobility Choice Initiative Board

The disruptive forces of new transportation technologies, demographic changes, and shifting societal values are compelling us to change our vision of the Denver region's mobility future.

To define that future, the Colorado Department of Transportation (CDOT), the Denver Regional Council of Governments (DRCOG), and the Regional Transportation District (RTD), in partnership with the Denver Metro Chamber, listened to transportation and thought leaders from the public, private, and nonprofit sectors to jointly understand how to harness the benefits of these new technologies to enhance mobility.

What we learned is that a proactive, integrated approach to mobility will maximize the benefits of public and private investments in emerging technologies and improve service affordability, reliability, equity, and accessibility. Taking action now, rather than waiting for and reacting to unpredictable outcomes, will ensure technology is used to the benefit of all our citizens to save time and money and to lead safer, healthier, and less stressful lives employing transportation options that fit their individual lifestyles.

Over the past year, we broke down barriers and engaged in open, honest dialogue with each other and a diverse range of stakeholders to identify and confront the challenges we will face in preparing for transformative mobility technologies. As the region's transportation leaders and planners, we worked with these stakeholders to set the vision and created a "Blueprint" for advancing regional mobility that will benefit all residents and position the region to be economically competitive in the global market.

This Blueprint contains a list of recommendations and actions of strategic programs, policies, and pilot projects that we as cities, counties, and transportation agencies can accomplish together with our private sector partners now and into the foreseeable future.

We believe in the vision, but the conversation has just begun. New and emerging technologies will continue to challenge us to redefine our evolving transportation system. Through ongoing collaboration and cooperation, we will seek strategies that are unifying and that encourage a community-based vision for our mobility future.

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Vectra Bank

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Vice Chair, Associate Principal,
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** Appendices can be found at MobilityChoiceBlueprint** Study**.com*

TOPICS

Chapter 1
Our Mobility Future

The pace of innovation and adoption of new technologies that transport people and goods are disruptive forces that affect our quality of life.

Left unchecked, the new CASE (Connected, Automated, Shared, Electric) technologies have the potential to worsen conditions, rather than offering substantial opportunities for positive outcomes. For example:

Safety benefits of connected vehicles could be delayed due to mismatched systems.

New options of shared mobility could be restricted to the few instead of improving equitable access.

Vehicle automation could add traffic congestion instead of reducing it.

Vehicle electrification could improve air quality, but will impact traditional transportation revenue streams.

Amidst these technology changes, the Denver metropolitan region is **projected to grow to a population of 3.9 million in 2030, a growth of 800,000 from 2015[1].** Traditional expansion of the transportation system will be limited. According to Denver Regional Council of Governments (DRCOG), person hours of delay are expected to more than double between 2017 and 2040, to 663,000 hours per average weekday[2] . Our travel habits contribute to the congestion problem. About 75 percent of workers traveled alone to work in single-occupant vehicles (SOV) over the period 2012-2016, according to the American Community Survey.

The extent to which technology changes will help the Denver region attain its community goals (such as those defined in DRCOG's Metro Vision Plan) will depend on how the technologies are used to contribute to a cohesive, efficient, and equitable transportation system.

The Need for a Proactive Approach

Robin Chase, founder of Zip Car, has described "Heaven or Hell" scenarios for the future of mobility depending upon the actions of communities to address technological changes[3]. Because most Americans choose to drive alone, and with the economic convenience of connected and autonomous (driverless) vehicles, Ms. Chase projects a "Hell" scenario if we follow current trends. High numbers of personal autonomous vehicles could lead owners to place their vehicles into circulation to run errands, serve as a taxi, or wander the streets to avoid parking costs. Looking ahead to the point well into the future when driverless vehicles have achieved prevalence, more than 50% of the vehicles could have zero occupants in some urban areas, dramatically increasing congestion.

Using a more proactive approach to discourage zero-occupant vehicles and to incentivize shared mobility could lead to a mobility future producing more benefits as a "Heaven" scenario. Chase notes that ridesharing with others would reduce congestion; and car sharing could eliminate parking, freeing urban space for other uses and reducing out-of-pocket costs to users because they choose not to own a car. "Active transportation" networks enabled by technology improve access to transit with micromobility options like bikesharing and scooter sharing. When active transportation is used widely, a range of benefits follow, including healthier lifestyles, more equitable access, and lower environmental impacts.

The choices are clear. Our mobility future is before us. Coming together as residents, agencies, companies, and organizations to make the right transportation choices will define how we will build our communities and improve our quality of life. Colorado Department of Transportation (CDOT), DRCOG, and the Regional Transportation District (RTD) have a collective role to provide safe and effective transportation systems for the public. This reinforces a need to work collaboratively to enact policies that are proactive rather than reactive. The Mobility Choice Blueprint provides guidance to work together to build a better future for all.

ECONOMY: LOSING GROUND

$50 Million in Lost Benefits

If current trends continue, increased traffic congestion and uncoordinated adoption of new technologies could cost the region $50 million each year of unrealized benefits by 2030, despite gains in economic productivity, safety and accessibility.[a]

AIR QUALITY

Moderate Pollution

Gasoline and diesel powered vehicles are responsible for 33% of the state's greenhouse gas emissions, increasing their annual output of pollutants by 4.5 million metric tons over 2010 levels.[e]

SAFETY

Unchanged Crash Rates

By 2030, the region could experience a 50% increase in crashes (compared with 2015).[d]

26% Population Increase

Greater Denver Region Population:

2015: 3.1 MILLION TO 2030: 3.9 MILLION [1]

About Mobility Choice Initiative and the Blueprint

The Mobility Choice Initiative, comprising CDOT, DRCOG, RTD, and the Denver Metro Chamber with business community representatives, was formed to create a mobility vision for metro Denver and develop key strategies to leverage our current assets using new technologies and provide an integrated system of the future for all. The Mobility Choice Initiative Board engaged a technical team to create the Mobility Choice Blueprint.

The Mobility Choice Initiative is a deliberate attempt to prevent the above negative outcomes and, instead, recommend clearly identified strategies and structure to support coordination and collaboration among agencies while leveraging partnerships with the private sector, nonprofit organizations, and other regional stakeholders. Building upon the existing framework with amplified attention on new technology, transportation system adaptation, and coordination gives the metropolitan area a strategic advantage.

Purpose of the Mobility Choice Blueprint

The metropolitan transportation agencies will collaborate, in partnership with community, nonprofit, and business leaders, to carefully consider a range of effective and efficient solutions to the challenges and opportunities presented by emerging mobility technologies. We will provide recommendations to encourage the most effective technologies and approaches, improving mobility to meet our long-term goals of enhanced quality of life and increased economic vitality across the metropolitan region.

Emerging Mobility Systems

The new mobility technologies cover a wide spectrum affecting transportation systems. To put an order and contextual understanding to the new mobility diversity, the Blueprint categorizes the new mobility technologies into five emerging mobility systems. Chapter 6 provides a complete description of each system and identifies challenges and opportunities. This glossary, presented in alphabetical order within each respective emerging mobility system, defines the new technologies.

Glossary of Terms

Shared Mobility

BIKESHARING

A service in which bicycles are made available for shared use to individuals on a short term basis. Bicycles are located at docking stations, or dockless systems allow bicycles to be parked anywhere.

CAR SHARING

A service in which cars are made available for shared use to individuals on a short-term basis.

MICROMOBILITY

Micromobility refers to personal shared transportation devices like bicycles, mopeds, and e-scooters that are paid for through an app.

MICROTRANSIT

A privately or publically owned and operated shared transportation system that can offer fixed routes and schedules, as well as flexible routes and on-demand scheduling. The vehicles generally include vans and buses.

RIDEHAILING OR RIDESOURCING

Procuring a ride from a 'for-fare' driver pool accessible through an app-based platform.

RIDESHARING

Transportation in which multiple people share the same vehicle to arrive at a similar destination. Includes carpooling and ridehailing services that match passengers with similar routes into a single vehicle.

SCOOTER SHARING

Similar to bikesharing, but the mode of transport is electric scooter. Electric scooter sharing can be docked or dockless systems.

SHARED MOBILITY

Shared mobility represents the wide range of transportation options involving fleet ownership or fleet operation of various modes of transportation. It includes public transit; taxis and limos; bikesharing; carsharing; ridesharing; ridesourcing or ride-hailing; scooter sharing; shuttle services and microtransit; jitneys and dollar vans; and more.

TRANSPORTATION NETWORK COMPANIES (TNC)

TNCs operate ridehailing services.

Vehicle Technology

AUTOMATED VEHICLES

Vehicles with automated driver assistance features, up to and including driverless vehicles. The Society of Automotive Engineers (SAE) has a classification scheme that categorizes automated vehicles into five levels.

CONNECTED VEHICLES

Vehicles with the capacity to communicate with other vehicles and infrastructure through interoperable networked wireless communications.

V2I

Vehicles that are connected by smart technologies to infrastructure (I)

V2V

Vehicles that are connected by smart technologies to other vehicles (V)

V2X

Passing of information from a vehicle to any entity (X) that may affect the vehicle, and vice versa. Includes V2I and V2V.

Transportation Systems Optimization

ADAPTIVE TRAFFIC SIGNALS

Continuously monitors arterial traffic conditions and the queuing at intersections and dynamically adjusts the signal timing to optimize one or more operational objectives, such as minimize overall delays.

ADAPTIVE RAMP METERING

Deploys traffic signal(s) on freeway ramps to dynamically control the rate vehicles enter a freeway. This smoothes the flow of traffic onto the mainline, efficiently using of existing freeway capacity.

BIG DATA

Datasets from a variety of public and private sources that are so large or complex that traditional data processing application software is inadequate to deal with them.

SMART PARKING

A parking system that uses parking occupancy sensors to provide information to users.

TRAFFIC MANAGEMENT CENTERS

Traffic management centers collect and disseminate data on weather, roadway, and traffic conditions to manage traffic congestion and to direct incident response.

TRANSIT SIGNAL PRIORITIZATION (TSP)

Adjusts traffic signal green and red times if possible as buses approach to improve bus travel time and reliability.

Travel Information and Payment

INTERMODAL TRIP PLANNER APP

An app that melds multiple modes of transportation, allowing commuters to find the fastest, cheapest, and greenest routes to their destinations. Similar to Google Maps, but includes additional travel options such as bikeshare, carshare, microtransit, etc.

MOBILE TRANSIT APP

An app that allows users to see real-time arrival information for transit services. Could evolve to include all forms of on-demand/scheduled transport in a unified format.

MOBILITY AS A SERVICE

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 (single trip Mobility as a Service program) or a monthly fee for a limited distance (subscription Mobility as a Service program).

MOBILE TRAVEL INCENTIVES APP

A trip planning and transportation demand management app that connects users with multiple options for commuting using a leaderboard to encourage more carpooling, biking, etc. Oftentimes the apps are connected to employer incentive programs, allowing users to track commuting behavior and receive benefits from their employer.

TRANSIT MOBILE TICKETING/PAYMENT

An app that allows transit riders to pay for fares online and use their phones to present proof of fare upon boarding. Could evolve to include all forms of fare-based transport in a unified payment platform.

Freight and Delivery

3D E-COMMERCE

A retailing system that can take custom orders for 3D printed items, print them, and have them sent out for delivery or picked up by the customer. Could evolve to printing at other commercial and residential locations to include physical products, food, and other consumable products.

COURIER NETWORK SERVICES APP

An app that allows customers to request pickup or delivery of goods by a local courier. Customers and couriers use the mobile app to interact and exchange payment. Concept is similar to ridehailing, but provides a different service.

DRIVERLESS FREIGHT/ PACKAGE DELIVERY

Automated (driverless) vehicles delivering packages, food, or other goods.

DRONE FREIGHT/ PACKAGE DELIVERY

Delivery by an unmanned aerial vehicle or drone of packages, food, or other goods.

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TOPICS

» APPROACH

» HUMAN EXPERIENCE

» VISION, THEMES & OUTCOMES

Chapter 2

Toward a Collaborative, Regional, and Integrated Approach

The Blueprint represents a coordinated strategy for how we leverage emerging technologies to enable more accessible and effective transportation mobility choices that enhance the quality of our social, cultural, and economic life now and in the future.

The Blueprint represents a unique approach to planning for connected, automated, shared, and electric transportation technologies in three important ways. It is a **collaborative** effort of all three sponsoring transportation agencies and the Denver Metro Chamber that have equal roles in the process - and they have engaged other stakeholders and the general public in the discussion. It represents a truly **regional** approach by focusing on actions that benefit from regional coordination and to support efforts in all of the region's 50+ cities and counties and more than 3 million residents. Finally, the Blueprint recommendations seek an **integrated** human experience with the inevitable introduction of new technologies to improve mobility and livability for all.

Collaborative

The Blueprint conversation started with the Mobility Choice Board at the Denver Metro Chamber and was joined by CDOT, DRCOG, and RTD.

Blueprint Process

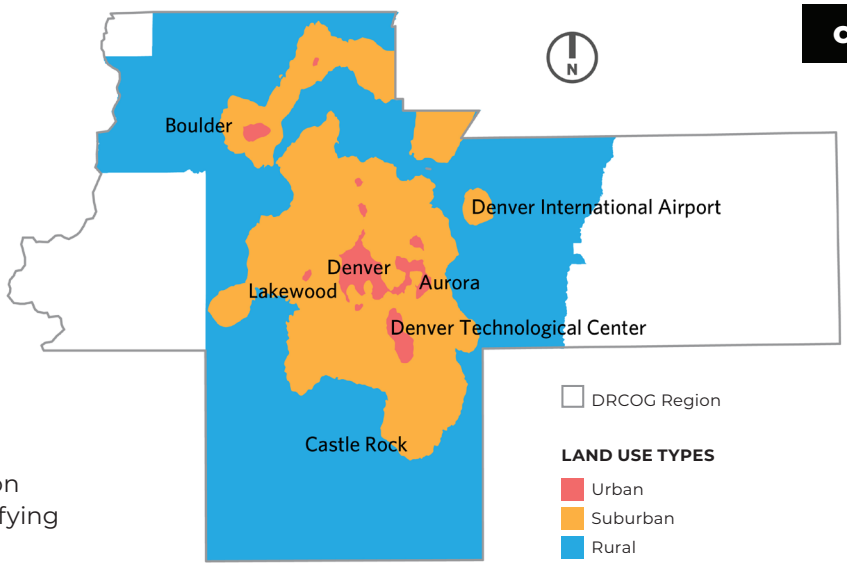
The partners developed a process that engaged transportation experts and other key stakeholders across the region. The result is the Blueprint with a list of Tactical Actions that seek to represent the needs of the Denver region cities, counties, residents, and community groups.

Integrated

The Mobility Choice Blueprint process assessed a range of futures based on the complex interactions of the different levels of mobility technology availability, local government intervention, and consideration of human experience. Discourse with global transportation experts, a review of the latest technical writings, and interviews with a dozen peer cities helped combine global and national trends with the anticipated reaction from metropolitan area travelers to predict likely future scenarios for the Denver region. The Blueprint reflects how this understanding of external influences, organizational frameworks, and end-users of the transportation system would impact transportation and livability across the region.

Regional

The Denver region is home to more than 3 million people in urban, suburban, and rural areas stretched over 9 counties and more than 5,000 square miles. DRCOG's established Metro Vision Plan articulates a shared regional vision, identifying several overarching themes. Building on this collective understanding of our communities, the Blueprint identifies policies, programs, and pilot projects that will take advantage of and adapt to new mobility technologies. The Blueprint is careful not to call out actions that are clearly within the purview of a single agency or local municipality. Instead, these are actions that will have a regional impact and require involvement from several agencies and/or private sector partners in order to improve Denver region mobility.



Metro Vision Themes Relevant to the Blueprint

+ An Efficient and Predictable Development Pattern
+ A Connected Multimodal Region
+ A Safe and Resilient Natural and Built Environment
+ A Vibrant Regional Economy
+ Healthy, Inclusive, and Livable Communities

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Strategic Planning Model

The Blueprint uses DRCOG's strategic planning model to address high-level regional needs through specific actions related to emerging technologies.

CH. 2

Community Engagement

To increase the success of implementing the Blueprint over the long term, we went out into the community and talked to people who are using the current transportation system. The conversations gave us insights about how people think and what they value, which allowed use to map the future of mobility with insight grounded in a deep understanding of end-users.

In-depth interviews involved 3-hour discussions with 20 residents representing a cross-section of the metropolitan area population. Broad-reaching **digital engagement** connected with a much broader audience within the same geographic boundary through two surveys and a user-friendly website. **Global thought leaders** informed us about initiatives and cutting-edge approaches across the United States and in the world regarding emerging technologies and mobility. Regular workshops with **Metro Ambassadors** representing regional agencies and stakeholder organizations helped to develop practical recommendations for our region.

PUBLIC INPUT

More than 1,000 participants in digital surveys,

helping to build an understanding of their priorities related to improving transportation and acceptance of new technologies.

STAKEHOLDER WORKSHOPS

40 Metro Ambassadors

represented several regional transportation management associations, transportation staff from several municipalities, economic development organizations, and advocates for disabled and elderly populations. They participated in several workshops to provide input on regional transportation needs, comment on the applicability of emerging technologies, and develop and prioritize tactical actions.

OUTREACH

70+ events hosted

to educate and provide opportunities for feedback about the Blueprint.

Quality of Life

How does mobility and transportation relate to quality of life factors like health, work, recreation, safety and education?

In order to design the future of transportation in Denver, it's important to have a firm grasp on how transportation fits into the lives of residents. What is the relationship between transportation and one's job or home location? How do residents decide what mode of transportation they will take? How does transportation relate to a resident's desired lifestyle? Transportation is only one piece of the puzzle and is connected to virtually every other aspect of life. Transportation is something people rarely think about beyond the frustration that comes from being stuck in traffic. However, mobility is fundamental to an individual's quality of life related to access to education, cultural events, meaningful work, and affordable healthcare. Transportation serves as the fundamental predecessor to being able to access these things. Moreover, mobility represents freedom and control — the ability to navigate wherever, whenever.

We gathered information about how people define quality of life and its relationship to transportation. We also asked residents to rank various factors that influence their quality of life in order of importance. By understanding their priorities, we can design a mobility future that enables the quality of life people desire.

Almost across the board, access to transportation fell in the middle of ranked priorities for quality of life factors. Health, safety, and financial wellbeing were ranked at the top. Good access to transportation options enables these higer-ranked quality of life factors.

Ranking the Quality of Life Factors

In our community engagement, participants ranked the below quality of life factors in order of importance to them.

- HEALTH
- SAFETY
- FINANCIAL WELLBEING
- YOUNG PEOPLE'S WELLBEING
- RECREATION AND LEISURE
- EDUCATION
- PHYSICAL ENVIRONMENT
- WORK AND PRODUCTIVITY
- ACCESS
- SUPPORT AND BELONGING
- RELIGION AND SPIRITUALITY
- CULTURE AND COMMUNITY IDENTITY
- DIVERSITY AND EQUITY
- HERITAGE

Key Discoveries

Missing links create gaps to connectivity

Mobility should be considered as a service ecosystem, with public agencies acting as coordinators among the various service providers and ensuring social equity in how transportation services are provided.

Importance of mobility – it's a key enabler of quality of life

For Denver area residents, mobility represents freedom, control, and quality of life. Availability of transportation options helps shape personal health and well-being, communities, and even relationships. For many metropolitan area residents, convenient access to the mountains, a regional bike trail, or the closest rail station is an important element of their lifestyle.

It's about more than infrastructure

People are moving between public and private modes of transportation. Agencies and private partners need to help support this by providing seamless information and payment systems to bridge the gaps between services and remove friction in the system. People may choose their trip modes based on cost, time, wellness, or other reasons. They want a system that makes their trip easy no matter how many modes or providers it may involve.

Safety and security are critical

The safety of new transportation technologies emerged as a significant concern among participants. Concerns about safety were reflected in many forms, including personal safety in shared vehicles and from new and untested technologies, and data security when sharing payment trip information.

Dan

Maria

Carl

Understanding Community Input Through the Lens of Personas

Out of our community engagement process, five representative personas emerged. These personas are not actual individuals, but they are inspired by real people. We use these personas to describe the mindsets and attitudes, behaviors, lifestyles, values, motivations, needs, and activities that relate to mobility in the Denver region.

These personas help us step into the diverse and multilayered daily lives of Denver region community members. They help us develop solutions to real everyday challenges based on current experiences with our transportation system and possible mobility choices in the future. The personas helped guide the Blueprint's scenario planning.

Tonya

Jordan

Hello

Meet Maria

Maria is a 22-year-old mother who lives in Aurora. She is a student at Metro State University who also works part time at a restaurant in downtown Denver. Her pride and joy is her 4-year old son Gabriel, who often stays with Maria's mother at her home in the Five Points neighborhood. Maria bought a used car but struggles with payments and repairs. She typically uses her car to get to her mother's house, but to avoid high parking costs in downtown Denver, she uses transit to get to school and work. She's open to a Mobility as a Service program if it saves her time and money — her strongest mobility motivators.

FRUSTRATIONS

+ Reductions in service
+ Route changes
+ Bus frequency
+ Public transit dead zones
+ Feeling unsafe on Free MallRide

NEEDS

+ Fill in the gaps
+ Clear communication
+ Affordable options

MOTIVATIONS

Cost

Time Efficiency

HOW I RANK MYSELF

Tech Savviness

New Technology Attitude

Quality of Life

These personas are not actual individuals, but they are inspired by real people interviewed during the engagement process.

Hello

Meet Dan

Dan is a 75-year-old, semiretired professor who is married and lives in a south Denver neighborhood. Dan is a lifelong learner who loves to read about current affairs and technology. He is motivated to have a positive contribution to society, and prides himself on minimizing time in his car. It's important to him to stay socially and intellectually engaged with his community. He and his wife enjoy walking each day to stay fit and would like to bike more if the route were comfortable and safe.

FRUSTRATIONS

+ Lack of pedestrian / cyclist safety
+ Number of connections for short distance
+ Negative perception of bus (safety)

NEEDS

+ Smart public transit routes / stops / frequency
+ Higher pedestrian safety
+ More sustainable options
+ Safe transit

HOW I RANK MYSELF

Tech Savviness

New Technology Attitude

Quality of Life

MOTIVATIONS

Wellness

Environmental Impact

Convenience

Safety

These personas are not actual individuals, but they are inspired by real people interviewed during the engagement process.

Hello

Meet Carl

Carl is middle-aged and married with a teenage son. His biggest concern is a recent health issue that is beginning to limit his mobility and forcing him to walk with a cane. He lives in Green Valley Ranch and works at Denver International Airport. His wife commutes from Green Valley Ranch to her job in Thornton. He has always had a car, ever since he got his license at age 16. He has never used public transportation. He "geeks out" on new technologies, such as autonomous vehicles, especially if they can provide him with new mobility opportunities as his physical capabilities deteriorate.

FRUSTRATIONS

+ Commuter rail opening delays
+ Lack of pedestrian safety
+ Number of connections for short distance
+ Potholes
+ Lack of timely response to growth

NEEDS

+ Safe transit
+ Accessible services
+ Help figuring out how to do certain things
+ Reliability

HOW I RANK MYSELF

Tech Savviness

New Technology Attitude

Quality of Life

MOTIVATIONS

Ease

Convenience

Safety

These personas are not actual individuals, but they are inspired by real people interviewed during the engagement process.

Hello

Meet Tonya

Tonya is a 34-year-old Colorado native who lives in Boulder and is married with three young children. Her husband works at the Federal Center in Lakewood. Her week is packed with juggling errands, home chores, managing kids' schedules, and trying to find time to stay connected with friends. She has always loved the mountains and most enjoys the times when she and her family are skiing, hiking, and maximizing their weekends in the Rockies.

