Colorado

Automated Vehicle Proving Grounds of the West

COLORADO
Department of Transportation

COLORADO
State Patrol
Department of Public Safety

COLORADO
Department of Revenue
Division of Motor Vehicles

on behalf of the State of Colorado

EXECUTIVE SUMMARY

Colorado

The Proving Ground for Connected Autonomous Vehicles

"Safety First" is more than a slogan, it's a philosophy that has been embraced and demonstrated by the Colorado Coalition that is proud to submit this application to become designated as the next-generation proving ground for Connected Autonomous Vehicles (CAV).

The Colorado partners are committed to improving safety on our roadways, and we recognize the tremendous potential CAV offers to save lives, improve mobility, enhance economic vitality and support ladders of opportunity. Colorado is taking proactive steps by establishing the Colorado CAV Task Force for the benefit of enhancing automated transportation. The Task Force consists of the Colorado Department of Transportation (CDOT), Colorado State Patrol (CSP) and Colorado Department of Revenue (DOR). This Task Force will help enable the deployment of CAV, while keeping the safety and welfare of Colorado citizens as a top priority. For this application, a Coalition of partners has been formed, augmenting the Task Force, with the following organizations:

- City and County of Denver
- National Renewable Energy Laboratory (NREL)
- City of Fort Collins

For this application, the powerhouse Colorado Coalition is being led by the CDOT RoadX Program, whose focus is to engage industry partners and bring CAV technologies to Colorado's Transportation network. The RoadX Program operates like a start-up business, housed within the CDOT. This business approach allows RoadX to move nimbly, entertain new partnerships and entice companies to deploy new technological solutions to address our transportation challenges. Our RoadX Program embodies "Colorado is Open for Business."

Why this emphases on a Coalition and a new business model? The CAV industry is seeking new and progressive partners that can move at the speed of private business. To make CAV more mainstream and attractive to customers, vehicle manufacturers need to demonstrate that their CAV technology works in all environments, not just closed-test-track facilities.

In addition to highlighting the attributes of several distinct Colorado venues identified below, we believe our strength lies in our ability to offer a plethora of opportunities that can be tailored to meet the needs of the CAV industry.

- Closed Test Tracks: CSP test track
- Highway Corridors: I-25, I-70
- Cities/Urban Core Demonstration Corridors: CCD & City of Fort Collins

Why should the U.S. Department of Transportation (USDOT) want the State of Colorado on the approved list for automated vehicle proving ground sites?

In addition to meeting and exceeding all criteria identified in the Notice of Intent, Colorado will showcase how we can adapt to the needs of the CAV industry. Colorado offers a unique opportunity to tailor safety plans, testing protocols and performance specifications that coincide with the objectives of the CAV industry. Further, Colorado will engage its diverse and innovative population, use its healthy economic climate for investment, and involve its diverse energy industry to support automated vehicle testing.

Through on-going programs, we are supporting:

1). Identification of legislative requirements and challenges

2). Establishment of a platform for data collection and integration

3). Development of a road classification system

We are excited to partner with the USDOT and CAV manufacturers to move this technology forward.

What is the benefit of choosing Colorado for the proving grounds?

This application identifies specific proving grounds that provide diverse options for testing and deploying CAV vehicles. Further, the value of partnering with the State of Colorado is our unique ability and willingness to identify and establish new proving grounds that are tailor-made to meet with requirements of CAV manufacturers.

Colorado is a proving ground with a willing and accepting population, ready to enhance automated transportation. We have a healthy economy for investment. Colorado also offers a variety of test site options and has been a proving ground for advanced technologies.

The Colorado Coalition believes any Proving Ground should be a partnership between the USDOT and the CAV industry, resulting in states having automated vehicles on their roads sooner.

Testing an automated vehicle on a closed track is a first step toward the safety benefits that the USDOT and states are seeking. Getting out of a closed environment and into real world applications is the path to full deployment.

The CAV industry will sell more vehicles to consumers when these benefits are proven in a real world environment.

Much like safety, it cannot be the sole responsibility of the USDOT, the CAV industry or the states to advance these technologies – we all need to work on this together.

A key benefit in Colorado's application is this understanding that our interests are more aligned then we give each other credit for and if we commit to working together we can all get what we want out of this while keeping people safe.

Further, we recognize that CAVs are advancing quickly. As transportation leaders we can wait for it or we can be proactive in shaping the future. Colorado is committed to helping shape the future – our constituents deserve it and we are accepting the challenge.