FRUSTRATIONS

+ Traffic to the mountains (winter and summer)
+ Commuter rail opening delays
+ Poor coordination of construction with traffic
+ Increase to three passenger requirement for HOV lane access

NEEDS

+ Clear, honest communication
+ Convenience with uncompromised sustainability
+ Extended public transit network

HOW I RANK MYSELF

Tech Savviness

New Technology Attitude

Quality of Life

MOTIVATIONS

Convenience

Time Efficiency

Freedom

These personas are not actual individuals, but they are inspired by real people interviewed during the engagement process.

Hello

Meet Jordan

Jordan is a 29-year-old who recently moved to Denver from the Bay Area. He works for a tech company downtown, but really wanted to own his own home and have a yard. Central Denver is not affordable for him, so he bought a home in Parker. He commutes four days a week and works from home on Fridays. He moved here for the renowned Colorado lifestyle, but he has plenty of job opportunities in whatever major metropolitan area he'd like to live. He's happy to take transit as long as it's comfortable and easy. He likes to head to the mountains for fun adventures on the weekend with friends, but doesn't plan to buy his own car.

FRUSTRATIONS

+ Bus frequency
+ Increases HOV #
+ Lack of pedestrian safety
+ Commuter rail opening delays

NEEDS

+ Smart public transit routes / stops / frequency
+ Convenient ways to get discounted passes
+ Higher pedestrian safety

MOTIVATIONS

Reducing Stress

Cost

Time Efficiency

HOW I RANK MYSELF

Tech Savviness

New Technology Attitude

Quality of Life

These personas are not actual individuals, but they are inspired by real people interviewed during the engagement process.

The Blueprint Vision

The Denver region employs a full array of flexible technology and services to maximize access to mobility choices connecting people of all ages, incomes and abilities to jobs, recreation, healthcare, amenities and other daily activities, enhancing and protecting our quality of life now and in the future.

Themes & Outcomes

Safety

All travelers, regardless of mode, trust the regional transportation network to prioritize their safety in the deployment of new mobility technologies.

Human Experience

Mobility systems improve the livability of our communities and enhance quality of life for all people.

Efficiency & Sustainability

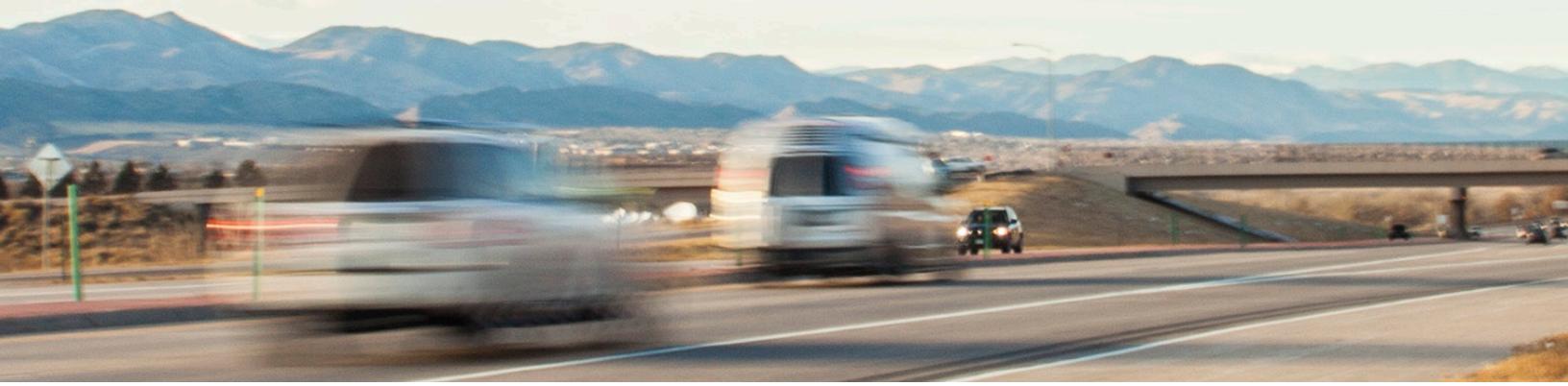
Emerging technologies improve air quality, lower mobility costs, and reduce travel times.

Funding & Finance

Modified and new sources of funding and finance are tied to deployment of mobility systems in ways that promote equity, maximize public resources, and engage private sector partners.

Infrastructure Governance

Regional transportation policies, programs, and pilot projects efficiently deliver an integrated mobility network and services.



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TOPICS

- SCENARIO PLANNING
- MOBILITY GRIDLOCK VS. MOBILITY BOLD
- HUMAN-SCALE EXPERIENCE

Chapter 3
Imagining the Year 2030

The actions we take today will affect our travel experiences in the future, setting us on a path toward one of several possible scenarios.

Given the cataclysmic potential of emerging mobility systems and the regional priorities identified by the Blueprint's themes and outcomes, how should the region's public agencies and private-sector organizations move toward a desired future?

Stakeholder groups imagined several possible future scenarios that reflect a range of coordination and investments designed to address new mobility technologies. These future planning scenarios shaped the development of the 34 recommended Tactical Actions described in Chapter 4.

TACTICAL ACTIONS DEVELOPMENT PROCESS

What is Scenario Planning?

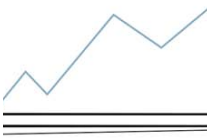
Scenarios are stories about the future that planners develop to consider and prepare for possible challenges and opportunities. Scenario planning helps transportation agencies work with stakeholders and the public to establish a vision and implement a strategic plan for success in uncertain times."

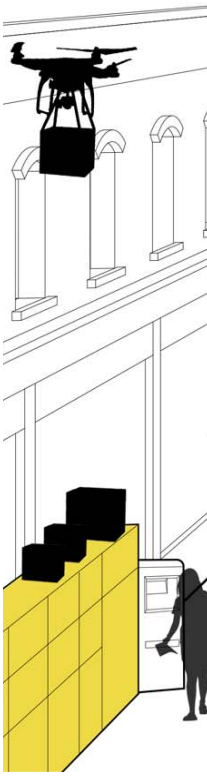
— Federal Highway Administration, Supporting Performance-based Planning and Programming through Scenario Planning, 2016

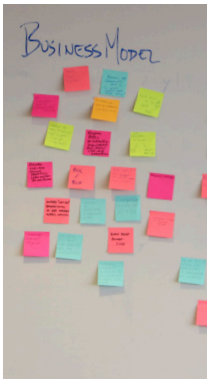
The scenarios for the Blueprint imagine two possible futures for year 2030.

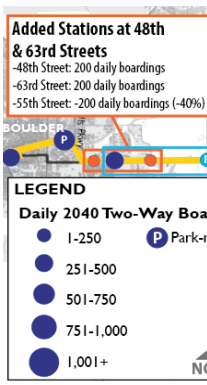
The **Mobility Gridlock** scenario assumes the Denver region continues to implement existing fiscally constrained transportation plans, without any change in how investments are made in emerging mobility systems and technologies. The private sector is left largely alone to implement new services and facilities, which continue to develop and be adopted at an exponential pace.

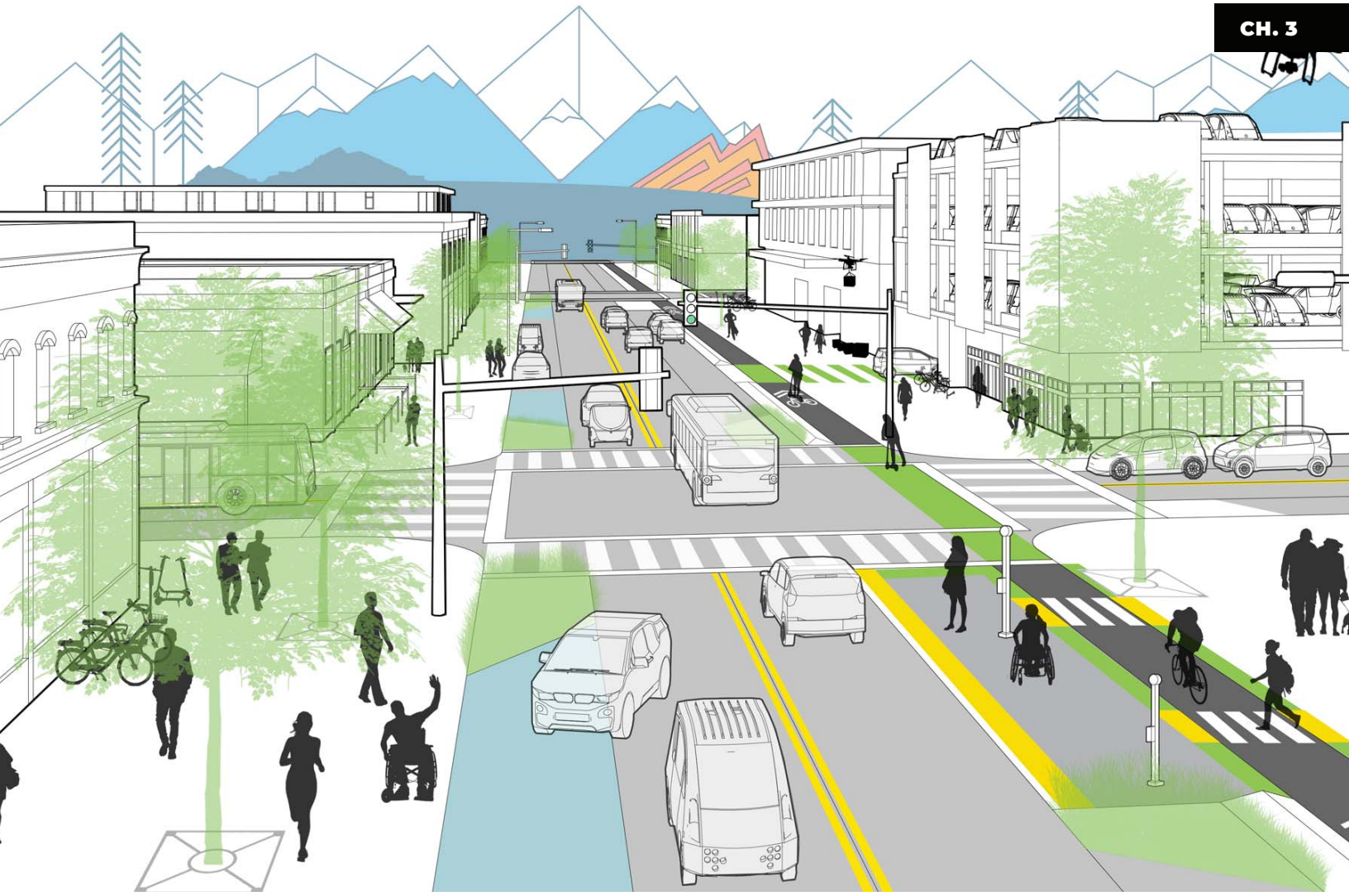
The **Mobility Bold** scenario assumes the Denver region's transportation agencies proactively collaborate to assess, invest in, and implement those emerging mobility technologies that will have the greatest impact on mobility in the region. Through coordinated regulation and incentive programs, the private sector is given a clearly-defined role and is actively encouraged to work alongside public agencies and other organizations to develop an equitable, safe, and efficient transportation network.



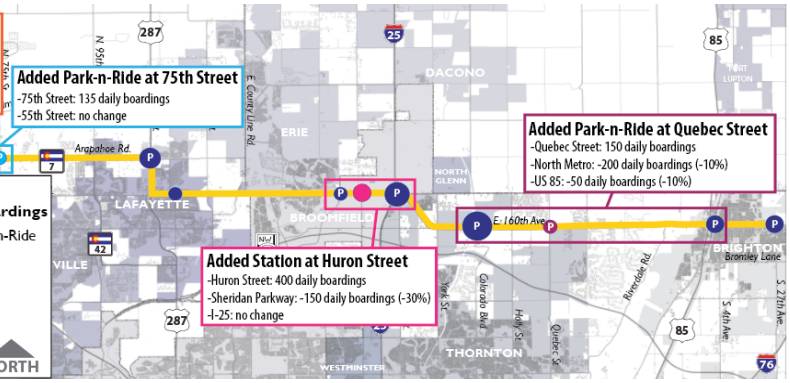









Tech
Infrastructure


Added Park-n-Ride at 75th Street
-75th Street: 135 daily boardings
-55th Street: no change
Added Park-n-Ride at Quebec Street
-Quebec Street: 150 daily boardings
-North Metro: -200 daily boardings (-10%)
-US 85: -50 daily boardings (-10%)
Added Station at Huron Street
-Huron Street: 400 daily boardings
-Sheridan Parkway: -150 daily boardings (-30%)
-I-25: no change
DACONO
ERIE
LAFAYETTE
BROOMFIELD
NORTH GLENN
THORNTON
WESTMINSTER
BRIGHTON
Bromley Lane
Arapahoe Rd.
E. County Line Rd
E. 160th Ave
Boardwalk Rd.
York St.
Colorado Blvd.
Holly St.
Quebec St.
S. 76th St.
S. 27th Ave.
S. 48th Ave.
287
25
85
76
42
7

Technology Is Changing
And So Is The Way We Travel

Mobility GRIDLOCK

Here's how our region looks and feels in 2030 if we simply *REACT* to new transportation technologies

In this scenario, the Denver region makes limited or uncoordinated efforts and investments to prepare for emerging mobility systems and technologies. Without a clear, coordinated public sector response, the private sector is left largely alone to implement new services and facilities that continue to develop and be adopted at a rapid pace.

- ***GRIDLOCK & DISARRAY***
- ***LIMITED ACCESS***
- ***ECONOMIC BARRIERS***
- ***CONGESTION***

ECONOMY: LOSING GROUND

$50 Million in Lost Benefits

If current trends continue, increased traffic congestion and uncoordinated adoption of new technologies could cost the region $50 million each year of unrealized benefits by 2030, despite gains in economic productivity, safety, and accessibility.

EQUITY

Reduced Access

The number of people who have no ready access to a vehicle (including elderly, low-income, and disabled persons) increases by 18,000 compared with 2015.

AIR QUALITY

Moderate Pollution

Gasoline and diesel powered vehicles are responsible for 33% of the state's greenhouse gas emissions, increasing their annual output of annual pollutants by 4.5 million metric tons over 2010 levels.

CONGESTION

Travel Delays

50% more hours of vehicle delay (compared with 2015).

SAFETY

Unchanged Crash Rates

50% increase in crashes (compared with 2015).

GRIDLOCK EXPERIENCES

> I am frustrated by my travel options."

> I live far from downtown, and my bus route is not flexible."

> My wife and I will walk around the park, but we're nervous about crossing intersections."

The statistics on these pages are derived from the regional travel demand model developed for the Blueprint. See endotes for supporting analysis.

Which will be our Mobility Choice?

If we act now, ***TOGETHER*** we can move toward a mobility future defined by people rather than technology.

Mobility BOLD

Here's how our region looks and feels in 2030 if we take a *PROACTIVE* approach to new transportation technologies

In this scenario, the Denver region maintains community visions and improves mobility for all by pushing boundaries and taking a chance on bold programs that work to break down traditional silos, build new partnerships, and prioritize impactful and innovative applications of emerging technologies.

ECONOMY: OPPORTUNITIES FOR ALL

$1.9 Billion in Benefits Gained

The actions recommended by the Mobility Choice Blueprint are expected to decrease time spent traveling, improve safety, allow more efficient freight movement, and compound gains to accessibility and productivity, resulting in an annual benefit to the region in excess of $1.9 billion annually (in 2018 dollars) compared with Mobility Gridlock.

ECONOMIC OPPORTUNITY

HAPPIER COMMUTE

ACCESSIBILITY FOR ALL

OPTIONS & CHOICE

EQUITY

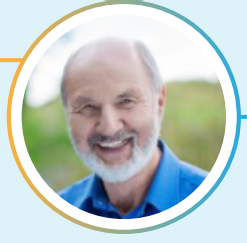
Fewer Barriers

91,000 people who would otherwise face mobility challenges enjoy a range of travel options enabled by coordinated adoption of new mobility technologies.

BOLD EXPERIENCES

"Getting around is much more affordable than I thought, and I have the flexibility to live my life."

"It's so easy to get around here, and there are so many options."



"I feel more connected to my community than ever."

CONGESTION

More Free Time

1.5 million fewer hours of vehicle delay per year (compared with Mobility Gridlock).

AIR QUALITY

Cleaner Air

Electric vehicles emit 41% less carbon per mile than gasoline-powered vehicles in the Denver area. Strategies and programs incentivizing the switch to electric vehicles significantly improve regional air quality.

SAFETY

Safer Roads

8,200 fewer crashes per year resulting $550 million saved.

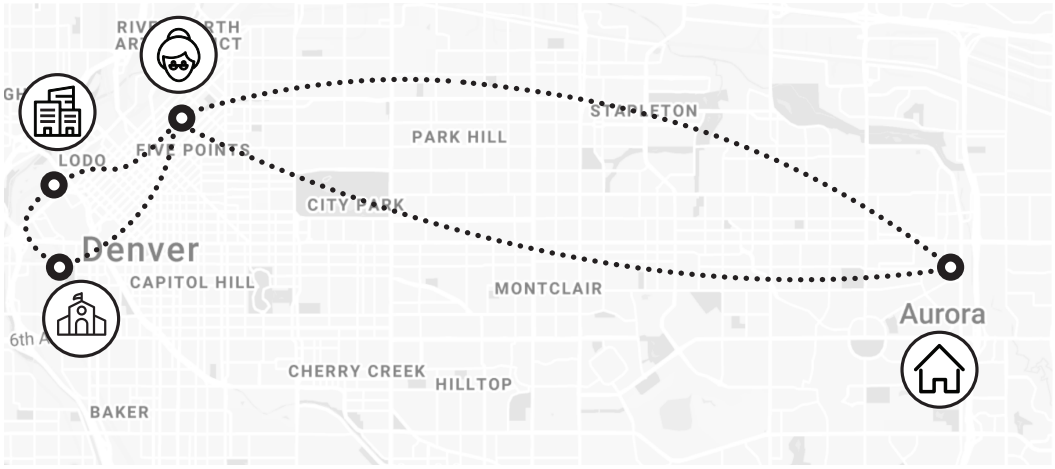
Exploring the 2030 Human-Scale Experience and Benefits Resulting From Mobility Choice Blueprint

As we imagine the year 2030 future of the Denver region, here's how the Blueprint's recommendations might affect the mobility and lifestyle experiences of each of the personas described in Chapter 2.

Maria

DAILY TRAVEL EXAMPLE

AURORA > FIVE POINTS > METRO STATE > DOWNTOWN DENVER > FIVE POINTS > HOME

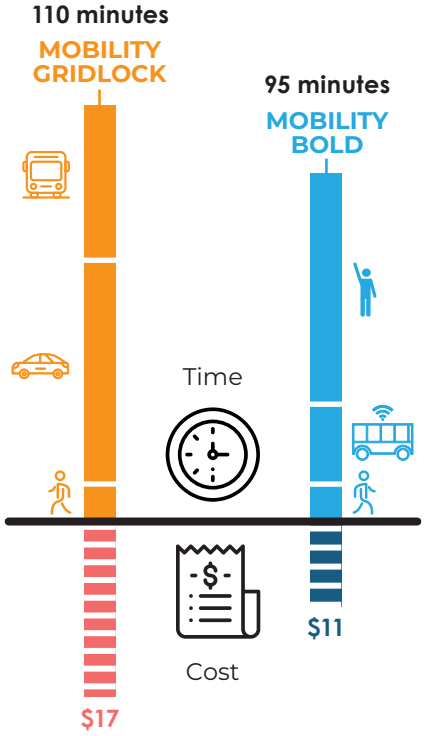


Mobility GRIDLOCK VS Mobility BOLD

2030 GRIDLOCK EXPERIENCE

"When I had Gabriel, my mother was just thrilled to become a grandmother. I really rely on my mom's help and she's happy to be there for us. I'm proud to be a first generation college grad as I finish my degree next year. I work part time to make ends meet, so time is precious but money is tight. Getting to daycare/school/work/home takes a long time and I struggle to find an affordable solution that doesn't require us to be up before dawn to get me to school on time and home so late. I am frustrated by my travel limitations, which also cut into my ability to stay connected with my friends."

DAILY TRAVEL BREAKDOWN



2030 BOLD EXPERIENCE

"Signing up for the new Colorado Mobility as a Service program has changed my life. Mobility as a Service is much more affordable than I thought and it has given me the flexibility to live my life. I sold my unreliable car, which had become a money pit of constant repairs. I love the opportunity to control my monthly costs and have more mobility choices based on my erratic schedule. Sometimes my mom takes Gabriel downtown to ride the autonomous microshuttle along the 16th Street Mall as an afternoon adventure. He loves it!"

These personas are not actual individuals, but they are inspired by real people interviewed during the engagement process.

Dan

DAILY TRAVEL EXAMPLE

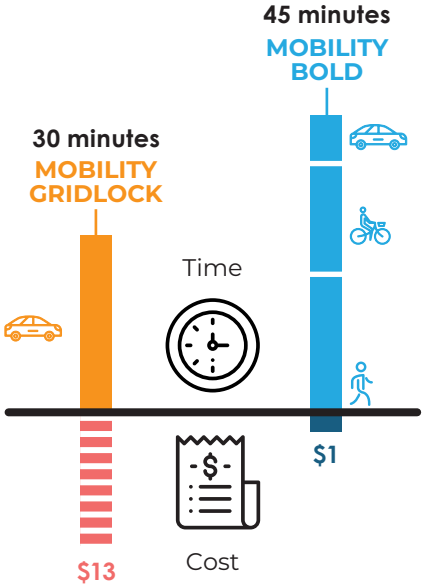
PLATT PARK >
UNIVERSITY >
GROCERY STORE >
COFFEE >
HOME

Mobility GRIDLOCK vs Mobility BOLD

2030 GRIDLOCK EXPERIENCE

"I used to be very active in my community, but I'm feeling more limited now that it doesn't feel as safe or easy to bike or walk to where I want to go. My wife and I will walk around the park, but we're nervous about crossing intersections. Walk light durations are too short. I can still drive, but I avoid it. I'm concerned my world is getting smaller and I'm losing some of the freedoms I've always enjoyed."

DAILY TRAVEL BREAKDOWN



2030 BOLD EXPERIENCE

"I feel safe and comfortable walking and biking around my community. There are new pedestrian detection systems in place at intersections in our neighborhood and new separated bike lanes that allow me to not only bike to the university, but also to my library and coffee shop. I feel more connected to my community than ever. I recently attended a seminar at the university on new autonomous vehicle research and visited the new mobility hub in my neighborhood to learn about the options that will help extend the mobility and freedoms my wife and I enjoy. We hope to remain in the neighborhood we love for many years to come."

These personas are not actual individuals, but they are inspired by real people interviewed during the engagement process.

Carl

DAILY TRAVEL EXAMPLE

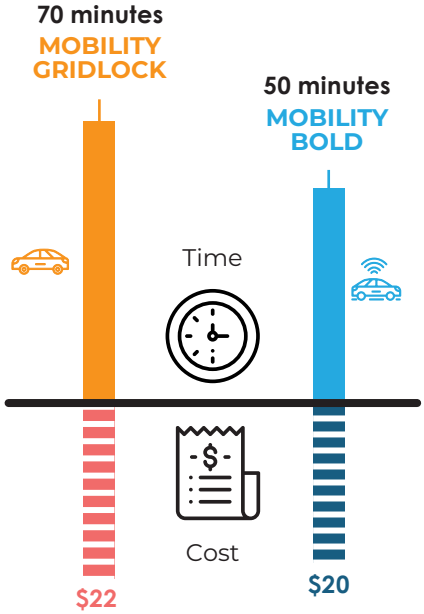
GREEN VALLEY RANCH > AIRPORT > SON'S SPORT PRACTICE/ GAMES > RESTAURANT > HOME

Mobility GRIDLOCK vs Mobility BOLD

2030 GRIDLOCK EXPERIENCE

"I have always relied on my car. But traffic congestion just keeps getting worse and I find it negatively affects my mood when I come home from work. I like my job and I need it to support my family. But my health problems are getting worse and I worry whether that will make me home-bound at some point, and reliant upon my wife to drive me around. My wife works in Thornton, and it seems like her commute gets longer every year due to increased traffic congestion. My son is competing regionally with his lacrosse team, so that means we spend a lot of time driving him around to various practices and games in the metro area, which takes a lot of time."

DAILY TRAVEL BREAKDOWN



2030 BOLD EXPERIENCE

"I rode in a driverless vehicle at a weekend festival at Peña Station NEXT last month and it was so cool! More comfortable and easier than I expected. I'm a car geek, so everything about smart cars is intriguing, including the mobility options it may open up for me as my physical disability gets worse. I might even try the new microtransit shuttle circulating between the airport and my neighborhood or I might buy an driverless vehicle, which could drop me at the airport and then park itself during the day. My son is in a new 'child-safe' on-demand shared ride service that he takes with his lacrosse teammates that I can track on my smartphone. My wife still prefers to drive, but the new 'smart corridor' along I-70 means her commute time is shorter. That means more family time together in the evenings, which we all love."

These personas are not actual individuals, but they are inspired by real people interviewed during the engagement process.

Tonya

DAILY TRAVEL EXAMPLE

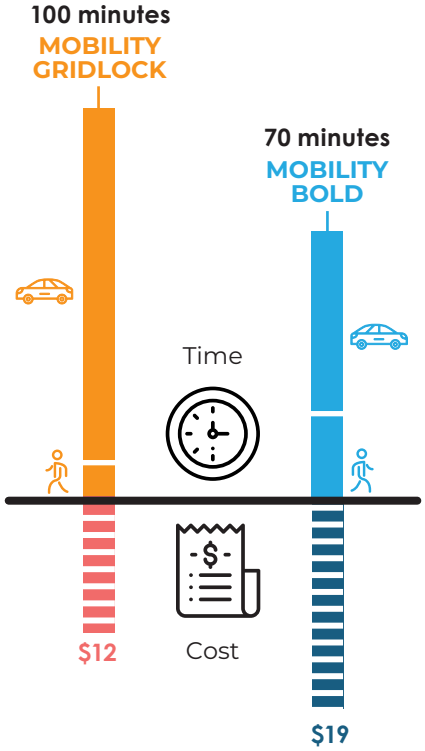
BOULDER >
TWO SCHOOL DROP-OFFS >
ERRANDS >
GYM >
HOME >
PICK-UP KIDS >
AFTER SCHOOL ACTIVITIES >
HOME

Mobility GRIDLOCK VS Mobility BOLD

2030 GRIDLOCK EXPERIENCE

"My life gets a little overwhelming sometimes. I try to stay on top of it all, but during the week I feel a little strung out. I am dependent on my car to get me around my community, but I'm always looking for ways to help make my life easier. I've started ordering my groceries online for pick up, which helps a bit. My family and I used to go up to the mountains at least one weekend every month, but these days it's just not worth the hassle. Traffic is a mess, and it's unreliable how long it might take us to get home. Mostly we just play in our neighborhood parks now, but I'm sad my kids aren't getting to enjoy nature and the mountains like I always did."

DAILY TRAVEL BREAKDOWN



2030 BOLD EXPERIENCE

"My life is busy and active, but I have found ways to make the week flow more smoothly. I signed up to test drone delivery grocery service from my local supermarket and it's great! That's one less errand I have to do. But my favorite time of the week is Friday afternoons when we hit the road and head for the mountains, almost two times a month now. We don't mind paying the extra fee to have a smooth and reliable trip up and back. The roadway technology now even alerts our car of winter conditions to minimize travel delays or problems due to weather. I'm proud to be raising kids who know how to set up a tent and build a campfire."

These personas are not actual individuals, but they are inspired by real people interviewed during the engagement process.

Jordan

DAILY TRAVEL EXAMPLE

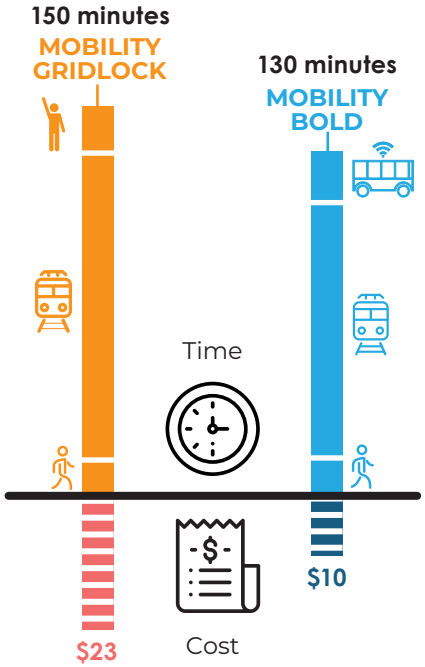
PARKER > DOWNTOWN DENVER > RESTAURANT > HOME

Mobility GRIDLOCK VS Mobility BOLD

2030 GRIDLOCK EXPERIENCE

"I moved to Colorado for a great job opportunity as well as a chance to try out a more balanced life. My job is pretty stressful, but there are always fun things to do here. Unfortunately, the great lifestyle promise hasn't quite been true for me. I live far from downtown, and my light rail route is not flexible, so it's hard for me to stay connected with friends during the week. I like being productive and getting work done during my commute, so transit is still my choice. But overall, the effort and stress that it takes me to live here is more than I expected, so I'm thinking about taking a job in a more affordable city like Salt Lake, where tech is up-and-coming and my dollar will go further."

DAILY TRAVEL BREAKDOWN



2030 BOLD EXPERIENCE

"I moved to Colorado not only for the great lifestyle, but also because it's becoming known as a smart city. The tech company I work for is creating some innovative new solutions to mobility-challenged communities. I feel like I'm really making a difference. It's so easy to get around here and there are so many options. I've been using the new mobility app to get to work, sometimes by shared ride, and sometimes by transit, which is faster and more reliable than it used to be. I've met great people and found fun spots to meet up with friends after work. I'm thinking about settling down here, and maybe starting my own company."

These personas are not actual individuals, but they are inspired by real people interviewed during the engagement process.

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4

TOPICS

- TACTICAL ACTIONS
- OBJECTIVES
- BENEFITS

Chapter 4
Tactical Actions

The Blueprint's sponsoring agencies have agreed to a regional approach to implement the Tactical Actions by the 2030 planning horizon year.

At the core of the Blueprint is a set of recommended Tactical Actions for regional policies, programs, and pilot projects that address emerging mobility technologies under the themes of Safety, Human Experience, Efficiency & Sustainability, Funding & Finance, and Infrastructure Governance. Through grassroots engagement and research on global best practices, the Blueprint process generated more than 130 actionable ideas. These were refined to a **final set of 34 recommended Tactical Actions** related to transportation technologies that will define the Denver region's mobility future.

Each Tactical Action has one or more Initiator (champion) agency best suited to lead its implementation. Because the actions require some level of regional collaboration, supporting agencies are identified as Additional Participants. Many of the actions are interrelated and contribute to one or more objective—Related Actions are shown where there is a strong connection.

Objectives & Actions

The Tactical Actions are grouped by the seven categories (or Objectives) below that describe the desired future effects of the actions. Where possible, quantitative, measurable effects are estimated for some specific performance measures. The numbers of the Tactical Actions are for reference purposes only and are not intended to represent priorities.

OBJECTIVE 1

Regional Collaboration

Close institutional gaps, update legal and regulatory frameworks, and coordinate with private sector technology implementers

OBJECTIVE 2

System Optimization

Connect transportation systems and vehicles with smart technologies to improve safety and operations

OBJECTIVE 3

Shared Mobility

Integrate new options of vehicle sharing and ride sharing into the existing multimodal transportation system network

OBJECTIVE 4

Data Security and Sharing

Analyze travel data from public and private mobility providers to improve transportation system performance while maintaining security and protecting privacy

OBJECTIVE 5

Mobility Electrification

Encourage use of electric powertrains in automobiles and transit vehicles

OBJECTIVE 6

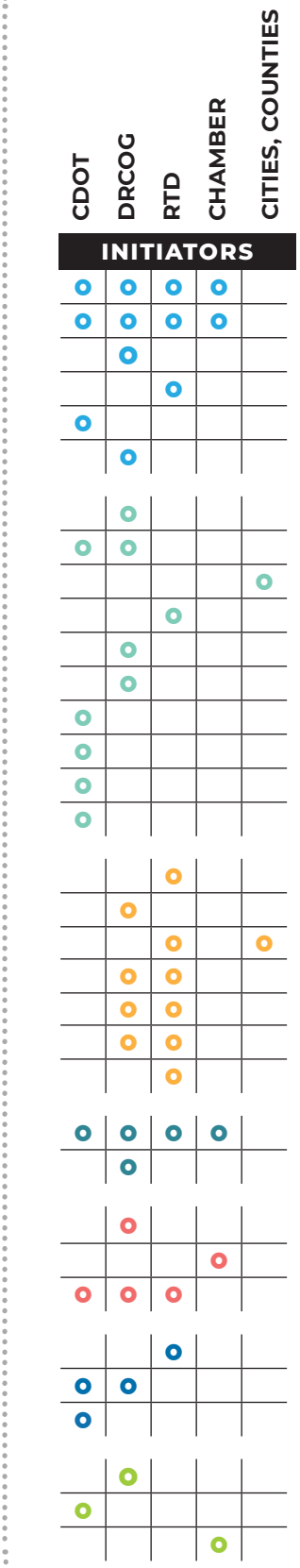
Driverless Vehicle Preparation

Prepare for autonomous vehicles to provide safe operations and reduced congestion while retaining a sound human experience

OBJECTIVE 7

New Transportation Funding

Establish new funding sources to replace traditional sources that are losing effectiveness



THE BLUEPRINT PROCESS HAS BUILT BROAD CONSENSUS AROUND NUMEROUS TACTICAL ACTIONS

These 34 policies, programs, and pilot projects represent a wide range of actions that build on the groundwork laid by the study's individual participants, as well as best practices emerging across the globe.

TACTICAL ACTIONS	
1.1	Establish a mobility technology advisory committee
1.2	Establish a new public-private mobility entity or entities to pursue mobility technology implementation
1.3	Engage university resources to develop mobility technology research and development
1.4	Make Mobility as a Service available to all
1.5	Develop regional guidelines for drone delivery and drone passenger travel
1.6	Establish a regional smart mobility navigator
2.1	Evaluate technology upgrades and interoperability in projects in DRCOG's Transportation Improvement Program
2.2	Prepare for technology upgrades and interoperability in project development of transportation projects
2.3	Accelerate testing of bicycle/pedestrian detection at crossings
2.4	Implement transit priority on all major bus corridors
2.5	Implement smart traffic signal control technology on all major regional arterial corridors
2.6	Pilot integrated corridor management on ten arterial corridors
2.7	Implement "smart corridor" operations on all regional freeways
2.8	Coordinate traffic management center systems and operations
2.9	Pilot mobility technologies on mountain corridors
2.10	Pilot modular lanes
3.1	Develop a universal mobility app for trip planning and payment
3.2	Adopt a regional compact defining common standards for micromobility services
3.3	Develop incentives to improve ridehailing and ridesharing operations
3.4	Implement curbside management standards
3.5	Pilot neighborhood-scale mobility hubs
3.6	Partner with the private sector to provide transportation in mobility-challenged communities
3.7	Pilot smart parking at Park-n-Rides
4.1	Establish a regional mobility data platform
4.2	Establish data sharing requirements for private sector roadway users
5.1	Incentivize ridehailing and ridesharing providers to use electric vehicles
5.2	Create an electrified mobility development program
5.3	Transition government fleets to electric and other zero-emission vehicles
6.1	Pilot driverless microtransit to increase public exposure to automated vehicle technology
6.2	Minimize zero occupancy and encourage high shared use of driverless automated vehicles
6.3	Support legislative efforts to ensure that automated vehicles operate safely
7.1	Expand DRCOG funding earmark for a mobility technology innovation fund
7.2	Explore the concept of a road usage charge for Colorado
7.3	Support legislative efforts to ensure that driverless automated vehicles generate appropriate funding

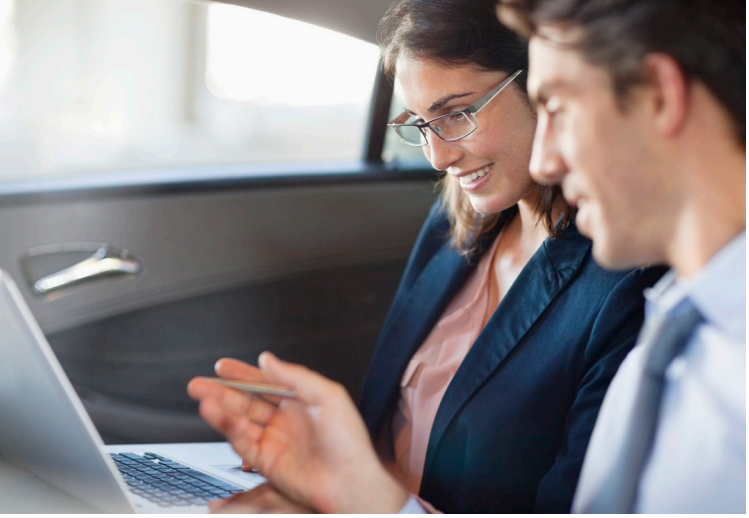
Objective 1

Regional Collaboration

Close institutional gaps, update legal and regulatory frameworks, and coordinate with private sector technology implementers

- Technology forum that coordinates and advises on regional policies, standards, regulations and legislation, priorities, and investments.
- Collaboration with the private sector in developing and implementing new technologies.
- Public-private partnership mobility entity to implement new technology for addressing regional mobility needs.
- Academia and private sector technology experts are involved in the research and decision-making process about adoption of regional technology.
- Laws and regulations govern new technologies and are flexible to effectively address yet-unknown technologies.

Without a relationship to public objectives, new technology from the private sector could focus on maximizing revenues at the expense of community goals.



BENEFITS

The following describes a mobility future for the year 2030 where the region has successfully closed institutional gaps and updated legal/regulatory frameworks.

The region leverages private sector investment, flexibility, and technological innovation in service of community goals and priorities (including equity, safety, and livability).

Mobility-challenged communities equitably enjoy a range of travel options.

The region optimizes applications of emerging mobility technologies by becoming a national leader in directing and managing the transformation of transportation.

Public agencies collaborate to effectively integrate, manage, and adapt to technological innovation.

All people across the region feel safe while traveling.

Drones and other technologies are regulated so they operate effectively and safely in the region.

Tactical Actions

1.1

Establish a mobility technology advisory committee

Establish a committee that may include several functions, including:

- Establish standards for public and private mobility data sharing to ensure interoperability among regional stakeholders
- Coordinate Pilot Projects conducted throughout the region to avoid duplication of efforts and share findings
- Provide guidance on best uses of available pooled funding across the agencies for coordinated technology Pilot Projects
- Coordinate agency staff resource sharing for technology related projects
- Create a process to prioritize corridors for technology projects
- Develop partnerships with private sector providers to incentivize private ridesharing
- Identify costs and potential funding associated with retrofitting infrastructure to support and maintain emerging technologies such as Connected Vehicles, Autonomous Vehicles, and Sensor Data Collection
- Benefit from a broad membership beyond public agency representatives

THEMES
Funding & Finance, Infrastructure Governance

ACTION INITIATOR
CDOT, DRCOG, RTD, Denver Metro Chamber

ADDITIONAL PARTICIPANTS
New mobility entity (see TA 1.2)

RELATED ACTIONS
1.2 1.3 1.6 3.2 4.1

1.2

Establish a new public-private partnership mobility entity or entities to pursue mobility technology implementation

Establish public-private partnership(s) to engage mobility technology innovators, coordinate and secure funding, identify projects and public partners, identify and implement pilot projects and simplify coordination with governments across the region. Desired characteristics of such an entity could include:

- Nationally recognized center of excellence for new mobility project deployment and commercialization
- Public and private sector participation/ collaboration/ownership
- Not-for-profit status
- Physical presence of staff and office space
- Connection to Colorado Smart Cities Alliance and Colorado local governments
- Collaboration with Colorado universities and the National Renewal Energy Laboratory
- Governance of the organization is balanced between the public and private sectors

THEMES
Human Experience, Funding & Finance, Infrastructure Governance

ACTION INITIATOR
CDOT, DRCOG, RTD, Denver Metro Chamber

ADDITIONAL PARTICIPANTS
N/A

RELATED ACTIONS
1.1 4.1

1.3

Engage university resources to develop mobility technology research and development

Build capability around emerging mobility by partnering with a regional academic institution to establish a university research center to benefit from the USDOT University Transportation Centers program that establishes and funds transportation research centers at host universities around the country.

THEMES
Safety, Efficiency & Sustainability, Infrastructure Governance

ACTION INITIATOR
DRCOG

ADDITIONAL PARTICIPANTS
New mobility entity (see TA 1.2), university collaborative

RELATED ACTIONS
1.1

1.4

Make Mobility as a Service available to all

Offer Mobility as a Service (MaaS) to all travelers in an equitable manner by developing subsidies or policies through a public-private partnership. MaaS offers a single point of access through a subscription account to public and private mobility services through which users travel across a variety of modes. Residents could choose from a selection of travel pass packages with different price structures for peak and off-peak travel. This may evolve from the universal mobility app described in Tactical Action 3.1.

THEMES
Human Experience

ACTION INITIATOR
RTD

ADDITIONAL PARTICIPANTS
New mobility entity (see TA 1.2), nonprofits and human service providers

RELATED ACTIONS
3.1

"Signing up for the Mobility as a Service program has changed my life! I love the flexibility and affordability."

1.5

Develop regional guidelines for drone delivery and drone passenger travel

Convene a working group to develop a set of recommendations to prepare for managing short-range and low-altitude unmanned aerial vehicles (drones) for freight and (eventually) traveler transportation. This could include conducting an assessment to determine locations and conditions where services like automated parcel delivery would not pose a safety hazard.

THEMES
Safety, Human Experience, Infrastructure Governance

ACTION INITIATOR
CDOT

ADDITIONAL PARTICIPANTS
Federal Aviation Administration, state legislature, Denver Metro Chamber

RELATED ACTIONS
N/A

1.6

Establish a regional smart mobility navigator

Establish a single point of contact for the region who will provide information to new mobility providers about common standards and guidelines for the operation of shared services in the region. The navigator will also provide individual municipalities resources to begin negotiations and contracting with service providers.

THEMES
Infrastructure Governance

ACTION INITIATOR
DRCOG

ADDITIONAL PARTICIPANTS
CDOT, RTD, cities, counties

RELATED ACTIONS
1.1

Smart Mobility Plan

CDOT began work in 2018 on the "Smart Mobility Plan" that outlines a five-year strategic approach to address the objectives of Safety, Mobility, Economic Vitality, and Maintaining the System. The Statewide Mobility Plan, to be completed early in 2019, includes "technology toolbox" components, for example:

+ Safety
+ Traffic control
+ Congestion management
+ Alternative modes
+ Data collection, analysis, and communication
+ Smart work zones

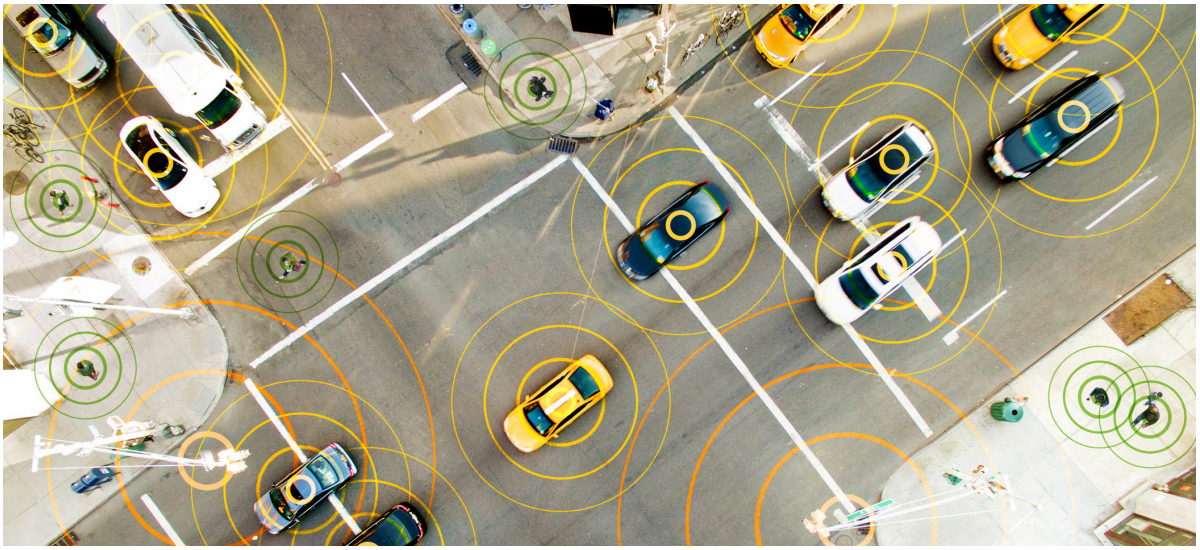
Objective 2

System Optimization

Manage transportation systems and vehicles with smart technologies to improve safety and operations

+ Upgraded infrastructure throughout the system to accommodate emerging technologies.
+ Integrated transportation system management and operations across jurisdictional boundaries.
+ Adoption of common technologies across jurisdictions.
+ Travel data that informs real-time system management and decision-making for travelers.

Traffic management centers operated by CDOT and municipalities offer the possibility for real-time, coordinated system optimization.



BENEFITS

The following describes a mobility future for the year 2030 where the region has successfully used smart technology to manage transportation systems and operations.

Infrastructure systems can support and optimize new mobility systems and cross-jurisdictional coordination.

The region identifies the best technological solutions to reduce crashes by providing real-time information to vehicles and drivers, as well as cyclists and pedestrians.

Increased transit ridership and maximization of the region's investment in FasTracks.

Improved capacity, reliability, and safety across jurisdictional boundaries for private and transit vehicles.

More flexible real-time traffic management and faster incident response across jurisdictional boundaries.

MEASURED EFFECTS

By implementing the policies, programs, and initiatives introduced in this section, the Denver region could expect to see quantitative improvements.

The Blueprint's regional travel demand modeling indicates that Intelligent Transportation System (ITS) improvements increase average corridor speeds slightly (about 0.5 mph). But because corridor vehicle miles traveled (VMT) is higher too, by about 1% to 3%, the ITS improvements allow more vehicles to travel more efficiently.

Implementation of Transit Signal Prioritization (TSP) on corridors typically can reduce bus route travel time by 10% to 15% (depending on the length of the corridor and the number of intersections installed with TSP), based on RTD's projections.

DENVER READY FOR VEHICLE TO INFRASTRUCTURE (V2I) COMMUNICATIONS

Denver is installing advanced traffic signal equipment with Dedicated Short Range Communications (DSRC) equipment on Federal Boulevard as a pilot project, which will enable V2I communications between traffic signals and vehicles equipped with DSRC technology. In addition, CDOT is updating its standard specifications to include requirements for DSRC in all future traffic signals.