Colorado's vision is to prepare for the future of autonomous vehicles. We are building the groundwork. We are a State focused on a full enterprise solution vs. just pavement for testing CAVs. To further the state's shaping of the future, we are:

1). Establishing a road classification system that identifies what roads are ready for various levels of automated vehicles

2). A partner in the CCD SMART cities application

3). Demonstrating the world's first automated truck delivery

4). Supporting and implementing flexible road environments - managed lanes, express lanes, HOV-3 lane

5). Identifying and developing additional, proving grounds that meet the specific and unique requirements of CAV manufacturers.

Colorado is willing to partner directly with the CAV manufacturers to ensure that our test tracks and proving grounds truly reflect the needs of the industry

Community Benefits

The CAV Proving ground designation for Colorado will benefit several communities. The CAV vehicles will improve mobility for commuters and transit riders by reducing congestion. People will have better access to employment and to educational institutions. Commercial motor vehicles will experience less delay which will be reflected in the delivery costs. Jobs will be created to complete the design and installation of new ITS infrastructure to support CAV technology.

CAV technology also benefits the environment. CAV will improve safety. Reduced crashes and reduced congestion means less wasted fuel and less emissions from vehicles. According to Texas Transportation Institute's 2012 Survey on mobility, congestion related impacts for the Denver–Aurora area are: 34 million gallons of wasted fuel and 76 million hours of total delay. The cost of this wasted fuel and delay totals $1.6 billion.

Proven Safety Record

Colorado Commitment to Safety

Safety is not the responsibility of one individual, it is the joint responsibility everyone involved the transportation industry. The notice of Intent requests that a specific individual be identified as the "Designated Safety Officer", Peter Kozinski will be that point of contact for the Colorado Coalition. The Coalition is not content in suggesting that this sole individual is the only one responsible for safety.

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Safety is the responsibility of everyone involved and to truly have a safe environment you need to foster a proactive safety culture with all involved. The subsequent sections will outline the members of the Colorado Coalition and showcase their commitment to safety.

Peter Kozinski, PE
Director of RoadX

Peter Kozinski will serve as the Designated Safety Officer responsible for CDOT's Safety Management Plan for the CAV Proving Ground and Test Track Project. Peter will participate in the Community of Practices' regular quarterly meeting of Safety Officers. He brings more than 20 years experience in transportation engineering and will ensure that safety is the first

Afsoon Ansari
CSP Captain

Afsoon Ansari, as the commander of the Colorado State Patrol Strategic Analysis and Business Research (SABR) Section, will provide oversight and support of the safety initiatives brought forth through the partnership in this Coalition, ensuring law and regulations are enforced and that safety is a priority in testing environments and beyond. As a representative of the law enforcement stakeholder in this Coalition, she will ensure the agency mission of safety is upheld.

Colorado Coalition

The nucleus of the Colorado Coalition is an existing Task Force consisting of the Colorado Department of Transportation (CDOT), Colorado Department of Public Safety that is represented by the Colorado State Patrol (CSP) and the Colorado Department of Revenue (DOR) representing the Division of Motor Vehicles (DMV). This Task Force is responsible for developing, implementing and enforcing the laws and regulations that govern the safe use of Colorado's roadway. While the mission of each organization, shown below, differs there is one underpinning theme that transcends all three organizations – and that is Safety.

Senior members from each of the Departments are engaged in this Task Force and this group has been meeting on a regular basis for approximately 2 years with an eye toward CAV. Having senior leadership on this Task Force allows for quick decision making, adherence to key schedules and a commitment of necessary resources to enact the desired outcomes.

For this application, the Task Force is being joined by the City and County of Denver (CCD), the City of Fort Collins (Ft. Collins) and the National Renewable Energy Laboratory in Colorado (NREL). Together this group constitutes the Colorado Coalition that is submitting this application.

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

CSP Mission: *The Mission of the Colorado State Patrol is to ensure a safe and secure environment for all persons by utilizing the strengths of our members to provide professional law enforcement services that reflect our core values of Honor, Duty and Respect.*

DMV Mission: *to provide excellent identification, driver and motor vehicle services to help make Colorado a safe place to live, work and play.*

Why this Coalition? The answer is straightforward – All of us are committed to a safer and better environment for our constituents.

While the true safety benefits of CAVs are still statistical unknown, agreed upon doctrine suggests that 80 percent of accidents can be avoided when Autonomous Vehicles are commonplace on our roadways. An 80 percent reduction in accidents and the associated number of lives that can be saved is too great of an attractor to the civil servants that constitute the Colorado Coalition to not want to advance these technologies.

As the needs arise additional members to this Coalition will be added with the nucleus being the Task Force that will remain as the commonality. Therefore, every Coalition member will be involved strategically at different levels during each Automated Vehicle test / demonstration.