Tactical Actions

2.1

Evaluate technology upgrades and interoperability in projects in DRCOG's Transportation Improvement Program

Create a new criterion in the DRCOG Transportation Improvement Program project selection process to incentivize local jurisdictions to include adaptable infrastructure and interoperable technology systems.

THEMES
Infrastructure Governance

ACTION INITIATOR
DRCOG

ADDITIONAL PARTICIPANTS
New mobility entity (see TA 1.2)

RELATED ACTIONS
1.1

NEW DENVER BICYCLE DETECTION SYSTEM
Through funding from DRCOG, Denver Public Works has installed bicycle detection at seven intersections across the City. The City began this effort in 2015 as a pilot project to test how well the devices allow people on bikes to change the traffic signal to green. The bicycle detection systems are intended to pick up the presence of a bicycle at the traffic signal, without a bicyclist relying on another car or pedestrian to trigger the signal, or having to dismount their bicycle to push the pedestrian call button.

2.2

Prepare for technology upgrades and interoperability in project development of transportation projects

Develop and recommend standards and best practices for new infrastructure installations of digital or electronic equipment along the roadside to be interoperable and capable of supporting future technologies.

THEMES
Infrastructure Governance, Efficiency & Sustainability

ACTION INITIATOR
CDOT, DRCOG

ADDITIONAL PARTICIPANTS
New mobility entity

RELATED ACTIONS
N/A

WASHINGTON STATE TRANSIT AGENCIES PILOT TRANSIT VEHICLE TECHNOLOGY TO AVOID CRASHES
King County Metro Transit is one of eight Washington State transit agencies that are piloting technology to help transit vehicles avoid crashes with pedestrians, bicycles, and vehicles. Each of the buses used in the pilot initiated in 2016 are outfitted with sensors, which trigger warning alerts to drivers. The system scans for pedestrians and bicyclists, and alerts bus drivers of imminent collisions with visual and audio warning alerts before they occur. The system also monitors if the bus strays from its lane without an active turn signal, the bus' following distance, and if the bus exceeds the posted speed limit.

2.3

Accelerate testing of bicycle/pedestrian detection at crossings

As new technology applications become available, test and learn from multiple pilot projects of pedestrian and bicyclist detection.

THEMES
Safety, Human Experience, Efficiency & Sustainability

ACTION INITIATOR
Cities, counties

ADDITIONAL PARTICIPANTS
N/A

RELATED ACTIONS
N/A

"I feel safe and comfortable walking and biking around my community thanks to the new pedestrian detection systems in place at intersections."

2.4

Implement transit priority on all major bus corridors

Develop policies and incentives to implement transit priority along all high-use bus corridors through application of such tools as transit signal priority, queue jumps, bypass lanes, bus bulb-outs, and peak hour exclusive bus lanes.

THEMES
Human Experience, Efficiency & Sustainability, Infrastructure Governance

ACTION INITIATOR
RTD

ADDITIONAL PARTICIPANTS
Cities, counties, CDOT

RELATED ACTIONS
2.5

REDUCTION IN TRIP TIMES FROM BUS SIGNAL PRIORITIZATION
RTD, working with the City and County of Denver, has experimented with bus signal prioritization at more than 17 intersections along key corridors, resulting in a 5-minute reduction in certain bus trip times.

2.5

Implement smart traffic signal control technology on all major regional arterial corridors

Implement technology that continually monitors and adjusts to traffic demands to optimize signal timing for prevailing conditions. To monitor effectiveness, evaluate according to FHWA automated traffic signal performance measures (ATSPM).

THEMES
Safety, Efficiency & Sustainability

ACTION INITIATOR
DRCOG

ADDITIONAL PARTICIPANTS
Cities, counties, CDOT

RELATED ACTIONS
2.5 2.6 2.8

COLUMBUS OHIO TRAFFIC SIGNAL SYSTEM PROJECT
A $79 million, multi-year program nearing completion will link 1,400 traffic signals in the central Ohio region to the Columbus traffic management center. The traffic signals include those owned by Columbus, Franklin County and many of the surrounding suburbs.

2.6

Pilot integrated corridor management on ten arterial corridors

Fund and implement ten pilot projects on key Denver region corridors using smart signal technology, as well as enhanced institutional coordination and operational adaptability using real-time information for all modes.

THEMES
Safety, Efficiency & Sustainability

ACTION INITIATOR
DRCOG

ADDITIONAL PARTICIPANTS
CDOT, RTD, cities, counties, new mobility entity (see TA 1.2).

RELATED ACTIONS
2.5 2.8

INTEGRATED CORRIDOR MANAGEMENT 101
Integrated Corridor Management combines two fundamental concepts: active management and integration. Active management involves monitoring and assessing the performance of the system and dynamically implementing actions in response to fluctuations in demand. Integration requires actively managing assets in a unified way so that actions can be taken to benefit the corridor as a whole, not just for individual modes.

2.7

Implement "smart corridor" operations on all regional freeways

Implement adaptive ramp metering, variable speed limits, and enhanced enforcement that use real-time traffic data to maximize capacity on the regional freeway system.

THEMES
Safety, Efficiency & Sustainability, Infrastructure Governance

ACTION INITIATOR
CDOT

ADDITIONAL PARTICIPANTS
Cities, counties, DRCOG

RELATED ACTIONS
2.8 2.9

CDOT CONDUCTS SMART 25 TOTAL MANAGED MOTORWAYS PROJECT
CDOT, through its RoadX program, is conducting a pilot project to install advanced ramp meters and traffic management systems to manage mainline interstate and arterial roadway traffic on I-25 from Ridgegate Parkway to Broadway.

2.8

Coordinate traffic management center systems and operations

Integrate management, operations, and center-to-center communications of the region's traffic management centers where real-time operational data is managed and processed to initiate control strategies and responses to incidents and to provide information to the traveling public and media.

THEMES
Safety, Efficiency & Sustainability, Infrastructure Governance

ACTION INITIATOR
CDOT

ADDITIONAL PARTICIPANTS
DRCOG, cities, counties

RELATED ACTIONS
2.5 2.6 2.7 2.10

2.9

Pilot mobility technologies on mountain corridors

Identify mobility technology pilot projects particularly well-suited to address and respond to the unique conditions of the Front Range's mountain corridors (I-70, US-285, US-6) and communities. The Front Range generates high demand on weekends and holidays to access the Rocky Mountains using a highway system that is often constrained by challenging topography and winter weather conditions.

THEMES
Safety, Infrastructure Governance

ACTION INITIATOR
CDOT

ADDITIONAL PARTICIPANTS
New mobility entity, (see TA 1.2), I-70 Mountain Corridor Coalition

RELATED ACTIONS
2.7

SMART I-70 PROGRAM INSTALLED BY CDOT
CDOT's Smart I-70 program has installed 100 V2X roadside units along the I-70 Mountain Corridor from Golden to Vail. Units communicate with the CDOT fleet, and eventually any other connected vehicles on the corridor.

2.10

Pilot modular lanes

Conduct a pilot project to investigate the feasibility and required technologies to implement modular lanes. Modular lanes use technology to adjust lane width and uses at different times of the day or week.

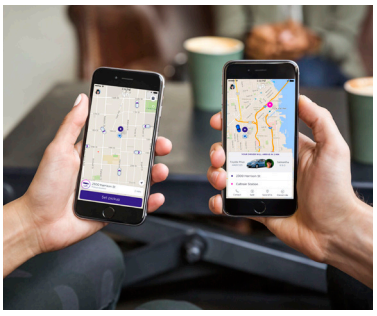
THEMES
Safety, Efficiency & Sustainability, Infrastructure Governance

ACTION INITIATOR
CDOT

ADDITIONAL PARTICIPANTS
N/A

RELATED ACTIONS
2.8

"The roadway technology alerts our car of winter conditions, giving us a smoother and more reliable trip to the mountains."



Objective 3

Shared Mobility

Integrate new options of vehicle sharing and ridesharing into the existing multimodal transportation system network

+ Incentives for sharing rides.
+ Flexible regulations for safely accommodating shared mobility options.
+ Collaboration between public agencies and private sector innovators.
+ New mobility options provided to residents in underserved areas.
+ Seamless access to all modes of travel across the region.
+ Maximized use of the existing transit system.

Shared mobility technologies could catalyze changes in travel behavior.

BENEFITS

The following describes a mobility future for the year 2030 where the region has successfully integrated shared mobility into the transportation system.

- Increased equity of access to mobility services across the region.
- Ridehailing patrons can expect consistent service.
- Reduced congestion caused by mid-block loading and reduced additional travel without a passenger.
- Maximized investments in the FasTracks system.
- Improved traveler experience across all modes.
- Micromobility services are safe and consistent.
- Parking, ridehailing loading, freight delivery, and other curbside activities are predictable, efficient, and equitable.
- Accessing multiple modes of transportation within a neighborhood is safe, equitable, and orderly.

MEASURED EFFECTS

By implementing the policies, programs, and initiatives introduced in this section, the region could expect to see quantitative improvements.

The Blueprint regional travel model replicating the effect of microtransit and First and Last Mile improvements (instead of local fixed-route service) indicates a 5% to 25% increase in feeder bus route ridership to rail stations.

A coordinated program to reduce travel without passengers and increase the rate of shared rides decreases the amount of VMT by 2% during the peak hour.

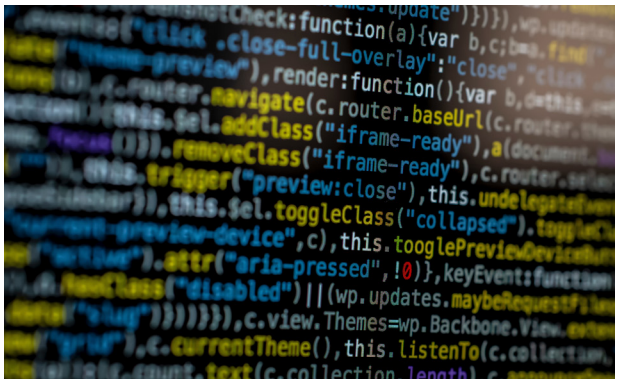
NEW REGIONAL SHARED MOBILITY PROGRAMS AND PILOTS

For a complete listing of new mobility pilot projects in the Denver region, see Appendix B.

- **FlexRide program** – RTD is developing a program to supplement its call-n-ride service (now FlexRide) with ridehailing. Passengers would book FlexRide trips on the web, mobile app, or via phone using the MobilityDR platform, which would schedule the passenger's trip onto ridehailing, taxi, or traditional FlexRide, as appropriate through the respective software platforms.

- **The Ditch Your Car program** – A collaboration between Lyft, Zipcar, and RTD challenged participants to go car-free for one month. In exchange, each traveler received $300 in Lyft shared credit, $150 in Lyft Scooter credit, a one-month regional RTD pass valued at $171 and a one-month Zipcar membership with a $100 drive credit to use toward covering the distance from their homes and offices to a train or bus stop.

- **The Link service** – The City of Lone Tree is piloting Uber software to allow on-demand routing of its Lone Tree Link buses at Lincoln Station. The Link is a free shuttle service that connects key employment centers along Park Meadows Drive with restaurants, retail, and the RTD transit system.



Tactical Actions

3.1

Develop a universal mobility app for trip planning and payment

Implement an account-based, multipurpose user-friendly mobility app accessible to all. The app would provide one-stop-shop access to trip planning, fare payment, and vehicle arrival times across all mobility providers, both public agencies (RTD and the E-470 Public Highway Authority) and private providers (Lyft, Uber, B-Cycle, and others). Development of the app would require a vendor partner to integrate and market the branded regional app.

THEMES
Human Experience

ACTION INITIATOR
RTD

ADDITIONAL PARTICIPANTS
New mobility entity (see TA 1.2), E-470 Public Highway Authority, Northwest Parkway Public Highway Authority

RELATED ACTIONS
1.4

3.2

Adopt a regional compact defining common standards for micromobility services

Adopt common standards and guidelines for micromobility services that address such issues as ensuring equitable access, data sharing requirements, protection of personal information, and use of the public right-of-way (including shared mobility lanes and mobility hubs).

THEMES
Safety, Human Experience, Infrastructure Governance

ACTION INITIATOR
DRCOG

ADDITIONAL PARTICIPANTS
Cities, counties

RELATED ACTIONS
1.1 4.2

3.3

Develop incentives to improve ridehailing and ridesharing operations

Develop a suite of incentives encouraging ridehailing services to integrate with the regional transit network, increase shared ride pooling, provide services in mobility-challenged communities, minimize travel without a passenger, decrease idling time, and improve safety of passenger loading.

THEMES
Safety, Human Experience

ACTION INITIATOR
RTD, cities, counties

ADDITIONAL PARTICIPANTS
DRCOG

RELATED ACTIONS
3.4 3.6 6.2

"The new single payment mobility app helps make my commute feel more seamless, even though I'm using multiple modes of transportation."

3.4

Implement curbside management standards

Implement standards for curbside passenger loading and freight delivery by developing policies and employing technologies to monitor, enforce, and monetize curbside operations.

THEMES
Safety, Human Experience, Efficiency & Sustainability

ACTION INITIATOR
DRCOG, RTD

ADDITIONAL PARTICIPANTS
Cities, counties, new mobility entity (see TA 1.2)

RELATED ACTIONS
3.3

"With my increasing physical disability, I need and appreciate the convenience of ridehailing more than ever."

3.5

Pilot neighborhood-scale mobility hubs

Conduct pilot projects of neighborhood mobility hubs at different scales in diverse locations, including mobility-challenged communities. Mobility hubs are nodes on the transportation network that connect many modes of transportation, such as transit, bike sharing, car sharing, and other on-demand services.

THEMES
Human Experience, Efficiency & Sustainability

ACTION INITIATOR
DRCOG, RTD

ADDITIONAL PARTICIPANTS
Cities, counties, new mobility entity (see TA 1.2), transportation management associations

RELATED ACTIONS
N/A

DRCOG WORKING TO IMPROVE COMMUNITY CONNECTIONS
DRCOG is developing guidance for jurisdictions hoping to implement mobility hubs, offering an array of transportation options near transit and high-density development.

3.6

Partner with the private sector to provide transportation in mobility-challenged communities

Create partnerships with ridehailing, microtransit, and other providers to establish mobility service in areas that do not meet fixed-route bus service standards. Consider connections to and from elderly housing, low-income areas, and human services facilities.

THEMES
Human Experience, Efficiency & Sustainability

ACTION INITIATOR
DRCOG, RTD

ADDITIONAL PARTICIPANTS
Cities, counties, neighborhood groups, transportation management associations

RELATED ACTIONS
3.3

3.7

Pilot smart parking at Park-n-Rides

Fund and implement a smart parking system that could provide digital signage, dynamic pricing, and real-time occupancy information. Conduct the pilot projects at congested park-n-rides on the RTD rail and Bus Rapid Transit system.

THEMES
Efficiency & Sustainability, Infrastructure Governance

ACTION INITIATOR
RTD

ADDITIONAL PARTICIPANTS
New mobility entity (see TA 1.2)

RELATED ACTIONS
N/A

Objective 4

Data Security and Sharing

Analyze travel data from public and private mobility providers to improve transportation system performance while maintaining security and protecting privacy

+ One commonly shared data platform across the region.
+ Shared data is secure and used for specific, defined purposes.
+ Private operators share data with public agencies.

Even with a coordinated regional approach to data analysis, concerns remain about maintaining the privacy of individual travelers and protecting sensitive information.

BENEFITS

The following describes a mobility future for the year 2030 where the region has successfully captured, shared, and analyzed mobility data.

Anonymous mobility data is available for analysis and traveler information.

Regional data security procedures and protocol are coordinated and effective.

The region employs common data sharing and security standards.

Standard data formats provide a platform for interoperability among end users.

STUDY LOOKS TO IMPROVE BIKE SHARE AVAILABILITY
Could location data help improve bike share stations? A recent study[vi] used mobile phone data to estimate potential demand of bicycle trips in a city and suggest locations of bike sharing stations based on the total demand generated at each cell phone tower.

Tactical Actions

4.1

Establish a regional mobility data platform

Create a regional mobility data platform that houses transportation-related data from all transportation sources with access provided to all agencies. The platform consolidates archived and real-time data from multiple agencies and private providers into a single data repository. Implementation of the data platform will involve:

+ Establishing policy standards for data sharing between regional stakeholders for interoperability
+ Establishing security standards for maintaining privacy and data anonymity
+ Creating policies that will ensure the interoperability of infrastructure and software
+ Developing open, machine-readable data publication from instrumented infrastructure
+ Promoting the development of open, well-documented Application Program Interfaces (API)

THEMES
Human Experience, Infrastructure Governance

ACTION INITIATOR
CDOT, DRCOG, RTD, Denver Metro Chamber

ADDITIONAL PARTICIPANTS
Cities, counties, National Renewable Energy Laboratory, universities, new mobility entity (see TA 1.2), Colorado Office of Information Technology

RELATED ACTIONS
1.1 1.2

SEATTLE USING VEHICLE SPEED DATA FOR SAFETY
The Seattle Department of Transportation (SDOT) collects vehicle speed data, which is particularly useful for making traffic safety decisions, such as those connected with traffic calming, Safe Routes to School, Seattle's Vision Zero Plan, and crossing improvements.

4.2

Establish data sharing requirements for private sector roadway users

Establish standard data sharing agreements that address travel use, privacy, and data security with private sector mobility providers to be offered to municipalities and other public agencies in the region for negotiating and contracting.

THEMES
Infrastructure Governance

ACTION INITIATOR
DRCOG

ADDITIONAL PARTICIPANTS
New mobility entity (see TA 1.2), cities, counties

RELATED ACTIONS
3.2

SMART COLUMBUS OPERATING SYSTEM
The Smart Columbus Operating System features an Open Data Platform, which will manage 1,100 data feeds and distribute them to government offices and private sector companies to give access to the city's latest mobility data. The City challenges and encourages anyone to use the data to solve mobility challenges in innovative ways. Columbus Mayor Andrew Ginther told AP that the launch marks a "major milestone" for the city. "Fundamental to 'becoming smart' as a city is discovering how to use data to improve city services and quality of life for residents," he said. (smartcolumbusos.com)

Objective 5

Mobility Electrification

Encourage use of electric powertrains in automobiles and transit vehicles

+ Individual and fleet ownership of electric vehicles is encouraged.
+ Government fleets are largely converted to electric or other zero-emission vehicles.
+ Charging kiosks are widely available.

Colorado is already a leader in mobility electrification. The state ranked sixth in electric vehicle sales in 2018.

BENEFITS

The following describes a mobility future for the year 2030 where the region has successfully encouraged mobility electrification.

Technology integration improves air quality and lowers costs.

Access to new mobility options increases while greenhouse gas emissions decrease.

Growing renewable energy resources facilitates the transition away from carbon-based fuels.

ELECTRIC VEHICLES IN THE METRO AREA

The emergence of plug-in electric vehicles has already spurred the installation of close to 300 charging locations in the Denver region. In August 2017, the City and County of Denver, the Regional Air Quality Council, and the Southwest Energy Efficiency Project issued the 'Opportunities for Vehicle Electrification in the Denver Metro Area and Across Colorado' report that examined some of the major barriers to higher plug-in electric vehicle adoption rates in Denver and identified steps to address those barriers.

COLORADO INVESTS IN POLLUTION REDUCTION

In March 2018, the state of Colorado unveiled a plan to spend its $68.7 million share of the $2.7 billion national Volkswagen Settlement to cut car and truck emissions statewide by investing in electric and alternative fuel vehicles and infrastructure.

MEASURED EFFECTS

By implementing the policies, programs, and initiatives introduced in this section, the region could expect to see quantitative improvements

Electric vehicles (EV) have zero tailpipe emissions and do not degrade air quality in areas where they operate. EVs do produce lifecycle emissions via the production of electricity and in building the cars themselves, as is the case with gasoline cars. The Argonne National Lab has developed a model that takes into account all those fa-ctors and calculates how much pollution each type of vehicle generates during its lifecycle.

THIS MODEL INDICATES THE FOLLOWING:

- EVs in the Denver area generate **41% less carbon dioxide** per mile compared to gasoline-powered vehicles.
- EVs in Denver generate **87% less carbon monoxide, 23% less nitrogen oxide, and 36% less volatile organic compounds** than gasoline-powered vehicles.
- In Denver, EVs result in **slightly more particulate matter generation**, mostly in the vicinity of the electricity generation plants, although not by the vehicles themselves.

Tactical Actions

5.1

Incentivize ridehailing and ridesharing providers to use electric vehicles

Develop a goal, create a policy, and incentivize the deployment and use of electric and other zero-emission vehicles by ridehailing providers.

THEMES
Efficiency & Sustainability

ACTION INITIATOR
DRCOG

ADDITIONAL PARTICIPANTS
New mobility entity (see TA 1.2)

RELATED ACTIONS
N/A

5.2

Create an electrified mobility development program

Identify regulatory hurdles and develop recommendations to encourage the adoption of electric vehicles by public and private fleets.

THEMES
Efficiency & Sustainability

ACTION INITIATOR
Denver Metro Chamber

ADDITIONAL PARTICIPANTS
Utility companies (i.e., Xcel), Public Utilities Commission, state legislature

RELATED ACTIONS
N/A

5.3

Transition government fleets to electric and other zero-emission vehicles

Work with public agencies to create an aggressive and agreed-upon goal for converting a portion of their fleets to zero-emission vehicles. The goals may be tailored to fleet types, as well as available vehicle technology.

THEMES
Efficiency & Sustainability

ACTION INITIATOR
CDOT, DRCOG, RTD

ADDITIONAL PARTICIPANTS
Cities, counties, Colorado Energy Office, Regional Air Quality Council

RELATED ACTIONS
N/A

Objective 6

Driverless Vehicle Preparation

Prepare for driverless vehicles to provide safe operations and reduced congestion while retaining a positive human experience

- Use of driverless microtransit vehicles for serving disadvantaged populations is commonplace.
- People are confident that automated vehicles are safe.
- The infrastructure and technology to support driverless vehicles are in place and integrated into the transportation network.
- Licensing and regulation for safe operation of driverless vehicles are established.

Without a coordinated effort to minimize single- and even zero-occupant vehicle trips, driverless vehicles could increase congestion, placing further burdens on infrastructure and worsening air quality.

BENEFITS

The following describes a mobility future for the year 2030 where the region has successfully prepared for driverless automated vehicles.

The public is more comfortable with the presence of AVs.

Agencies are able to effectively, safely, and equitably integrate AVs into the transportation system.

The future growth in congestion is lessened as a result of increased vehicle occupancy.

Zero-occupant vehicles do not create unnecessary vehicle miles traveled (VMT) and associated congestion.

Tactical Actions

6.1

Pilot driverless microtransit to increase public exposure to automated vehicle technology

To ease the transition to this new mobility paradigm, conduct additional demonstrations of automated microtransit to increase First and Last Mile connections to FasTracks stations and create more opportunities for the general public to experience driverless vehicle technology firsthand.

THEMES
Human Experience, Efficiency & Sustainability

ACTION INITIATOR
RTD

ADDITIONAL PARTICIPANTS
New mobility entity (see TA 1.2), cities, counties, CDOT, DRCOG, transportation management associations

RELATED ACTIONS
N/A

6.2

Minimize zero occupancy and encourage high shared use of driverless automated vehicles

Investigate and develop recommendations for policies to discourage zero-occupant trips. In addition, develop a goal, create a policy, and provide incentives to build a framework that encourages sharing rides in driverless, automated vehicles as they enter the regional market.

THEMES
Efficiency & Sustainability

ACTION INITIATOR
CDOT, DRCOG

ADDITIONAL PARTICIPANTS
State legislature, ridehailing providers

RELATED ACTIONS
3.3

EASYMILE AUTONOMOUS SHUTTLES TO CONNECT TO UNIVERSITY OF COLORADO A LINE STATION
EasyMile, which has located its North American headquarters at Peña Station NEXT, is preparing to operate autonomous shuttles to connect with RTD's A Line commuter rail stop.

Preparing for the Future of Transportation; Automated Vehicles 3.0

In October 2018, USDOT released the third, cumulative guidance document and policy "Preparing for the Future of Transportation; Automated Vehicles 3.0," which affirms that states retain responsibilities for:

+ Licensing and registering vehicles.
+ Defining and enforcing traffic laws.
+ Regulating insurance and liability requirements and policies.
+ Addressing unnecessary impediments to safe use of AVs.
+ Updating references to human drivers in motor vehicle codes.
+ Jointly working with jurisdictions to standardize roadway signs, markings, signals, lights, and other infrastructure.

6.3

Support legislative efforts to ensure that automated vehicles operate safely

Develop recommendations for the state legislature on potential approaches to testing, licensing, and regulating private and shared automated vehicles to ensure the safe operation of such vehicles in Colorado.

THEMES
Safety, Infrastructure Governance

ACTION INITIATOR
CDOT

ADDITIONAL PARTICIPANTS
USDOT, Denver Metro Chamber, state legislature

RELATED ACTIONS
N/A

Objective 7

Transportation Funding Options

Establish new funding sources to replace traditional sources that are losing effectiveness

- Existing transportation budgets are redistributed to align with emerging mobility technology opportunities.
- Sustainable and equitable funding streams based on alternate revenue models to the gas tax.
- Maximum use of all applicable federal and private grant funding programs.
- Funding models are used to incentivize behaviors.

Regardless of the method, there is a clear imperative to think creatively to establish new sources of mobility funding as travel options enabled by new technology are expected to further increase the gap between needs and available funds.

BENEFITS

The following describes a mobility future for the year 2030 where the region has successfully established new funding sources dedicated to mobility.

The region can rely on a sustainable and equitable source of transportation funding.

New mobility technologies pay their fair share and are efficiently integrated in the region's transportation system.

Transportation investments reflect technology's impact on mobility.

PILOT PROGRAMS EXPANDED TO TEST USE OF MILEAGE-BASED USER FEES
Washington, California, and Utah have conducted pilot projects to test mileage-based user fees as alternative to the gas tax. Oregon has implemented a voluntary road usage charge (RUC) program. CDOT completed a RUC pilot study to test its feasibility, along with different options for the state.

Tactical Actions

7.1

Expand DRCOG funding earmark for a mobility technology innovation fund

Expand upon the current funding set aside for mobility technology projects within the DRCOG Transportation Improvement Program.

THEMES
Funding & Finance

ACTION INITIATOR
DRCOG

ADDITIONAL PARTICIPANTS
N/A

RELATED ACTIONS
N/A

7.2

Explore the concept of a road usage charge for Colorado

Build on past CDOT studies to pilot systems, develop policies, and formulate recommendations to the state legislature on the potential creation of a Road Usage Charge system that to provide an alternative funding source for transportation.

THEMES
Funding & Finance

ACTION INITIATOR
CDOT

ADDITIONAL PARTICIPANTS
DRCOG, state legislature, Denver Metro Chamber

RELATED ACTIONS
N/A

7.3

Support legislative efforts to ensure that driverless automated vehicles generate appropriate funding

Develop recommendations for the state legislature on potential new user fees, registration fees, or other appropriate revenue streams to prepare the region for the anticipated future deployment of private and shared driverless automated vehicles.

THEMES
Efficiency & Sustainability, Funding & Finance, Infrastructure Governance

ACTION INITIATOR
Denver Metro Chamber

ADDITIONAL PARTICIPANTS
CDOT

RELATED ACTIONS
N/A

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5

TOPICS

Chapter 5
Alignment of Recommended Actions

Summary of Actions

The Blueprint establishes a means for the three major transportation agencies in the Denver region to align their policies, programs, and pilot projects to deal with the transformation of our transportation systems brought about by technology. Concurrent with the alignment process, attention to the roles and partnerships offered through engagement with the private sector is critical for overall success.

The Memorandum of Agreement that brought the Mobility Choice partners together to prepare the Blueprint expired at the end of 2018. There is a critical need for the partners to take on the responsibilities for individual Tactical Actions, but also to continue working together to jointly implement the overall Blueprint. This section outlines the next steps to advance the set of recommended actions.

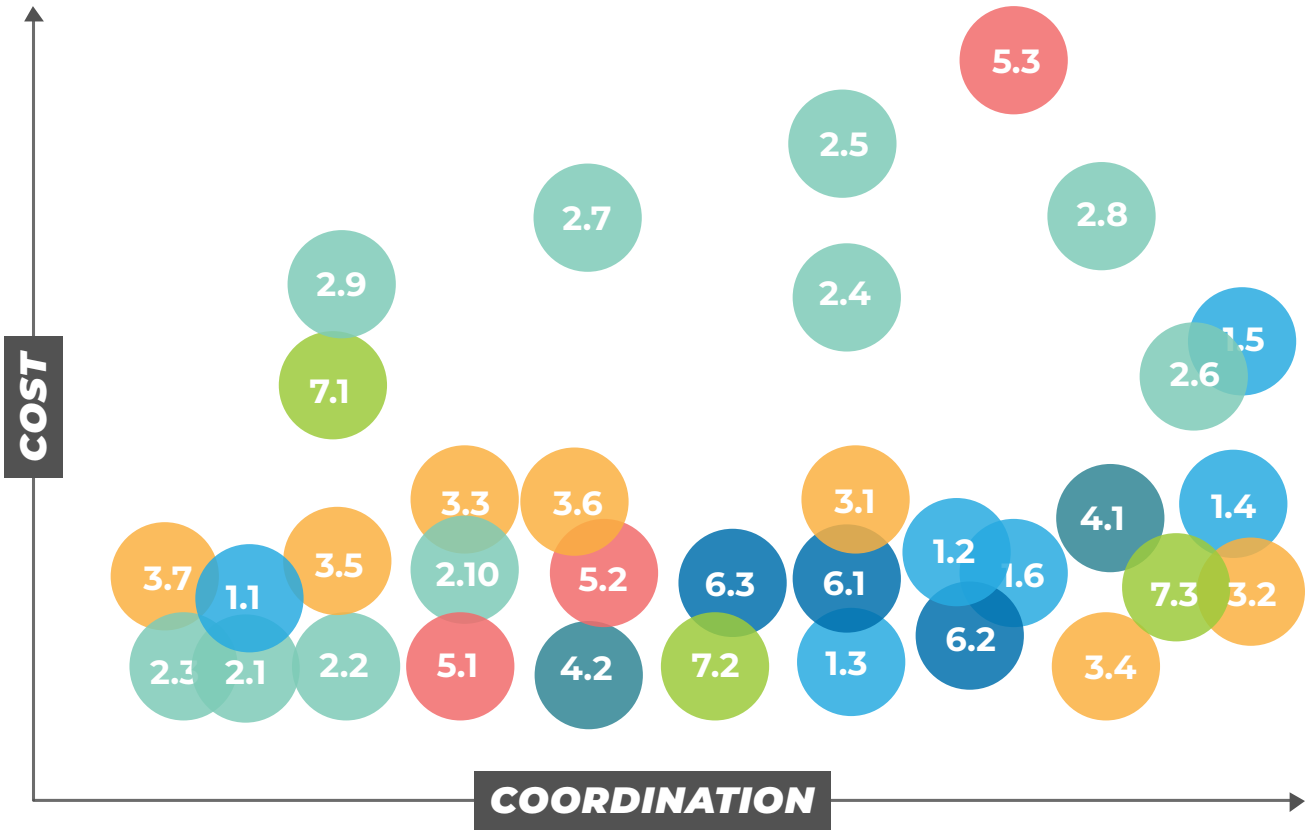
IMPLEMENTATION OF THE BLUEPRINT WILL REQUIRE TWO THINGS FROM THE REGIONAL AGENCIES, IN PARTNERSHIP WITH THE PRIVATE SECTOR:

Investment and Funding (Cost)

Policy Development and Coordination (Coordination)

IMPLEMENTATION OF TACTICAL ACTIONS

Each of the Blueprint's Tactical Actions will require some level of monetary investment. In addition, their implementation will take some level of coordination.



Objectives of Tactical Actions

- REGIONAL COLLABORATION
- SYSTEM OPTIMIZATION
- SHARED MOBILITY
- DATA SECURITY AND SHARING
- MOBILITY ELECTRIFICATION
- DRIVERLESS VEHICLE PREPARATION
- NEW TRANSPORTATION FUNDING

Rating each of the Tactical Actions across these two axes sets expectations about the relative level of effort for each of these levers required to successfully implement the actions. The graph shows that relatively few of the Tactical Actions are high cost. And, some of them will take a high level of collaboration and coordination between regional agencies.

The takeaway is that coordination presents a greater challenge than cost for the majority of the Tactical Actions. Agencies will need to strengthen existing ties and establish new collaborative mechanisms, among themselves and with the private sector, to maximize the opportunities presented by new mobility technologies.

Investment & Funding

One of the two primary components that public agencies can employ for developing and directing transportation programs is the level of public investment in the policies, programs, and pilot projects. Addressing needs that arise due to the technology transformation and resulting emerging mobility systems will likely require changes in the way transportation is funded and then programmed. When considering the CASE mobility systems (Connected, Automated, Shared, Electric), it is clear that each system type will have shared requirements but also specific needs for implementation. Funding will be required for capital improvements at the outset, and then operations and maintenance over time.

GENERALIZING THE TRANSITION TO "CASE," THERE ARE FOUR FUNDING OPTIONS TO CONSIDER:

+ Public investment using existing and new sources, as well as discretionary grant funding.
+ Private sector investments from for-profit businesses.
+ Investment partnerships between and among public agencies and the private sector.
+ New funding sources.

Public Investment

Traditional funding sources are not adequate to maintain, operate, and improve the existing transportation system, let alone make investments preparing for emerging technologies. Just as critical portions of the Denver region's infrastructure near the ends of their useful life, existing funding mechanisms deliver less revenue per user than ever before. Increases in fuel efficiency have diminished the ability of the gas tax to keep up with modern roadway demands. CDOT alone estimates that it faces a $25 billion funding gap over the next 25 years.

Traditional transportation funding sources are also structured around the assumption of private vehicle ownership. As AVs help accelerate a shift to fleet ownership, new revenue models will be needed. To this end, several cities and states are experimenting with strategies for ridehailing services taxes and fees.

In addition to broad-base funding structures there are numerous federal and private grant funding that cities and states can use to pilot and deploy advanced transportation technologies.

Regardless of the method, there is a clear imperative to think creatively to establish new sources of mobility funding as travel options enabled by new technology stand to further increase the gap between needs and available funds.

Public agencies at all levels—federal, state, regional, and local—have been actively planning for the expected integration of CASE projects and programs. DRCOG's Transportation Improvement Program (TIP) covers a four-year timeframe and includes primarily traditional transportation projects, with some technology infrastructure. Changing the focus of existing programmed funding to incorporate more technology projects would likely delay the timing of construction of needed improvements.

The likely approach will be to incrementally transition the priorities for funding traditional capacity projects to prioritizing funding for technology projects so that they receive an increased share of the programmed funds.

DRCOG Programs

In the Denver region, DRCOG uses a four-year TIP and is presently developing the 2020-2023 TIP. In this program, there are several sources that could be tapped to implement the Blueprint's Tactical Actions, including:

REGIONAL TRANSPORTATION OPERATIONS & TECHNOLOGY SET-ASIDE PROGRAM

In anticipation of the need to fund technology-related actions, DRCOG adjusted the TIP programming process to establish this set-aside program funded at $20 million over the four-year period. Calls for projects are tentatively scheduled for the fall of 2019 and again in 2021. Each set-aside program will have its own eligibility requirements and criteria, including minimum project funding amount requests, along with a scoring system to recommend projects to the DRCOG Board for inclusion into the TIP at appropriate times.

SURFACE TRANSPORTATION BLOCK GRANT PROGRAM

This program is the most flexible and can be used for a variety of transportation projects and programs, including:

- Construction/ reconstruction, rehabilitation and operational improvements on the existing system.
- Capital costs for transit projects.
- Vehicle-to-Infrastructure (V2I) communication equipment.
- Capital and operating costs for traffic monitoring, management and control.
- Transportation system management actions.
- Studies as necessary to plan and implement the above.

CONGESTION MITIGATION/AIR QUALITY (CMAQ)

These funds are for projects and programs that provide air quality benefits by reducing emissions and congestion. Example projects related to technology include:

- Traffic signal coordination
- Intelligent transportation systems
- V2I communication equipment
- Arranged ridesharing
- Bicycle and pedestrian travel projects
- Rapid and bus transit improvements (new/ expanded/capital service)
- High-occupancy vehicle/ high-occupancy toll (HOV/ HOT) lanes
- Traffic flow improvements
- Alternative fuels (electrified mobility) infrastructure and vehicles
- Intermodal freight facilities that reduce truck VMT or emissions
- Studies as necessary to plan and implement the above.

COURTESY OF DRCOG

CDOT Programs

From 2018 to 2023, CDOT is implementing an aggressive Advanced Mobility program to integrate emerging mobility systems into the state transportation network. Portions of this program could be directed to Blueprint Tactical Actions. The Advanced Mobility program has two areas of focus related to emerging mobility systems:

CONNECTED AND AUTONOMOUS MOBILITY

- Infrastructure for navigation and maneuverability: striping and signing standards, interoperable data, work zone and lane closure data, V2X infrastructure
- Operations strategies: signal operations, variable speed limits, platooning, winter operations
- Connections to local destination/mobility centers: consistent physical and digital infrastructure standards (broadband, Wi-Fi, electric charging)

SUSTAINABLE MOBILITY

- Electrification: charging systems, solar generation, inroad infrastructure
- Mobility on demand: trip planning/payment platforms; services (first/last mile, car/ride sharing, mobility centers)
- New infrastructure/technology: rapid speed/ hyperloop, vertical takeoff/landing vehicles, smart pavement, smart truck parking

ADVANCED MOBILITY PROGRAM

Starting in 2019 and into 2020, CDOT will be implementing its Advanced Mobility Program that will include the following:

MOBILITY OPERATIONS (FY 19 INVESTMENTS - $20.5 MILLION)

FOUNDATIONAL INFRASTRUCTURE - $6 MILLION

- Fiber optics
- IT sensors
- Leverages public-private partnerships
- Supports rural broadband
- Operations Center co-located with Colorado State Patrol

DATA INTELLIGENCE - $23.5 M PLUS BUILD GRANT

- V2X Ecosystem (Panasonic $17.4 million)
- Internet of Roadways (V2X roadway network – 2,000 miles of State System)
- 2018 recipient of FHWA BUILD grant of $20 million to be programmed)
- Data analytics intelligence system (DAISy)

HIGHWAY AUTOMATION - $1 MILLION

- Planning
- Standards development
- Work zone data
- Proposed striping improvements

ROADX (PILOT PROGRAMS - $12 MILLION)

- Smart 25 - $7 million
- Smart Pavement – up to $1 million
- Smart Truck Parking - $500,000
- Bicycle/Pedestrian Challenge - $250,000
- Rapid Speed Travel - $250,000
- Rural Road Challenge – up to $250,000

UPCOMING:

- Smart Powered Lanes
- Urban Air Mobility
- Workforce of the Future

RTD Programs

RTD is initiating the Transportation Transformation program, or T2, that will reshape the agency to be a "mobility integrator" for the region. T2 will establish a new vision and direction for the agency as it completes implementation of the FasTracks program and looks toward the future and emerging technologies.

TECHNOLOGY-DRIVEN CHANGE RESOURCES

The program will provide several resources to plan for and respond to technology-driven change and includes several of the Blueprint Tactical Actions, for example:

- T2 Comprehensive Plan - a comprehensive operational analysis/ system optimization plan
- Alternative service delivery approaches (non-traditional fixed-route public transit)
- Focused bus service improvements, including bus rapid transit
- Other transit First and Last Mile opportunities
- Account-based fare payment
- Completion of unfunded transit corridors
- Fleet electrification

TRANSIT CAPITAL & OPERATING EXPENSE RESOURCES

Funding and other resources that are available for RTD for transit capital and operating expense include: :

- Federal Transit Administration (FTA) Mobility Sandbox ($12 million; ~four to five awards per year).
- FTA 5310 formula grants for Enhanced Mobility of Seniors & Individuals with Disabilities - Funding for the purpose of assisting private nonprofit groups in meeting transportation needs of the elderly and persons with disabilities.
- FTA Congestion Mitigation and Air Quality (CMAQ) Program - 23 USC 149. The flexible funding program provides funding to areas in nonattainment or maintenance for ozone, carbon monoxide, and/or particulate matter. States that have no nonattainment or maintenance areas still receive a minimum apportionment of CMAQ funding for either air quality projects or other elements of flexible spending. Funds may be used for any transit capital expenditures otherwise eligible for FTA funding as long as they have an air quality benefit.
- FTA 5339(a) formula grants for Buses and Bus Facilities - Provides funding to states and transit agencies through a statutory formula to replace, rehabilitate and purchase buses and related equipment and to construct bus-related facilities
- FTA formula grant Low and No-Emission Component Assessment Program (LoNo-CAP). Eligible institutions of higher education can apply for funding to conduct testing, evaluation, and analysis of low or no emission (LoNo) components intended for use in LoNo transit buses used to provide public transportation.
- FTA 5339(c) Low or No Emission Vehicle Program - Provides funding through a competitive process to states and transit agencies to purchase or lease low- or no-emission transit buses and related equipment, or to lease, construct, or rehabilitate facilities to support low or no emission transit buses. The program provides funding to support the wider deployment of advanced propulsion technologies within the nation's transit fleet.
- FTA 5309 Pilot Program for Transit-Oriented Development Planning - Provides funding to local communities to integrate land use and transportation planning with a transit capital investment that will seek funding through the Capital Investment Grant (CIG) Program.
- FTA Zero Emission Research Opportunity (ZERO) –Nonprofit organizations can apply for funding to conduct research, demonstrations, testing, and evaluation of zero emission and related technology for public transportation applications.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Federal Discretionary Grant Programs

USDOT

The USDOT has several programs with discretionary funding for transportation projects meeting specific criteria. For example, under the $1.5 billion “Better Utilizing Investments to Leverage Development” or BUILD discretionary grant program, the USDOT awarded funding to 91 projects in 49 states and the District of Columbia for a wide variety of road, rail, transit, port, and even broadband infrastructure projects. The agency noted that demand far exceeded available funds, as it received 851 eligible applications from all 50 states, as well as U.S. territories and the District of Columbia, representing collectively more than $10.9 billion in funding.

USDOT evaluates and selects the projects based first on a broad series of criteria – such as safety, economic competitiveness, quality of life, environmental protection, and state of good repair – then on more specific goals, such as support for connected and autonomous vehicle or CAV infrastructure, broadband service to underserved communities, plus public-private sector infrastructure partnerships or P3s.

Two projects in Colorado were successful in receiving awards under the current fiscal year BUILD program. The City of Glenwood Springs was awarded more than $7 million for the reconstruction of South Midland Avenue, which includes monies to install broadband infrastructure, coordinate traffic signals, and relocate existing overhead utilities. CDOT also received $20 million to create a 537-mile commercial-scale connected vehicle environment—the country’s first commercial-scale network using vehicle to everything (V2X) technology. The project will form an “Internet of Roadways” using vehicle-to-everything (V2X) technology with real-time communication capability. That system will send safety and mobility-critical messages directly to drivers through infrastructure-to-vehicle (I2V) channels, as well as notify CDOT of crashes or hazards on the road via vehicle-to-infrastructure (V2I) communication. The eventual system is planned to cover 2,000 miles in total.

GRANT PROGRAMS

Grant programs are also being developed to respond to changing conditions in the technology marketplace. For example, USDOT issued a Notice of Funding Availability for “Automated Driving System Demonstration Grants” on December 21, 2018. Applications are due March 21, 2019 with up to $60 million to be awarded for “demonstration projects that test the safe integration of automated driving systems into the Nation’s on-road transportation system.”

With implementation of Tactical Action 1.1 "Establish a mobility technology advisory committee," and Tactical Action 1.6 "Establish a regional smart mobility navigator," the Denver region would be ready to benefit from these types of funding opportunities.

Private sector investments from for-profit businesses

A wide number of private sector businesses are already working to respond to technology changes in our regional transportation system. These businesses are at times disrupting and at times complementing the facilities and services that transportation agencies are operating. The Blueprint recognizes these forces and is seeking to integrate the actions to achieve our overall desired mobility future.

Private sector companies are currently making significant investments to fill the demand from consumers for transportation services. TNCs are the most obvious example, but private investment is also being made in connected and autonomous vehicles, in shared transportation, and in the conversion to electrified mobility. Allowing the marketplace to dictate the direction and magnitude of private investment will likely result in "easy adoption/high revenue return" projects being implemented early by the private sector. In many cases, the result is that agencies and the public would be left to develop and implement the more costly and more difficult actions to achieve overall Blueprint objectives, such as balanced access and mobility equity.

Through use of an organizing structure, such as the Blueprint, the public and private sectors will be encouraged to work together to achieve desired outcomes. Policies and programs to incentivize or to discourage private sector actions can help to direct private investments. Partnerships can use the mixture of funds to implement actions.

Private sector investments will continue to be made if there is a return that accrues to the investor. Some level of profit must be available to the private sector as they fulfill roles in the transportation system. Some roles would be integrated with agency programs while others would be independent. In each case, a reasonable return will be necessary to gain their participation.

The private sector also has an overall business development interest that could be used to engage participation. Emerging mobility systems use successful applications to demonstrate benefit and utility. Pilot projects and similar research and development activities seek ways to demonstrate "proof of concept." The numerous pilot projects referenced in Appendix B are examples of research and development activities that, if proven successful, could have applications in other locations.

A key reason for Tactical Action 1.2 "Establish a new public-private mobility entity or entities to pursue mobility technology implementation" is to consider the ways in which the private sector conducts business differently from the public sector. The entity would help to "merge" the two types of approaches to achieve the Blueprint objectives and to implement pilot projects. Funding participation could be a part of those partnerships. The public sector has developed good experience in forming public-private partnerships (P3) for major infrastructure projects; this experience will be helpful to structure ways to partner with the private sector for mobility services.

As the Denver region moves forward with the Blueprint, one of the key challenges will be the transition from thinking about and consuming transportation facilities and services as a "commodity" to choosing and consuming transportation as a "service."

As the Denver region moves forward with the Blueprint, one of the key challenges will be the transition from thinking about and consuming transportation facilities and services as a "commodity," to choosing and consuming transportation as a "service." In the later condition, successful transition to a Mobility as a Service program depends upon the collaboration, regional perspective and integration of new programs across the entire transportation system. In many ways, change will require a new way of thinking to build partnerships that will be a new way to offer and then consume mobility. To be successful, the Blueprint must generate benefits to both the private sector and the public sector.

Partnership Funding Programs

A key element of the Blueprint is the formation of public and private sector partnerships to implement the Tactical Actions. In some cases, federal and state grant monies are available to support partnerships. Some programs support participation by higher-education institutions. The proposed alliance of the University of Colorado, University of Denver, and Colorado State University could jointly apply for funds. The three higher-education institutions are currently discussing the creation of an alliance for applied mobility research and education. The National Renewable Energy Lab (NREL), a federally funded institution based in Golden dedicated to the advancement of energy efficiency, sustainable transportation, and renewable power technologies, could also be a member of the university alliance.