Coalition Members Joining the Task Force

City and County of Denver *is the urban core of Colorado and encompasses approximately 155 square miles and has a population of approximately 685,000 people. When you include the surrounding metropolitan areas this urban core has a population of approximately 3,500,000. The City and County of Denver as a shortlisted contender in the USDOT SMART City challenge and remains committed to advancing the efforts proposed in their grant application.*

City of Fort Collins *is a Northern Front Range City of approximately 65 square miles and has a population of approximately 175,000 people. Nestled at the base of the Rocky Mountains, Fort Collins offers exciting recreational opportunities, unique cultural offerings, and is a regional center for employment and shopping. Fort Collins is home to Colorado State University a land grant university, and the Flagship University of the Colorado State University System.*

National Renewable Energy Laboratory's *mission is to advance the science and engineering of energy efficiency, sustainable transportation, and renewable power technologies and provide the knowledge to integrate and optimize energy systems. Given the strong likelihood that future CAVs will be electrified, NREL will help the Task Force ensure that the long-term needs and impacts to our power grid are evaluated as CAVs are deployed throughout the broader network.*

Safety Planning

The Colorado Coalition believes that safety is not a stagnant thing, rather an interactive effort unique for each situation. Colorado is not proposing one test track / facility, race track, city / urban core, highway corridor or campus but is proposing that as our CAV industry partners are interested in proving that their technologies are ready to become more commonplace, Colorado will "marry-up" the features that industry is desiring to test / demonstrate with the appropriate facilities.

Once a desired location (track, highway, urban area, rural area) is identified the Task Force will engage interested and effected stakeholders in the development of a safety plan specifically tailored to that demonstration.

Planning for safety is an interactive process which will be documented for each CAV test and deployment. The Colorado Coalition proposes several facilities which are immediately available to Automated Vehicle manufactures for use to prove their technologies. These may be the CSP test track, a city/urban core, a highway corridor or other campus. Colorado will pair the features that manufacturers desire to test with the appropriate facilities. The 10 step process on the following page will create a Safety Plan for each deployment.

Safety Planning Process

Meet with industry/OEM/vehicle manufacturer about new technology

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Define the goal for the tested technology

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Coordinate with stakeholders to accept the goal, understand concerns, and establish an ongoing dialogue

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Decide on road classification needed

↓

Select appropriate venue

↓

Create customized safety plan based up steps 1-5 above: technology, stakeholders, goals road class and venue.

The Public	First responders including CSP and any local emergency response staff	Manufacturers and CDOT Staff	Potentially impacted property

↓

Decide on road classification needed

↓

The Safety Plan should identify risks and threats and develop mitigations for each

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Follow an ICS process and complete an Incident Action Plan (IAP) and Traffic Control Plan (TCP) to include in the Safety Plan

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Review safety plan with all affected stakeholders prior to deployment

ROADX and Innovation

RoadX is Colorado's bold vision and commitment to leading the nation in using innovative technology to improve the safety, mobility and efficiency of the transportation system, driving our state's continued economic vitality for business and community.

RoadX is a collaborative program focused on building partnerships, entrepreneurial relationships and delivering innovative solutions that will revolutionize our transportation system. No single transportation undertaking in this decade is more important for the long-term economic strength of Colorado and for the quality of life of our residents.

Through RoadX, the Colorado Department of Transportation (CDOT) will build the transportation system of tomorrow, today. At CDOT, we are creating an environment that directly connects and partners with industry to deploy large-scale technological solutions that will transform an aging transportation system.

CAV technologies are advancing at a rate not seen since the Model-T started to roll off the assembly line in 1908 some 108-years ago. As two points of reference, the Tesla Model S debuted in 2012, less than 5-years ago, the Ford Motor Company states, it will have a fully autonomous vehicle available for ride share services by 2021, 5-years for now.

Colorado's RoadX Program is a demonstrator and implementer of CAV technologies and is innovative in engaging with the CAV industry, Tier 1 suppliers and others in the connected vehicle space. RoadX is also starting to prepare Colorado roadways for Ford's fully autonomous vehicle that will be available in 2021.

As an example of how RoadX is thinking differently, it has developed a Connected Road Classification System (CRCS) that corresponds to differing levels of vehicle technology.