Additional Sources

Additional sources available to support partnerships for the Tactical Actions include:

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST) SMART CITY GLOBAL CITY TEAMS CHALLENGE (GCTC)
The program brings together smart-community leaders from around the country to collaborate on common issues.

NATIONAL SCIENCE FOUNDATION (NSF) SMART AND CONNECTED COMMUNITIES (S&CC)
Awards monies for integrative grants for research that addresses the technological and social dimensions of smart and connected communities.

BLOOMBERG PHILANTHROPIES MAYORS CHALLENGE
A program that awards funds to test innovative ideas and advancement of policies related to potentially breakthrough solutions to homelessness, the opioid crisis, mobility, climate change, and economic opportunity.

UNIVERSITY TRANSPORTATION CENTERS (UTC) PROGRAM
A USDOT grant program that advances the state-of-the-art in transportation research and technology through education, solutions-oriented research and technology transfer, and the exploration and sharing of cutting-edge ideas and approaches.

FHWA AND FTA BROAD AGENCY ANNOUNCEMENTS
Applied research funds focused on technology research and development. In 2017 FHWA sponsored research under the Exploratory Research Grants on the Impacts of Automated Transit, Pedestrian, and Bicycling Facilities on Urban Travel Patterns)

SAFETY RESEARCH AND DEMONSTRATION PROGRAM
Part of a larger safety research effort at the USDOT, the program provides technical and financial support for transit agencies to pursue innovative approaches to eliminate or mitigate safety hazards with a focus on demonstration of technologies and safer designs.

AUTONOMOUS VEHICLE PROVING GROUNDS (AVPG)
In 2017, the USDOT designated 10 AVPG sites across the country where testing and research by public and private entities could be performed. Several of these proving grounds have kick-started their activities through the use of a public-private partnership. For example, as part of the Texas Alliance, the City of Arlington, Texas is establishing a microtransit service within the city limits through a partnership with Chariot, a private transportation provider.

New Funding Sources

As emerging mobility systems cause changes in the way that transportation is offered and consumed, the way transportation systems are paid for and maintained must change. The current primary system of paying for the transportation network with user fees (through the gas-pump or through fares to transit agencies and transportation network companies) is generating less revenue. The gas tax as a user fee is being eroded as vehicle efficiency increases mileage-per-gallon and as zero-emission vehicles (electric and alternate fuels) become more widely used. Also, gas taxes have not been raised at the federal and state levels since the early 1990s and have not kept up with inflation, adding to the shortfall.

State agencies across the country are examining replacement options to the gas tax. Funding sources based on "vehicle per mile usage" are likely to be implemented as part of the emerging mobility systems. CDOT conducted the Road Usage Charge Pilot Program (RUCPP) Research Study in 2017 to determine the feasibility of a road usage charge (RUC) to replace the gas tax over time. The Oregon Department of Transportation has implemented a voluntary road usage charge program, capped now at 5,000 drivers. Washington state is conducting a pilot program, and Utah is preparing to implement a RUC for alternative fuel vehicles. Privacy concerns, collection and payment systems, and data security are among the issues that must be addressed to convert to such a system.

The Blueprint Tactical Actions will be easily integrated and supportive of changes to the revenue streams. By 2030, it is likely that consumers will have a much different perspective on choosing their transportation options. One of the major challenges facing transportation agencies is the transition from "mobility-as-a commodity" to "mobility-as-a-service"; it will be important for the Blueprint partners to continue to engage the public in the transition and to incorporate their interests and ideas to build the overall program.

The current primary system of paying for the transportation network with user fees (through the gas-pump or through fares to transit agencies and transportation network companies) is generating less revenue.

Policy Development & Coordination

The Blueprint must be responsive to other concurrent activities dealing with the "technology transformation" beyond the immediate region. Understanding these activities at the federal, state, and local levels relative to the Blueprint is necessary for its successful implementation over the next several years.

Resources for Implementation

There are numerous resources that outline ways for state, regional and local agencies to prepare for, develop, and implement policies, programs, and pilot projects for emerging mobility systems. Their emphasis in these resources has been on suggested actions to introduce CASE vehicles and operations across the transportation system. Resources include:

+ Preparing for the Future of Transportation – Automated Vehicles 3.0, USDOT, August 2018 (and versions 1.0 and 2.0).
+ Preparing for Automated Vehicles: Traffic Safety Issues for States, Governors Highway Safety Association, August 2018.
+ Advancing Automated and Connected Vehicles: Policy and Planning Strategies for State and Local Transportation Agencies, National Cooperative Highway Research Program (NCHRP), 2017.

COURTESY OF DRCOG

Strategies for Implementation

Each of the resources for implementation encourages the development of "ecosystems" of policies, programs, and pilot projects that begin to integrate actual autonomous driving systems (or automated vehicles) components or to provide flexibility to integrate them in the future. For example, the NCHRP guidance suggests:

> ***"Society could benefit if state, regional and local governments were to implement policy and planning strategies to:***
>
> - ***Internalize externalities (such as Traffic Crashes, Congestion, Pollution, Mobility and Land Development) in decisions by consumers; and,***
> - ***Reduce negative societal effects and increase positive societal effects of AVs and CVs regardless of whether they are internal or external to market decisions.***
>
> ***Both types of strategies would result in better societal outcomes."***

Engagement of stakeholders and the broader public in the process to develop such an ecosystem will be key to the successful implementation of the Blueprint and any actions beyond its scope. Increasing awareness and educating residents of the region about the benefits and the risks of automated vehicles are a key role for the Blueprint sponsoring agencies going forward.

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Partner Roles

The Blueprint identifies an Initiator agency that will take the leadership role in advancing each Tactical Action to the next step. With progress, the lead role is likely to evolve and change. Different entities could be identified as a more appropriate leader, and/or key partners could be added. Flexibility to respond to new information and conclusions will be important to building the preferred mobility future.

To benefit from emerging technologies, the Blueprint partners have recognized the significance of improved regional governance for advancing coordinated, integrated, and complementary mobility systems. The goal is not to merely amass a collection of new technologies, applications, and devices, but rather to achieve a tightly integrated network of highly functioning institutions that are aligned around a common regional goal. Through this deliberate collaborative effort to align agencies to advance enhanced mobility in the region, the private sector will be better able to approach the region as an innovative partner, rather than a system disrupter.

With increased synergy between agencies, the private sector will have a better understanding of the mobility problems the region is trying to address, as well as where individual technological applications can best be applied. The more open and collaborative the relationships between the Blueprint partners and the private sector, the greater the opportunity to deliver real access and mobility solutions to the region. In many cases the private sector is already modeling behaviors and deploying improved mobility applications within companies or campuses, which demonstrates commitments to the region's mobility future.

The Blueprint conversation started with CDOT, RTD, DRCOG, and the Denver Metro Chamber. The next step will be to engage and mobilize cites and counties along with interested organizations and the private sector to integrate Blueprint Tactical Actions into our communities.

Next Steps

The Blueprint charts a series of next steps, one of which is to more directly engage the public and private sectors to build our mobility future. Tactical Action 1.2 recommends to "Establish a public-private entity or entities to pursue mobility technology implementation." The Blueprint sponsoring agencies are actively working together to describe and then develop these relationships that could lead to a new entity or entities to fulfill this role.

Such an entity would be a partnership structured to bring together public and private members to accelerate the adoption of advanced mobility technologies. This public-private entity would be positioned to leverage and funnel such things as projects from research centers across the United States for commercialization and deployment in the Denver region. Such a center of excellence would signal to the transportation industry that Colorado is an innovator in mobility technology and stands ready to partner with businesses to deploy new products and systems.

MOBILITYNEXT EXAMPLE

An example organization for a public-private entity is the nascent MobilityNEXT. This new organization in the Denver region is partnered with the Colorado Smart Cities Alliance (CSCA), which is a coalition of public agencies, private companies, and academic institutions that provides an overarching connection to Colorado's municipalities, including those in the Denver region. MobilityNEXT seeks to forge a connection between public agencies and entrepreneurs to identify incubator opportunities for mobility integration. At the time of publishing the Blueprint, MobilityNext has initially explored partnerships with CDOT, DRCOG, RTD, City and County of Denver, Denver International Airport, and others. Because this partnership is just coming together, additional work to define partner roles and to add new partners is ongoing.

ADDITIONAL EXISTING PARTNERS

There are additional existing organizations that could support the MobilityNEXT or other public-private entities to bridge the gaps in the coordination or implementation of emerging mobility technologies. These additional partners might include state universities, particularly if a Colorado institution or an institutional alliance were to secure USDOT University Transportation Centers grant funds in the coming years. Furthermore, academic curricula for engineering, computer science and business programs are being evaluated to better prepare and develop students for this changing mobility environment. Universities and the federal national laboratories thus become an important partner to support the mobility technology industries and strengthen the potential for locally developed technology solutions for the region.

PLANNING TOOLS, PLANS, AND PROGRAMS

Finally, the region's traditional transportation planning tools will need to be augmented to reflect the diversity of travel options that are available now and in the future. Because the Blueprint is tied to the themes, outcomes, and objectives of DRCOG's Metro Vision, it will be important to begin to incorporate the relevant parts of the Blueprint pieces into future updates to the plan. The region's long-range transportation plans and short-range improvement programs also will need to be updated and refined to reflect Blueprint recommendations.

Our ability to work together to improve our quality of life has made the Denver region the envy of many across the nation. We now have an opportunity to confront the technology transformation of our transportation systems and to proactively work together to craft our preferred mobility future. The Blueprint gets us started. It is up to all of us to take the next steps.

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6

TOPICS

- SHARED MOBILITY
- VEHICLE TECHNOLOGY
- TRANSPORTATION SYSTEMS OPTIMIZATION
- TRAVEL INFORMATION & PAYMENT
- FREIGHT & DELIVERY

Chapter 6
Emerging Mobility Systems

The Blueprint categorizes the mobility technologies into five types of emerging mobility systems.

New mobility technologies began emerging over the last decade and continue to be introduced and evolve at a rapid rate. The nomenclature of these technologies is also in flux. The Blueprint, to put an order and contextual understanding to the new mobility diversity, refers to five emerging mobility systems:

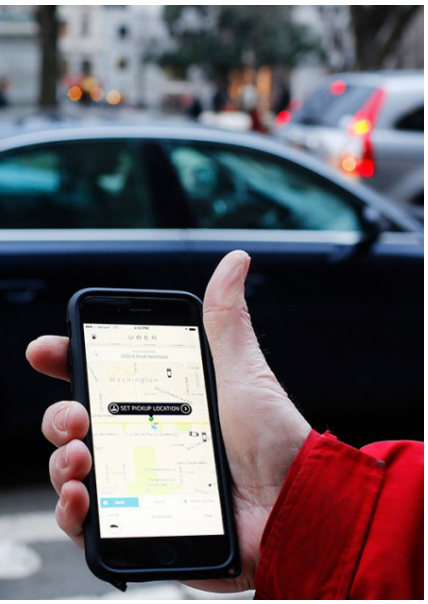
SHARED MOBILITY

VEHICLE TECHNOLOGY

TRANSPORTATION SYSTEMS OPTIMIZATION

TRAVEL INFORMATION & PAYMENT

FREIGHT & DELIVERY



Shared Mobility

Shared mobility represents the wide range of transportation options involving fleet ownership or operation of various modes of transportation. It includes "sequential sharing," where different travelers use the same vehicle back-to-back, as well as "concurrent sharing," where multiple travelers use a given vehicle simultaneously[4]. Shared mobility encompasses a wide range of business models, including business-to-consumer (B2C), business-to-government (B2G), business-to-business (B2B), and peer-to-peer mobility marketplace (P2P- MM). According to the Shared Use Mobility Center, it "includes public transit; taxis and limos; bikesharing; carsharing; ridesharing; ridesourcing or ride-hailing; ride-splitting; scooter sharing; shuttle services and "microtransit"; jitneys and dollar vans; and more."[5]

Travel behavior is being changed by shared mobility technologies. For example, ride-hailing is replacing personal driving trips, decreasing the need for parking spaces. Meanwhile, a lack of parking and cost are the main reasons people choose not to drive in the first place, so decreasing parking supply could further incentivize ridehailing (and possibly shared rides).[6]

Shared mobility technologies are challenging traditional approaches to designing a transportation network. One recent example is the rapid deployment by entrepreneurial companies, of app-based subscriptions to electric scooters. The quickness with which these scooters were introduced initially, without coordinating with the city agencies responsible for managing roadway and right-of-way safety on sidewalks and streets, illustrates the need for cooperation between the private sector providers and public agencies as alternative transportation options are introduced.

There are generally five commonly adopted categories within Shared Mobility. The Blueprint focuses on three — Micromobility, Ridehailing Services, and Carsharing.

Regional transportation agencies can make unique contributions toward integrating shared mobility, as detailed in a 2018 FHWA White Paper: "Regulation of shared mobility operations is typically the purview of local and state governments. Transit agencies have shown an ability to form partnerships with shared mobility providers. MPOs are uniquely positioned to lead regional coordination and consensus building activities because of their traditional role as a regional convener."[7]

There are generally five commonly adopted categories within Shared Mobility—Micromobility, Carsharing, Ridehailing Services (also referred to as Transportation Network Companies [TNC]), Public Transit, and Microtransit. Mobility Choice Blueprint focused on Micromobility, Ridehailing Services, and Microtransit because they rely upon emerging technologies and have a significant potential to change how the transportation system is used and to improve mobility in the Denver region.

Micromobility

Micromobility refers to personal shared transportation devices like bicycles, mopeds, and e-scooters that are paid for through an app. Initially, the devices were located at docking stations and intended to support First and Last Mile trips from transit stops. More recently, dockless versions of these systems have increased adoption of these modes because they are more convenient and flexible.

Bicycle sharing systems have been present in many U.S. cities since 2017.[8] B-Cycle, Lime, and Jump offer traditional and electric-assist bicycles through docking systems and as dockless bikes throughout the Denver region. Reservations are available online and through apps. Bird, Lime, Skip, Spin and Scoot are now providing e-scooter and moped service in the Denver region and more than 40 other cities.[9] These companies offer rental of an electric scooter through a smart phone application with dockless pickup and dropoff at approximately $2 per ride. Ford purchased Spin for $100M in November 2018,[10] while Uber has heavily invested in Lime.[11]

They are also a less costly option to driving or ridehailing, particularly for short trips. Scooter riders are "surprisingly diverse," according to recent studies.[12] Women and persons with lower socioeconomic status are adopting scooters more rapidly than bicycle sharing possibly because riding a scooter on the sidewalk is considered safer or more comfortable than riding a bicycle in the street. Scooter use on sidewalks may increase the risk of collisions with pedestrians. In some locations, electric scooters are currently illegal for street operation even if there is a dedicated bike lane. The City and County of Denver now has implemented a permitting system for electric scooter-share companies, which promotes locating the scooters around transit stops to help make First and Last Mile connections to transit.

Micromobility solutions are popular where there is a density of population and a strong contingent of bicycle and scooter enthusiasts.

Ridehailing Services

Ridehailing services (also known as ridesourcing and Transportation Network Companies [TNC]) are privately operated, shared ride services accessed through a mobile application for personal trips, typically one user or group after another. Uber and Lyft are the dominant players in this market; emerging players include Waymo, GM, and Ford.

Originally touted as solutions to congestion and air pollution and an option to fixed public transit, some studies have shown that the high numbers of ridehailing services have actually increased congestion. This results from ridehailing operators circling or idling without passengers (deadheading) and the passenger shifts from more sustainable modes to ridehailing services.[13] In San Francisco, Boston, and other cities ridehailing-generated trips account for roughly 15% of all daily trips generated within the city limits.[14] Because the Denver region is less dense than these cities, the share of ridehailing trips is likely smaller but unknown. San Diego conducted a travel survey in 2016 that found that less than 1% of all trips were with ridehailing services across the region.[15] Ridehailing services also offer a travel alternative in less populated areas where there are fewer established public transit services.

The use of ridehailing services to and from airports in San Francisco, Denver, Portland, and Kansas City is growing and accounts for up to 18% of passenger ground transportation. While parking and car rental revenues appear to be in decline on a per-passenger level, airports implementing a fee for ridehailing pick-ups and drop-offs are seeing increases. Denver and San Francisco are seeing upwards of $600,000 to $2 million in new service fee revenue per month.[16]

The impact of ridehailing services on fixed public transit use is mixed. A recent study by the Transportation Research Board under the Transit Cooperative Research Program found that "there is no clear relationship between the level of peak-hour ridehailing use and the longer-term changes in the study regions' public transit usage."[17] This suggests that ridehailing services may not reduce public transit use in the long term, which is consistent with findings that most ridehailing trips are of a short duration and during evening hours and weekends. However, this same report concludes that transit travel wait times are the top reason that transit users choose ridehailing over public transit, which suggests that ridehailing directly decreases public transit use. In addition to the TRB report, other recent research suggests that ridehailing services have a negative impact on public transit use. In particular, a survey of seven cities in the U.S. found a 6% decrease in bus trips and a 3% decrease in light rail trips as a result of ridehailing operations; Bruce Schaller has reported similar findings for New York City. [18]

Some transit agencies have adopted ridehailing services as a solution to the First and Last Mile connection to public transit modes. Dallas Area Rapid Transit (DART) and other agencies have integrated Uber into their own apps. Denver's RTD is conducting a First and Last Mile Strategic Plan to identify innovative strategies and technologies to promote accessibility and connectivity to its transit stations.

Ridehailing companies are private, profit-making entities, and pricing could make ridehailing services unaffordable for lower-income passengers and entry-level workers who often rely on public transit to access jobs. Denver's RTD acknowledges this by providing a 40% discount to low-income riders.

Ridehailing services companies gather a tremendous amount of information on travel origins and destinations, trip times, routes, etc. While much of this information is not yet available to public agencies, the information could help to better plan transportation services to the traveling public.

Microtransit

The USDOT defines Microtransit as "a privately owned and operated shared transportation system that can offer fixed routes and schedules, as well as flexible routes and on-demand scheduling[19] . The vehicles generally include vans and buses." The on-demand service typically transports 3 to 10 people. Routes are planned based on public and census data that can optimize the routes and the pick up and drop off locations. Passengers access the service through an app, making it responsive to real-time needs. Operators include Chariot, Via, Lyft Shuttle, and others.

Trials of microtransit in at least 24 cities are in progress in 2018, many of them subsidized by public funds or operated by transit agencies. The success of the services have been mixed. Early tests in Kansas City, Santa Clara, and East Bay were relatively unsuccessful, and at least two providers, Bridj and Chariot, have gone out of business. [20] While the success of microtransit may still be unclear, researchers and agencies explore these solutions because in many cases, a subsidized microtransit service with smaller and more nimble vehicle fleets could have a much lower cost, better response time, and a greater coverage area than the traditional fixed-route, large passenger bus service. Many of the early microtransit trials and pilots operated parallel to corridors with an existing fixed-route service. New trials, such as the one in Arlington, Texas, are implementing microtransit service where there is no existing transit service. Since opening in December 2018, the service in Arlington has provided more than 53,000 rides with an upward trending ridership, and the service area will be expanded. [21]

Microtransit is ideally suited for paratransit services provided by transit agencies and private operators for critical door-through-door services.

Microtransit is ideally suited for paratransit services provided by transit agencies and private operators for critical door-through-door services to transport people from within their home, stay with them at their destination, and accompany them back to the safety of their home. It is also effective as a First and Last Mile service.

In Denver, Chariot, a subsidiary of Ford Mobility, operated pilot shuttle services in the University of Denver campus area, and between the Cherry Creek commercial district and downtown Denver. These pilot projects have been discontinued.

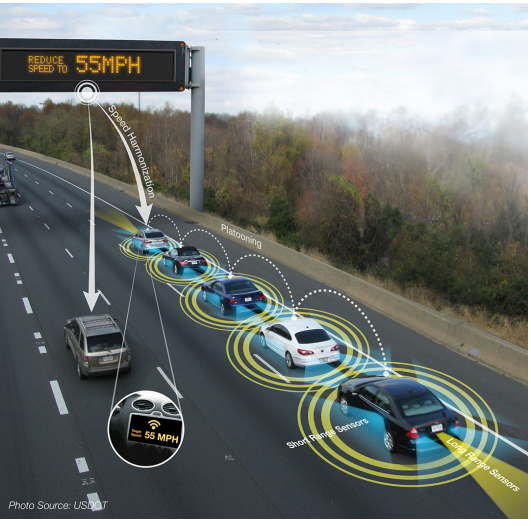
Microtransit is beginning to be tested with driverless vehicles. One such pilot being conducted is at Peña Station NEXT in Denver, while there are more than 20 additional pilots ongoing in 2018 throughout the U.S.[22]

Shared Mobility Opportunities

- The costs of owning and operating shared mobility vehicles are widely distributed across users, reducing the total out-of-pocket costs to individual travelers.
- With a true pay-to-travel environment door-to-door, on-demand service eliminates the large personal capital investment in an automobile.
- Increased use of these personal travel modes in lieu of automobile-based travel can reduce congestion and improve personal mobility.
- Micromobility provides environmentally friendly travel for short-distance trips, particularly within an urban environment like the Denver region where outdoor enthusiasts are predisposed to use bicycles and walk.
- Micromobility is a less costly option to taxis and ridehailing services for persons with lower socioeconomic status.
- Through partnerships, public agencies could benefit from the data ridehailing services companies gather to optimize existing transportation systems.
- Ridehailing services can supplement traditional transportation services in geographical areas that are predominantly underserved by fixed-route transit systems.
- Partnerships between public and private paratransit services providers could reduce costs through economies of scale.
- Smaller microtransit vehicles and on-demand service are an option for transit agencies to "right-size" vehicle fleets and service offerings, reducing overall operational costs.
- Microtransit is a potential use for driverless vehicles.

Shared Mobility Challenges

- Private sector operators are largely unregulated and have started operations without coordination or permission from government entities, resulting in potentially unsafe operations.
- Shared mobility operators have been reluctant to share the travel data they collect with public agencies.
- Micromobility vehicles under a dockless system are a potential hazard with unused vehicles filling sidewalks, alleyways, parking spaces, and other public areas. Some municipalities have resorted to "cease-and-desist" orders and confiscation of vehicles to mitigate the hazard.
- Many micromobility vehicles, particularly e-scooters, are operated on public sidewalks that are not designed for their use, resulting in injuries to both pedestrians and riders.
- There are inadequate laws, regulations, and licensing for micromobility devices, and existing ones are not always appropriate for them.
- Ridehailing services have been found to increase congestion and environmental emissions in dense urban environments. Traffic flow is frequently interrupted by unexpected passenger pick-up and drop-off areas, causing safety concerns for drivers, bicyclists, and pedestrians.
- Ridehailing services may attract travelers away from public transportation, which could result in an increasing gap between transit agency operational costs and revenue.
- A shifting market from public transit to ridehailing services could reduce mobility options for lower-income households or require public subsidies to ensure access.
- Difficulty in identifying a viable application of microtransit in existing transportation systems that is operationally and economically feasible.
- Many vehicles used by many microtransit operators are not ADA compliant, which could reduce access for some populations.



Vehicle Technology

For purposes of the Mobility Choice Blueprint, Vehicle Technology refers to Connected Vehicles, Automated Vehicles, and Vehicle Electrification.

Connected Vehicles

The transportation sector is benefitting from a growing network of vehicles and other components embedded with electronics, software, sensors, actuators, and network connectivity. Smart technologies are being used to communicate real-time information among a range of transportation modes—passenger vehicles, bicyclists, transit vehicles, and pedestrians. Vehicle-to-Everything (V2X) capabilities are being widely tested and initially used to optimize a regional transportation system to maintain optimal corridor speeds, improve throughput, and increase safety by reducing crashes of all types, including those with pedestrians and bicyclists. V2X includes connected vehicles that are connected by smart technologies to other vehicles (V2V) and to infrastructure (V2I).

V2V uses a combination of Dedicated Short Range Communications (DSRC) and GIS technologies that enable vehicles to wirelessly communicate and exchange information about their location, speed, and heading. Applications for vehicles are being developed that will enhance a driver's level of predictability. [23]

Safety applications provide warnings and alerts about imminent crashes, deteriorating or dangerous driving or traffic conditions, potential dangers at intersections like warnings about others running a red light, and numerous other safety risks. This technology has been very effective in preventing collisions and in reducing secondary crashes by alerting nearby vehicles of the crash location. [24]

Mobility applications use data to maintain optimum traffic flow conditions and maximize multimodal connectivity. Examples include notifications about congestion on the chosen travel route, impediments to emergency response vehicles during incident response, automated ridehailing, and assistance in making next connections in a transit system.[25]

Traffic management is effective within a single jurisdiction, but there is an even greater benefit when transportation management centers share data across jurisdictions. In most cases across the metropolitan area, data is not easily shared or coordinated for the benefit of the regional transportation system as a whole.

EXAMPLES OF V2I TECHNOLOGY ALREADY IN USE IN THE DENVER REGION

V2I technologies capture vehicle-generated traffic data and wirelessly communicate advisories about safety, mobility, or environmental conditions. Examples of V2I technology already in use in the Denver region include:

- The City and County of Denver has installed emergency vehicle preemption detectors at 60 intersections to manipulate traffic signals in the path of an emergency vehicle, which has helped reduce response times and enhance traffic safety.
- The City and County of Denver has installed bicycle detection at seven intersections to test how well the system can pick up the presence of a bicycle at the traffic light, without a bicyclist relying on another car or pedestrian to trigger the light, or having to dismount their bicycle to push the pedestrian push button.
- CDOT is pioneering the use of Road and Weather Information System (RWIS) technology. RWIS sensors provide CDOT winter maintenance crews with constantly updated information on current weather and roadway conditions including air temperature; amount and type of precipitation; and pavement temperature and whether the pavement is wet or dry.
- The City and County of Denver is installing advanced communications technology equipment with DSRC equipment on Federal Boulevard as a pilot project, which will enable Vehicle to Infrastructure (V2I) communications between traffic signals and vehicles equipped with DSRC technology. In addition, the CDOT is updating its standard specifications to include requirements for DSRC in all future traffic signals.
- CDOT and the City and County of Denver manage traffic through traffic management centers. These centers collect and disseminate data on weather, roadway, and traffic conditions and use it to manage traffic congestion. At this time, the traffic management centers are currently only able to manually monitor traffic conditions through video cameras and vehicle detection systems. Examples of traffic management through V2I technologies already in place in the Denver region include ramp metering, dynamic speed and lane controls, smart tolling, adaptive signal control, transit signal priority, and smart parking.

Connected Vehicles Opportunities

- Improved safety for vehicles, pedestrians, and bicyclists.
- Reduced congestion, contributing to a better environment.
- Improved mobility across all travel modes and across the region.

Connected Vehicles Challenges

- Maintaining security and privacy of the data generated by connected vehicle technologies.
- Limited financial resources for implementing infrastructure required to support connected vehicle technologies.
- Agreeing on a regional common data platform for different vehicles and infrastructure.

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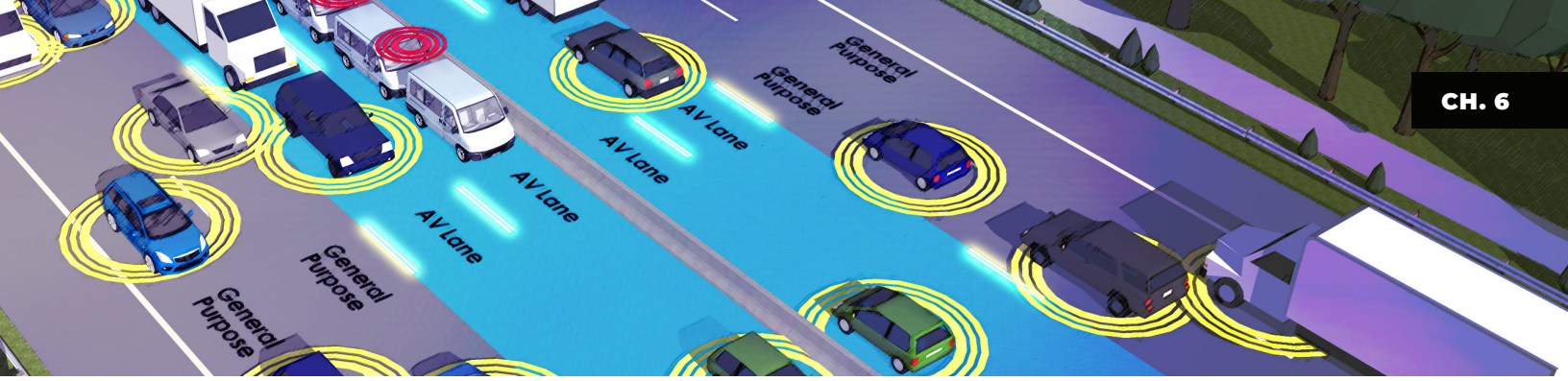


Automated Vehicles

For the Blueprint, Automated Vehicles (AV) refers to vehicles with automated driver assistance features, up to and including driverless vehicles. The Society of Automotive Engineers has a classification scheme that categorizes automated vehicles into five levels.[26] AVs for personal trips and transit vehicles are anticipated to cause the most disruptive change to mobility since the introduction of cars powered by internal combustion engines over a century ago. As an increasing number of driver assistance features are introduced into personal and ridehailing vehicles, the transportation system and the infrastructure supporting it will have to change.

Examples of lower-level driver assistance features include adaptive cruise control; lane-keeping; and automatic emergency braking, steering, or acceleration. The next higher levels allow a vehicle to take full control and operate when certain operating conditions are met, for example, on an open highway, but the driver can retake control of the system. The highest levels of automated vehicles have minimum to no driver control. Nearly 50 companies are testing driverless vehicles that operate within a prescribed geographic area under acceptable environmental conditions.[27]

Although drivers will benefit from the features in personal vehicles, most of the current passenger vehicle manufacturers have indicated that ridehailing fleets will be where highly autonomous vehicles will be introduced first; large-scale commercial production is expected to occur in the 2025-2030 timeframe.[28]

Ridehailing services provide vehicle manufacturers a controlled, real-world environment to develop algorithms and to refine both the sensor platform and the processing. Driverless ridehailing services have been introduced in urban areas with higher job and population densities where personal vehicle operation is exceptionally costly. In operation since May 2018, Lyft's driverless vehicles along the strip in Las Vegas have been largely accepted by customers.[29] Uber has resumed testing on its driverless vehicles after a fatal pedestrian accident in Tempe.[30] Waymo (a subsidiary of Alphabet, Google's parent company) recently launched Waymo One, a driverless ridehailing service, to a limited number of users in the Phoenix area the beginning of December 2018.[31] Honda is working with General Motors and Cruise Automation to develop a driverless vehicle that is already being tested on public roads in San Francisco, Scottsdale, Detroit, and other cities.[32] GM's goal is a driverless ridehailing service by 2019, and Ford is targeting 2021. In Denver, EasyMile, a driverless shuttle bus manufacturer, is currently testing its 15-passenger vehicle to connect RTD's University of Colorado A Line commuter rail Peña Station with office buildings and a local bus stop, which demonstrates that driverless vehicles are being used as a First and Last Mile connection option.[33]

In Colorado, the state law has been changed to allow for Autonomous Driving Systems across the state. The state legislature initially addressed the legal status of autonomous vehicles through Senate Bill 17-213, which focused on safety and improved mobility.

In operation since May 2018, Lyft's driverless vehicles along the strip in Las Vegas have been largely accepted by customers.

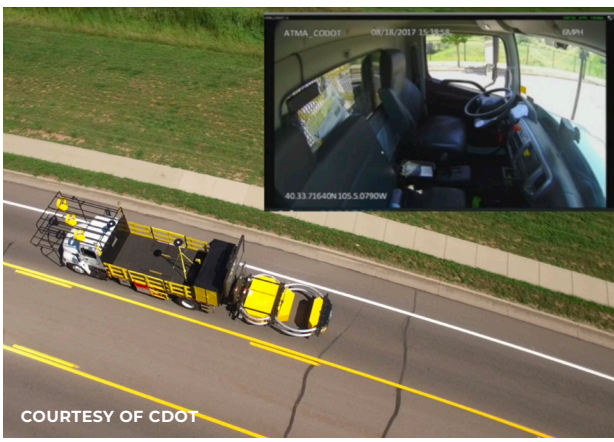
AUTOMATION IN DENVER REGION

Subareas of the Denver region will likely see driverless ridehailing in the next few years, but colder cities will lag sunbelt locations due to the technical challenges of operating on snow and ice.[34] From a legal perspective, if a driverless vehicle is otherwise compliant with federal and state standards, such as the Federal Motor Vehicle Safety Standards, the State of Colorado allows higher-level AVs, including fully driverless vehicles.[35] As AVs are introduced, individuals in the Denver region are expected to have a high rate of early adoption. Still, according to a January 2018 Reuters/Ipsos poll, 66% of Americans are uncomfortable with the idea of riding in driverless AVs.[36]

SHARED EFFECTS OF DRIVERLESS RIDEHAILING & DRIVER-OPERATED RIDEHAILING

Some effects of driverless ridehailing on the transportation system are shared with driver-operated ridehailing. These include:

- Providing mobility options in paratransit for physically challenged, elderly, and youth populations. These services could augment or replace the existing paratransit service, which is costly and challenging for many transit agencies to operate. Nearly 57 million people in the U.S. have a disability, and 68% of those reported transportation as a difficult issue.[37]
- Driverless ridehailing could magnify this effect that single-occupant ridehailing services may reduce transit trips. Since the average bus trip is less than four miles in length, affordable driverless ridehailing for point-to-point service could displace shorter transit trips.
- Most observers now agree that driverless vehicles will increase total vehicle miles traveled by single-rider trips and a new category—zero occupant vehicle trips as the vehicles reposition for the next passenger. Early studies in San Francisco have found ridehailing services, such as Uber and Lyft account for roughly half of the increase in congestion between 2010 and 2016, as measured in vehicle hours of delay, vehicle miles traveled, and average speeds. [38] As driverless vehicles make ridehailing cheaper and more available, the congestion will worsen.
- A driverless vehicle would be able to relocate without a human driver, potentially allowing households with multiple vehicles to reduce to a single vehicle or give up personal vehicle ownership altogether. A personal vehicle costs over $9000 per year to own and operate and is parked and unused 95% of the time. In the extreme, should all vehicles become shared (driverless or not), it may be possible for a household to have overall lower annual travel costs because the capital and operating costs are more widely distributed among users.



COURTESY OF CDOT

POTENTIAL AUTOMATION IMPACTS

There are conflicting opinions about the effect of AVs on the traffic stream and congestion. Many studies cite huge benefits for capacity and safety. Recent research found that by controlling the pace of the autonomous car in the field experiments, the driverless car controlled the traffic flow by dissipating the stop-and-go waves so that traffic wasn't oscillating as it does when all of the cars are controlled by humans. The research determined that even a small percentage of autonomous vehicles (5 percent) could have a significant impact in eliminating waves and reducing the total fuel consumption by up to 40 percent and the braking events by up to 99 percent. However, there remains some concern by others that the AVs will be programmed to keep a lot of space between vehicles and not go above speed limits – and will end up overall reducing the effective flow of vehicles.

As many as 94% of all accidents are caused by human error. There were 37,133 traffic-related deaths in the U.S. in 2017, including 648 in Colorado.[39] AVs could prevent thousands of crashes, injuries and deaths every year.

Driverless vehicles free passengers to use their journey time for work, entertainment or communication on mobile devices, or any number of personal activities. For example, the average commute time by car in the Denver region is about 26 minutes, close to the national average. That computes to about 226 hours per year, or a month's worth of 8-hour workdays, that a commuter in a driverless vehicle could use for other purposes.[40]

Automated Vehicles Opportunities

+ Automated vehicle technology for personal and microtransit vehicles expand mobility options in paratransit services that serve mobility-challenged populations, such as the elderly, disabled, and youth.
+ Automated vehicles could create a safer driving environment.
+ Shared driverless vehicles are a lower-cost option to owning a personal vehicle.
+ Driverless vehicles are an option for First and Last Mile trips to transit modes.
+ Driverless vehicles are an opportunity for increased personal productivity.

Automated Vehicles Challenges

+ Deployment of driverless vehicles could potentially increase the number of vehicles on the roads, increasing vehicle miles, congestion, and pollution.
+ Increased availability of driverless ridehailing services could cause a decline in public transit ridership.
+ People with disabilities and the elderly may need special vehicle modifications or physical assistance entering/exiting and getting to/from an AV and their destinations.
+ New public policy is required to accommodate special conditions caused by driverless vehicles.

As many as 94% of all accidents are caused by human error.

Vehicle Electrification

An electric vehicle (EV) is powered by one or more electric motors using energy typically stored in batteries, and are recharged by common electricity. Technologies related to the electric-drivetrain of vehicles and battery technology have progressed rapidly in recent years. Original Equipment Manufacturers (OEM) like Honda, Volvo, Ford, GM, Tesla, Proterra, BYD, and others are prioritizing the development EVs.

AVAILABILITY

Virtually every analysis of the automotive market predicts rapid and significant growth in EV sales. Forbes magazine reports that in the U.S., EV sales grew an average of 32% annually from 2012-2016 and 45% over the year ending June 2017. Bloomberg New Energy Finance (BNEF) predicts that by 2040, nearly 60% of new cars sold will be battery EVs. Reflecting the linkage between AVs and EVs, BNEF also says they expect 80% of all autonomous vehicles in shared applications to be electric by 2040 because of lower operating costs.

There are about 25 models of electric vehicles (EV) for sale in Colorado, from General Motors, Nissan, Tesla, Volkswagen, and others. While market share for EVs remains tiny overall, Colorado has the sixth largest market share of EVs in the country at 2.46% as of August 2018.[41] As of August 2018, there were close to 16,000 EVs registered in Colorado.[42] The State of Colorado has authored the Colorado Electric Vehicle Plan, supporting Colorado's clean energy transition. The plan includes goals, actions, and strategies to ensure that Colorado remains a leader in the EV market. [43]

Right now, there aren't many types of EVs available and some are still quite expensive. However, that is predicted to change soon. The big global automakers have invested $90 billion in electrification according to Reuters, and that investment is growing. GM reportedly plans 18 EVs in the next five years (several crossovers, a sedan, a sports car, mini-vans and SUVs). The same is true for Ford, Hyundai, Kia, Mercedes, and Volkswagen. Electric trucks and heavy equipment are rapidly becoming available—all the major truck OEMs and a number of small startup manufacturers offer EVs that range from pickup trucks through to large Class 8 tractors and goods movement equipment. Electric buses are also a growing market with OEMs like Proterra and BYD exclusively producing battery electric buses instead of diesel buses.

With the Colorado Air Quality Control Commission's adoption of the Colorado Low Emission Automobile Regulation (CLEAR) in November 2018, it is expected that OEMs will be motivated to more aggressively market EVs and other low emission vehicles (LEV) in Colorado. The regulation approves new LEV standards, similar to those in California and the federal government, for new light-duty and medium-duty motor vehicles sold in Colorado beginning in the 2022 model year. The resolution means that Colorado will adhere to the tougher standards even if the federal government rolls back its standards.

COURTESY OF CDOT

The big global automakers have invested $90 billion in electrification according to Reuters, and that investment is growing.

ENVIRONMENTAL

The U.S. Environmental Protection Agency estimates that conventional internal combustion vehicles are responsible for between 50% and 90% of air pollution in urban areas like Denver's.[44] EVs have zero tailpipe emissions, meaning the areas where they operate have fewer vehicle-generated pollutants. Greenhouse gasses (CO_2 in particular) are a less localized concern, but EVs are significantly better than gasoline cars. The Department of Energy tool at https://afdc.energy.gov/vehicles/electric_emissions.html indicates that electric vehicles in the metropolitan area emit 41% less carbon per mile than gasoline-powered vehicles. A Synapse Economics analysis states that, "...these environmental and health benefits can be achieved alongside employment and GDP growth in Colorado."[45]

In 2019, Colorado Air Quality Control Commission will be deciding whether to adopt ZEV, which would require manufacturers to meet targets for EV deployment that grow through 2025, and will likely be strengthened for 2016-2030.

COST

Recent research from the University of Michigan suggests that owning and operating an EV could prove about half as expensive as owning and operating a gasoline-powered vehicle.[46] The tipping point in EV adoption will be when battery EV become cost-competitive with gasoline- or diesel-powered Internal Combustion Engine Vehicles (ICEV), without subsidies.

Electricity is less costly per mile than other fuels, and this will likely remain the case because of the massive electric generation and distribution infrastructure nationwide. However, demand charges on electricity use may cause these costs to be higher than anticipated. A 2018 University of Michigan study found that in Colorado a gasoline car would have to deliver 61.4 miles per gallon for it to cost the same as driving an equivalent EV.[47] Since EVs have far fewer moving parts, they have demonstrated notably lower maintenance costs. There are no oil changes, and regenerative braking (where the motor captures energy from deceleration and recharges the batteries) means brake pads last longer.

Right now, the Total Cost of Operation (TCO) for a battery electric transit bus is expected to be equal to or less than a diesel bus in many operating scenarios. As a result, transit agencies nationwide are starting to shift from diesel to electric. Some are even phasing out fairly new compressed natural gas buses for electric. BNEF forecasts electric vehicles will become price competitive on an unsubsidized basis beginning in 2025.[48] A study conducted by M.J. Bradley & Associates suggests that at a high rate of EV adoption, there is potential for $29.1 billion in cumulative savings for Colorado drivers due to reduced annual vehicle operating costs.[49]

The switch to electrification will put a new demand on the power grid. Electric utilities will need to invest in the development of technologies like vehicle-to-grid (V2G). V2G offers the potential for using EVs to more efficiently distribute electric resources to balance the variability in the growing renewable power supply. Even without V2G, managed charging will allow most charging to take place off peak, which will allow more efficient use of generating capacity, make it easier to integrate wind, and exert downward pressure on electric rates.[50] The M.J. Bradley & Associates study concluded that at a high rate of EV adoption and off-peak charging, the average Colorado household could realize nearly $80 in annual utility bill savings in 2050. Cumulative utility bill savings could exceed $4.1 billion statewide by 2050 (net present value) scenario.[51]

NON-VEHICLE USE OF BATTERIES

Individuals will be able to use EV batteries for non-vehicle use with the right technologies (e.g., during emergencies and downed power lines). Lithium-Ion battery packs from EVs can be used in several ways and can be disassembled and recycled. It is not yet clear how long EV batteries will last and how they can be used after vehicle use, and there has not been sufficient volume of used battery packs for a second-life market to develop. Concepts being tested include utility electrical grid storage to capture intermittent renewable energy like wind and solar, and making home energy storage systems or EV charger backup storage. Applications that improve grid resilience are a leading area of investigation.

EMPLOYMENT

As the demand for electricity grows, there will be employment gains in the electric sector at the local and state level. A 2018 study of clean vehicle scenarios for Colorado by Synapse Economics states, "Besides generating net fuel savings, increased EV penetration causes a shift in fuel expenditures from the petroleum sector to the electric sector. This shift results in additional net employment and GDP gains because the electric sector is fundamentally more local than the petroleum sector. While oil is a globally traded commodity, investments in the electric infrastructure that serves Coloradans tend to be concentrated within the state. For that reason, each dollar invested in the electric sector produces more than twice as many jobs as the same dollar spent on gasoline."[52]

In the future, there will be a shift from technicians to service internal combustion engines to high-voltage batteries and EVs. Community colleges and trade schools are developing programs, but they lag behind the curve.

The demand for skilled EV technicians is large and growing.

CHARGING STATIONS

The availability of charging stations is critical for the EV market to grow. Right now, the lack of EV fueling infrastructure is slowing the growth of EV sales. McKinsey & Company has found there were 12.4 EVs in 2015 for every U.S. charging station, and 13.2 EVs per station in 2016. BNEF says that, "The amount of public EV chargers has grown significantly in the last five years, but more is needed[53] . Even when EVs have reached cost parity with internal combustion engine vehicles, lack of home charging will be a significant barrier to adoption and will restrict EV sales from reaching 100%..." The Volkswagen/Audi/ Porsche Diesel Emissions Settlement Program is bringing millions of dollars to every state, and Colorado is one of the states that has created a program for EV charger deployments with those funds.

Colorado is currently the only state with a legislative prohibition on utility ownership of charging stations, which discourages a significant utility role. In other states utilities are investing hundreds of millions of dollars in charging infrastructure.

Potential vehicle owners have "range anxiety" when there are long distances between charging stations in more rural areas. Also, condo and apartment buildings do not have adequate facilities to charge vehicles (vs. electrical outlets in single-family homes). There will need to be new building codes for provision of outlet/charging in wall infrastructure as part of construction.

Vehicle Electrification Opportunities

+ Reduced cost of vehicle ownership with lower fuel and maintenance costs.
+ Improved air quality and reduced greenhouse gas emissions in the Denver region.
+ Upgraded electric grid modernization and resilience.
+ Net employment gains in Colorado in the electric sector.

Vehicle Electrification Challenges

+ Inadequate numbers of charging station locations or accommodation of charging for multifamily dwellings.
+ Narrow range of EV model options and cost of EVs.
+ Undeveloped market for second-life of vehicle battery packs.
+ Lack of workforce training for repair and maintenance for the EV industry.
+ High upfront capital costs for governments transitioning fleets to electric vehicles.
+ Reduction in transportation revenue from the gas tax.

COURTESY OF CDOT

Transportation Systems Optimization

An optimized regional transportation system relies on real-time analysis of traffic data to optimize traffic flow. It requires sophisticated equipment to collect the data and sophisticated software to analyze the data and communicate to traffic control devices in real time. Active management of the transportation system through adaptive signal control technologies improves traffic flow, reduces congestion, and maximizes use of highway and transit investments.

Adaptive signal control technology adjusts the timing of traffic signals to adapt to actual traffic demand. DSRC sensors continuously relay traffic data to a control system that determines the optimum signal timing based on traffic flow and adjusts the timing in real time. In the Denver region, state-of-the-art sensors have been installed in select corridors, but have not been implemented across a wider geographic area. Infrastructure may be updated in urban areas first, putting those in outlying areas at a disadvantage. CDOT's Smart I-25 is a pilot adaptive traffic signal program under development that will monitor traffic volumes and adjust ramp metering signal cycle lengths to optimize the flow on the freeway.

Transit Signal Prioritization (TSP) adjusts traffic signal green and red times if possible as buses approach to improve bus travel time and reliability. The more advanced application of TSP uses real-time ridership data to change traffic signal timing and prioritize traffic movements for buses that have more passengers. RTD has implemented TSP on some corridors and has plans to introduce it on others as resources allow.

Transit Signal Prioritization (TSP) adjusts traffic signal green and red times if possible as buses approach to improve bus travel time and reliability.


COURTESY OF CDOT

Regional Optimization

Transportation system optimization at a regional level requires standardization of equipment, operating conventions, and shared management and control across agencies and jurisdictions. DRCOG has conducted a regional Traffic Operations Program for almost 30 years. The program involves DRCOG, CDOT and local governments to coordinate traffic signals on major roadways in the region. However the program may not effectively respond to new technologies. Agreement on the type and level of standardization requires cooperation and may require execution of intergovernmental agreements. In addition current legal frameworks for roadway and transit uses and mobility operations have unintended consequences for emerging systems, or don't address them at all.

The level of connectivity and redundancy required to generate regional system benefits means a significant investment in equipment, software, and infrastructure by all of the regional agencies. Being able to benefit from rapidly evolving applications requires that public agencies have the organizational and jurisdictional structure to act promptly to approve investments and keep the system flexible enough to incorporate yet unknown technologies. Some of the jurisdictions may be reluctant to make the initial investments if others aren't doing the same.

Data Sharing, Protection, and Management

Public agencies already collect and store large amounts of data about transportation system operations and performance on a daily basis. The challenge from a regional perspective is how to unify data format across jurisdictions. For example, the City and County of Denver and City of Westminster use the same traffic controllers. However, due to different data preference, the data archived by Denver is more complicated to retrieve. This type of situation hinders the sharing of data across jurisdictions and ability to optimize the overall system.

Exponentially more information, derived from new technological sources and private sector providers will be available in the coming years. Public agencies are struggling to figure out what data is relevant, how to extract it, and how to use it to optimize their systems. Definition of the "right data" that can be utilized to optimize system operations and performance is important to all public sector and private sector entities. Also, at the system or regional level, there is currently no consistent way to share the data among multiple sources so it can be used to influence real-time traffic demand strategies.

Without a relationship to public objectives, new private sector technology could focus on maximizing revenues at the expense of those community goals. A regional forum of some kind is a crucial first step in developing infrastructure that supports effective, meaningful, and equitable applications of new technology.

In addition, there are concerns about maintaining the privacy of individual travelers and protecting sensitive information. Agreements will be required between public agencies and private companies to share big data generated by smart technologies to realize the analytical benefits of system operations. Management and maintaining security of the data is a critical need.

Transportation Systems Optimization Opportunities

- Improved bus travel time predictability and reliability, making transit a more attractive choice for travel, supporting continued transit ridership and maximizing the region's investment in transit.
- Real-time signal optimization and variable freeway operations improve highway capacity and travel time reliability and reduce congestion.
- Predictability and real-time response to traffic conditions improve traffic flow impacted by special events, construction, and crashes.
- New uses for big data to inform decisions about future investments in smart technology and infrastructure.

Transportation Systems Optimization Challenges

- Obtaining agreement across multiple jurisdictions on standard equipment, operating conventions, and demand management strategies.
- The system must be flexible enough to accommodate the traditional and incorporate the newer technologies.
- Insufficient CDOT and local jurisdiction budgets for ongoing maintenance of transportation system infrastructure like roadside equipment, signing, and pavement markings.
- Hesitancy of individual jurisdictions to be the first to make a significant investment in infrastructure.
- Public agencies must be flexible and willing to take on the risk of investing in technologies that may become obsolete quickly, which is sometimes counter to a fiscally conservative budget.
- There is the potential that only those living and traveling within certain geographic areas will benefit from the updated technologies.
- Automakers and third-party companies currently control cellular connected car data and have shown a desire to monetize the information rather than share it with government.
- Public agencies need increasing resources to manage, analyze, share, and benefit from the data generated by these smart technologies.
- Jurisdictions must implement measures to maintain data integrity, manage ownership and access to data, secure data, share the "right data" at the right time, and address personal and business privacy considerations.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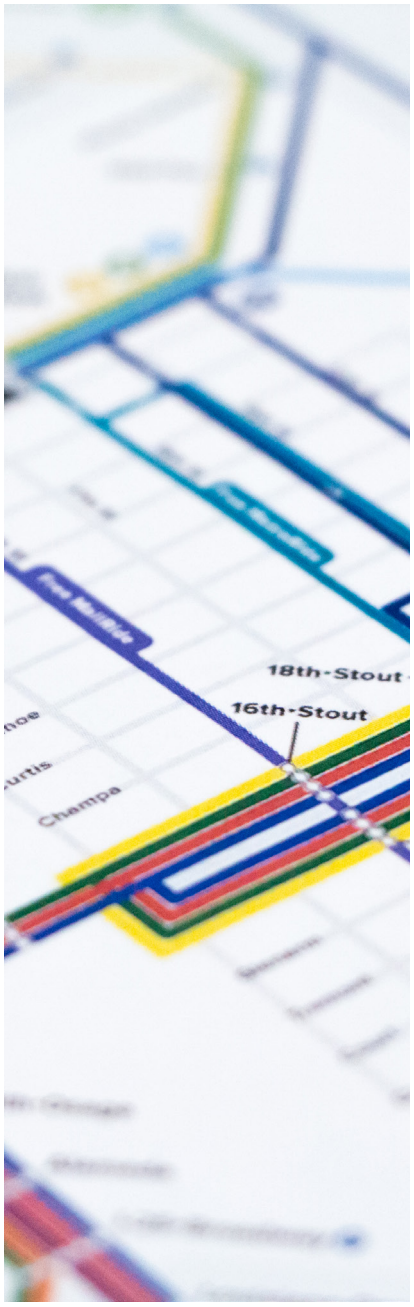


Travel Information and Payment

Mobility as a Service consolidates travel information and route planning across multiple transportation modes on demand and allows one payment for all services, regardless of mode or provider. Linking payment with trip planning is a logical step that greatly increases the reliability and convenience for consumers and offers a true "door-to-door" travel option. Mobility as a Service offers customers a single app to arrange and pay for travel on all modes either as pay-as-you-go or a monthly subscription.

Integrated trip planning and trip payment is at the core of ridehailing services. Early and rapid adoption of ridehailing apps for Uber and Lyft demonstrated the utility and identity-security of this form of travel planning and payment.

Several cities around the country are integrating trip planning and payment with First and Last Mile access options. The services are already integrating the newer microtransit modes with transit and ridesharing options. In "Implications to Public Transit on Emerging Technologies", NCTR, November 2016, Steve Polzin states, "The mobility-as-a-service concept envisions a far more substantial role for either the private sector or the government agency to be the dominant provider of mobility versus reliance on one's household as the dominant supplier of mobility."

RTD

RTD has launched a mobile ticketing and payment app to transition from a "ticket-based" business to an "account-based" business. Eventually, users could subscribe to the full range of travel options as a monthly service. Transit agencies in the Denver region are partnering with third-party trip planner apps to implement an integrated trip planning and payment app across the region that incorporates public and private transportation providers. RTD is sharing real-time data with third-party app developers and is already working with Uber to incorporate its service into its app. The inclusion of all ride options in a person's account for each trip segment will allow RTD to offer a more seamless trip experience initially, and could be integrated with other travel options in the future.

Early adoption of ridehailing apps for Uber and Lyft demonstrated the utility and identity-security of this form of travel planning and payment.

WAZECARPOOL
Wazecarpool is an app that is dynamic and connects people real time for carpooling. Users can choose carpooling partners based on profiles.

MYWAYTOGO
DRCOG has been an early adopter of traveler information and trip planning platforms. The MyWayToGo program site launched more than four years ago, and DRCOG improves functionality each year. For example, in 2018, DRCOG added overlays for traffic information, park-and-ride lots, car-share and bike-share. Currently more than 20,000 registered users are on the site; outreach and campaigns aimed at attracting a wider group of users are underway. The MyWayToGo website has information on metropolitan area mobility choices with links to partner websites. It now has a smart commute trip planning and tracking app (powered by rideamigos) for registered users that compares travel options—carpool, vanpool, transit, walk, bike, and drive—and will track the user's use of travel options either through a dashboard or automatically.

DRCOG and CDOT are planning to develop a sub-site of MyWayToGo that is micro-targeted to the I-25 South corridor for use during the I-25 Gap construction project. The addition will integrate Waze Carpool (the dynamic ridesharing app), microtransit options, rail and bus services, and CDOT's traffic and camera information, along with ride-matching for vanpool and carpool formation.

TRIP EXCHANGE ELECTRONIC (HUB)
Human service transportation providers are planning to integrate trip opportunities as well. For example, DRCOG's Veterans Transportation & Community Living Initiative is developing a Trip Exchange Electronic (HUB) for providers to share information about available services and to exchange trip data. It has the capability to exchange information among software vendors through the use of data standards and application program interfaces (API). More widespread use of this application by other human service providers is expected.

TRAVEL INFORMATION AND PAYMENT IMPACTS
Integrated travel information and payment has a strong potential to increase convenience and service reliance for users. However, individuals who lack access to the app or are not comfortable using technology applications will continue relying on traditional ways to gain information that may not have the same level of convenience or be able to provide the full range of options. As stated by Steve Polzin in "Implications," "To the extent that alternative mobility options undermine the provision of public transportation as we know it, mechanisms will need to be in place to ensure access to mobility for those with resource constraints." an initial step for more inclusive payment options for those without credit cards is that ridehailing services accept payment using fare cards like the Chicago "Ventra".

To provide a widely used, integrated trip planning/payment platform, regional agencies must be able to make prompt decisions about which technologies to incorporate and how to integrate them. This will be difficult because of how rapidly applications evolve and become obsolete.

Resources to provide technical support to these integrated applications will need to be budgeted for and maintained. Also, a means to redistribute revenues to the provider for each segment of a trip must be developed. A secure means of payment and then back-office allocation of revenues to the provider are in place in locations like Helsinki, Finland, and Vienna, Austria. Models are being established in the US that can be followed. As a result of legislation In the Denver region, payment for CDOT and E-470 Public Highway Authority toll facilities has been centralized in a common provider that can provide a model for distributing revenues from a shared mobility app.

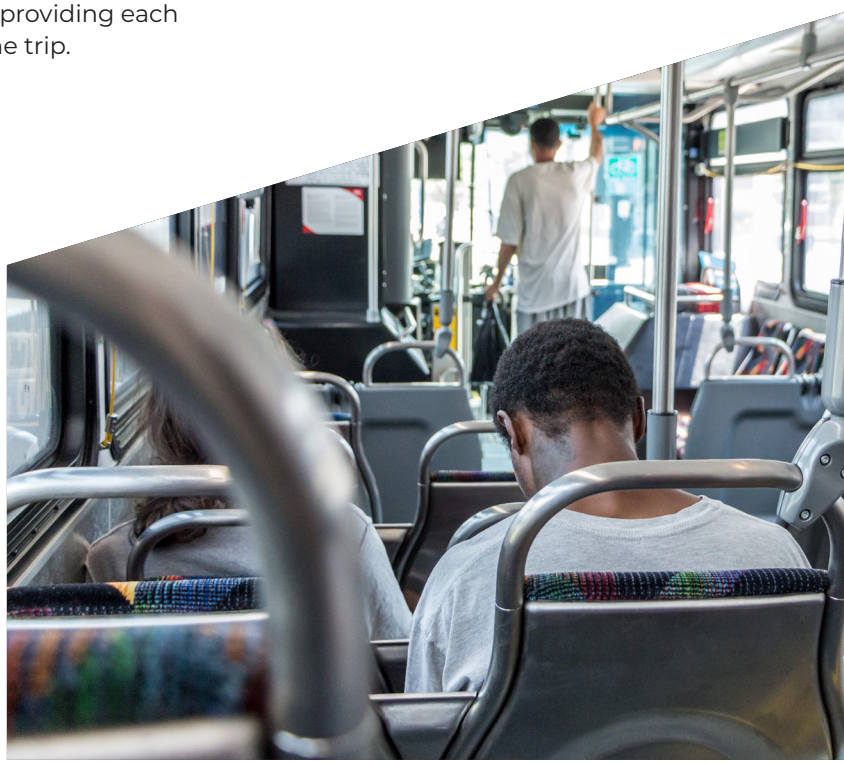
Public transit agencies will need to share data with private companies to realize the benefits of full integration, especially with trip planning/payment apps. For example, RTD will need to link directly with ridesharing services to provide reliable "first-and-last mile" services.

Travel Information and Payment Opportunities

- With real-time information about all travel mode options and costs provided by trip planning tools, travelers gain confidence in the transportation system, which could lead to choosing multimodal trips over using a personal automobile.
- Integration of microtransit, ridehailing services, and bus and rail transit travel options through applications are opportunities for public transportation agencies, private providers, and human services transportation providers to collaborate with the private sector and begin sharing data.
- Better coordination of trips across the region through multiple providers and modes will result in more flexibility for multimodal travel throughout the region and better use of limited resources.

Travel Information and Payment Challenges

- Difficulty in keeping ahead of rapidly evolving applications and potential for obsolescence will be an important consideration.
- Maintaining equitable and fair access to trip planning and payment options for slow adopters of technology apps and emerging mobility systems, for those who cannot afford the tools, and for those who are do not have accounts at banks or other financial institutions, while implementing cutting-edge technologies.
- Maintaining universal access to the transportation system that includes both traditional and new methods of accessing information and payment options.
- Determining how to provide the back-office support needed to distribute revenue to the party providing each portion of the trip.
- Overcoming concerns by the public agencies to share big data with private sector application developers and transportation providers through integrated trip planning and payment systems.



Freight and Delivery

Freight and delivery activity is critical for residents and businesses. Every day, the food we eat, the products and goods we buy, the materials used in construction, and the waste we generate, require freight transportation. Accommodating ever-growing freight volumes and customer demand for quicker delive Peña ries, while maintaining livable streets and mitigating the impacts of freight activity associated with the safety of vulnerable road users and air quality, will require a considered approach by public agencies and the freight industry as to how freight operates in urban areas.

Automated vehicle technology is also being tested in trucks. While one of the first semi-autonomous trucks was tested in the Denver region with the 132-mile journey between Fort Collins and Colorado Springs, the application of such technology and where and how it may be used continues to stimulate much debate. Looking forward, the technology is likely to be adopted earlier in less complex situations like interstate driving, rather than more complex situations such as a downtown delivery route.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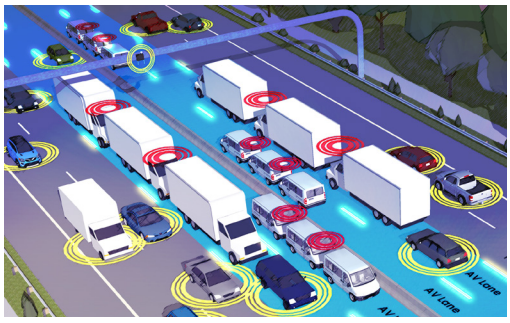

FREIGHT AND DELIVERY TRENDS

For the foreseeable future, most of the goods generated by users in the region are expected to arrive or depart by truck, van, or car. However, the following trends are changing freight demand:

+ E-commerce is rapidly growing, and now accounts for 9.5% of all retail sales, up from 3.3% in 2008.[54] Home delivery is replacing in-store purchases and convenience-driven single-item purchases.
+ 3-D E-commerce printing is also emerging and has the potential to significantly change some supply chains and alter freight transportation demand patterns.
+ Some notable companies are testing drones, but the applicability of this technology in delivering in an urban environment is still being researched.

Trucks and freight movement contribute significantly to the production of greenhouse gas emissions and fine particulate matter. Replacing combustion-fueled trucks with EVs in urban and metropolitan areas will improve air quality. Cargo bikes, such as those being trialed by UPS in Seattle and Pittsburgh, can reduce the number of trucks on the streets and have zero pollutants.

During a five-year period, USDOT/Volpe identified 1,746 pedestrians and bicyclists were killed from impacts with large trucks.[55] In crash statistics, when comparing 2017 with 2016, fewer people died in crashes, with standout exceptions for large truck and urban area fatalities.[56] Trucks are not designed for maneuvering in dense urban areas where there are blind spots and lack of protection for other road users. Trucks equipped with connected vehicle technology will be able to sense pedestrians, bicycles, and nearby vehicles and warn drivers of potential collisions.

Local regulations requiring trucks to have better safety equipment may conflict with federal standards and Interstate Commerce rules. Some cities have resolved these issues by upgrading their own fleets and requiring their contractors to also comply with the regulations.

Because the main drivers of the industry are profit/loss and maintaining service levels, fleet conversions to connected, automated, and electric vehicles may be slow. However, as costs come down and the safety and efficiency benefits become more clear, the trucking industry will begin to adopt these emerging technologies.

Freight and Delivery Opportunities

+ Increasing numbers of alternative fuel and electric trucks will improve overall air quality.
+ Connected vehicle technologies like proximity sensors will improve truck safety and prevent crashes.
+ Using technology for pre-booking and demand management will help manage freight and delivery vehicle parking demand and improve curbside operations.

Freight and Delivery Challenges

+ Regulations for the trucking industry are different than for personal vehicles and must be updated to accommodate changing technologies and traffic operations.
+ Costs of the technology-enabled vehicles may be a hindrance to trucking companies converting their fleets.
+ Increases in delivery vehicle traffic due to changes from in-store multiple purchase to single item delivery.

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Endnotes

a. The MCB team used the regional travel demand model to gain insight to the impacts that new mobility technology could have on the regional economy. Travel time savings reduces the cost of congestion and increases the productivity of region. Greater accessibility to transportation creates job opportunity, access to healthcare, education and promotes consumer spending. Safety and quality measure that promote biking and walking improve health, reduce congestion and provide benefits to air quality. These are all examples of system wide performance metrics that have been reviewed to measure the benefits of the Mobility Choice Blueprint.

   The programs, projects, and initiatives recommended in the Mobility Choice Blueprint Bold Scenario are expected to provide an annual user benefit to the region in excess of $1.9B annually (in 2018 dollars) above the 2030 Gridlock Scenario. This total includes:

   + $380M Increased productivity for personal travel in shared and automated vehicles
   + $790M Personal travel time savings due to congestion reduction and service improvements
   + $645M Crash reductions and safety benefits
   + $282M Consumer spending generated due to transportation access to those unable to drive or without transportation choices
   + $7M Health benefits accrued to increased cycling and walking
   + Additional benefits not included in the above calculation are expected for crash reductions, economic growth due to job gains and GDP or environmental benefits such air quality improvements.

   For additional documentation of the economic impacts of the Mobility Choice Blueprint, see Appendix E, Scenario Comparison: Qualitative & Quantitative Evaluation

b. The regional travel demand model indicates there are 73,000 households without access to a vehicle in 2015 in the Denver region, and 91,000 such households in 2030 – a growth of 18,000 households. Implementing the Tactical Actions of Mobility Bold would improve the mobility of all 91,000 households without access to a vehicle.

c. In 2015, the regional travel demand model estimates there are 357,196 vehicle hours of delay (VHD) per day in the Denver region. In Mobility Gridlock this grows to 536,955 VHD in 2030, an increase of 50%. The VHD is 532,629 in Mobility Bold, a savings of 4,326 VHD. Applying an annualization factor of 338 results in 1.46 million VHD saved annually.

d. The regional travel demand model estimates 78.8 million vehicle miles traveled (VMT) per day in 2015 in the Denver region, and 97.9 million daily VMT in 2030, an increase of 24%. In 2015, there are 223 traffic crashes per day (according to DRCOG's 2017 congestion report), a rate of 346 crashes per 100M VMT. For the study, daily VMT was separated between self-driving and non-AV personal vehicles assuming 1.5% of all personal vehicle trips are AV in Gridlock and 10% of all personal vehicle trips are AV in Bold. NHTSA (2019) Topics: "Automated Vehicle for Safety" report 94% of all serious automobile crashes are due to driver error or choice (https://www.nhtsa.gov/technology-innovation/automated-vehicles-safety). The MCB study assumed the average crash rate for AVs to be 34.6 per 100M VMT and non-AV crash rate to be 346 per 100M VMT. These rates were applied to the annual VMT estimated for AV and non-AV personal vehicle travel for each scenario to estimate annual crashes. Crash type were applied to total crashes based on the 200-2016 summary of rashes for the City and County of Denver (www.codot.gov/safety/) and applied cost/crash according to the 2017 cost by crash type.

e. The Colorado Department of Health & Environment (CDPHE) produced a statewide greenhouse gas inventory in 2014 (https://www.colorado.gov/pacific/sites/default/files/AP-COGHGInventory2014Update.pdf). To generate this inventory, CDPHE used a modified version of the Environmental Protection Agency's (EPA) State Inventory Tool (SIT) model to break down emissions by sector and fuel type and project future levels. In this report, greenhouse gases include CO_2, N_2O and CH_4. Fossil fuel combustion in the transportation sector totaled 29.94 million metric tons of CO_2 emissions ($MMTCO_2e$) in 2010, and CDPHE projects this number will grow to 33.37 $MMTCO_2e$ in 2030, if current trends continue.

f. The Argonne National Lab has developed a model that takes into account emissions generated from making the fuel for both electric vehicles (electricity) and internal combustion vehicles (gasoline), and in building the cars themselves. The model calculates how much pollution each type of vehicle generates during its lifecycle. This model indicates that electric vehicles in the Denver area generate 41% less carbon dioxide (CO_2 or Greenhouse Gas – GHGs) per mile compared to gasoline powered vehicles. Argonne AFLEET model, accessed at https://afleet-web.es.anl.gov/afleet/.

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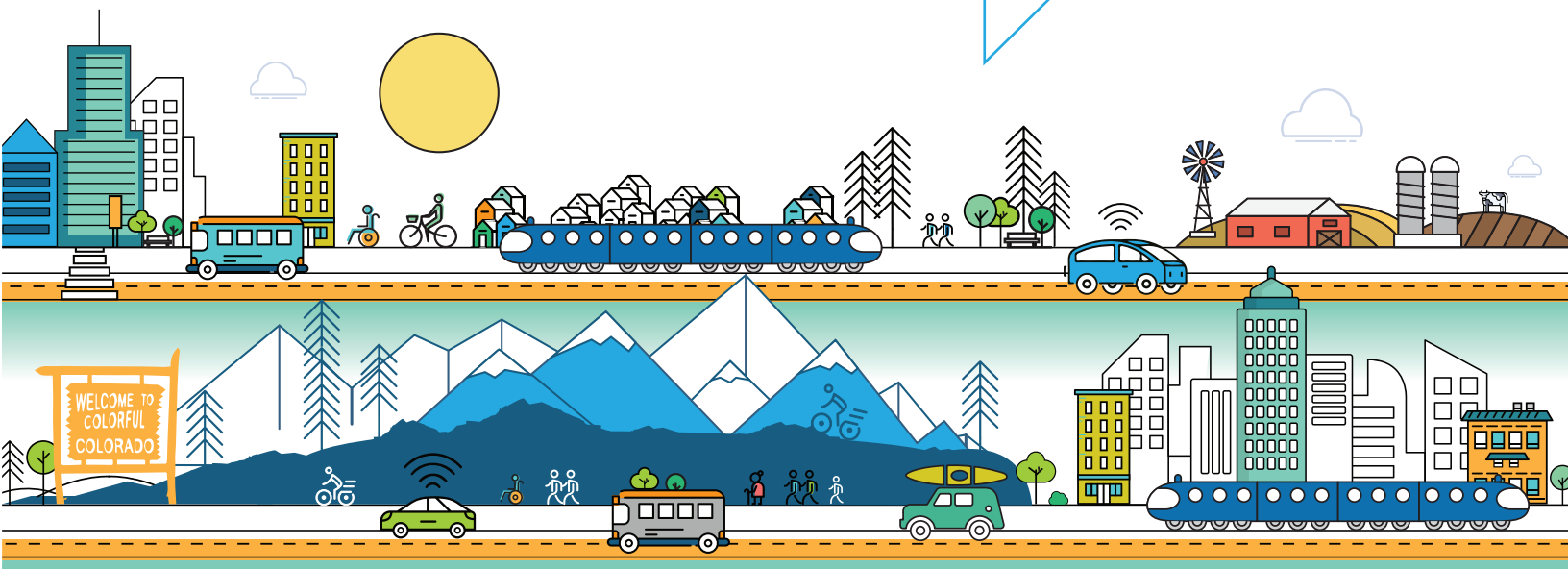

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