- CRCS1: Unpaved and/or non-striped roads designed to a minimum level of standard of safety and mobility
- CRCS2: Paved roads designed to AASHTO's standards with MUTCD signage. There is not Intelligent Transportation System (ITS) equipment or infrastructure to collect connected vehicle data (Dedicated Short Range Radio). Access to cellular date service may be available.
- CRCS3: There is Intelligent Transportation System (ITS) equipment operated by a Traffic Operation Center (TOC) and/or, one way electronic data share between DOT/Vehicle/User and/or, mixed use lanes
- CRCS4: Roadway or specific lane(s) has adaptive ITS equipment (i.e. smart signals hold for vehicles, highway lighting that turn on for vehicles, etc.) with Traffic Operations Center override only, and/or two way data share between DOT/Vehicle/User, and/or lanes designated for vehicle levels 3 & 4 only
- CRCS5: (Advance Guide-way System) roadway or specific lane(s) designed for vehicle level 4 only with additional features that may include inductive charging, advance/enhanced data sharing, etc. Additionally, no roadside signs are needed as all roadway information is direct to vehicles' on-board systems.
- CRCS6: All lanes on a roadway designed for only vehicle level 4 systems - no signs, signals, striping needed.

As an example of how we are proposing to use this in Colorado:

1). All roads in the system are being evaluated and assigned a CRCS level.

2). The existing infrastructure within key commuting and freight corridors are being evaluated for their readiness to move from one CRCS level to the next.

3). An investment estimate by corridor/logical segment to move from one CRCS level to the next is prepared.

4). An investment strategy is developed and agreed upon.

5). Design, implement, and operate.

In Colorado's case, our goal is to advance 20 percent of our interstates lane-miles from CRCS3 roadways to CRCS4 within the next three years.

Endless Possibilities

Beyond CDOT, beyond CSP, beyond municipalities, and even beyond the CAV industry, what is needed to ensure a successfully proving grounds for CAV and other mobility innovations?

- A citizenry ready for the future
- Diversity for testing innovations
- Healthy economic setting and diverse energy portfolio
- Access to test sites and data

A young, well-educated community ready to embrace new technology

Colorado Millennials, people between the ages of 20 to 34, are the workforce's largest age group, meaning attracting millennials is more important now than ever. Additionally, millennials are more ethnically diverse, with 44.2 percent being part of a minority race or ethnic group.

US. News & World Report unveiled its annual Best Places to live rankings for cities in the United States and Denver is #1 for 2016. William Frey, senior fellow of the Metropolitan Policy program for the Brookings Institution, parsed the numbers and determined that from 2008 through 2010, more young adults between the ages of 25 and 34 moved to Denver than any other city.

Millennials go beyond being receptive to innovation, they crave it! Denver will provide the population support needed to embrace the test tracks and their results.

Diversity in terrain, weather, urban and rural settings

One of the most scenic states in the country, Colorado has 42 recreational parks, including Rocky Mountain National Park and Great Sand Dunes National Monument. Colorado has elevations ranging from 3317 to 14,440 feet, and has 51 of the 80 peaks in North America over 14,000 feet high, thus laying claim to the name "top of the world." The Continental Divide runs north-south along the Rocky Mountains in Colorado. Colorado's eastern expanses are part of the High Plains section of the Great Plains and most of western Colorado is occupied by the Colorado Plateau, where deep canyons have been formed by the action of rivers.

Colorado enjoys 300 days of sunshine a year and yet weather can change in an hour to snow and sleet. All drivers in Colorado learn to be prepared and to maneuver on snowy roads.

The Denver metropolitan area, known around the world as the "Mile High City" because of it 5280 foot elevation, has a population of more than 3 million people and yet many Coloradoans live on rural ranches and farms.

Colorado has a diversity in terrain, in weather conditions, in urban and rural highways and in its population and their occupations. No other Rocky Mountain state can provide the diversity for proving grounds and test tracks like Colorado.

Current economic success

A strong economy results in strong public sector investments in infrastructure and innovation. Colorado's economy outpaced national averages in unemployment rate and job growth in 2015, and the outlook for 2016 remains strong. Companies are investing in new facilities in the Denver International Airport Aerotropolis.

Colorado's unemployment rate was far lower than the national average. Job growth rose 1.9percent in 2015, and the state is expected to experience an increase of 2.6 percent in 2016, according to University of Colorado Boulder economists. As baby boomers exit the workforce, the talent gap is expected to drive up wages for qualified individuals. With low unemployment, high job growth, increased migration and the quality of life appeal that Colorado offers, the state remains positioned for continued economic growth in the coming year.

Access for the world, the country, and industry

Access to the region, for people and goods, and access to data are critical to the shared knowledge culture needed to make CAV test track projects accessible to everyone.

Denver International Airport is a major hub in the country's air traffic pattern. It is served by almost all major U.S. airlines; carriers link Denver with other Colorado cities, with neighboring states and with international destinations.

Railroad lines in Colorado are mainly bulk-freight carriers using multilevel railcars and flatcars for containerized freight, and a main east-west Amtrak passenger route passes through Denver and the Rockies.

Colorado boasts a diverse energy portfolio. Colorado produces coal, hydroelectric, solar and wind power. With 300 days of sunshine a year, solar power has been tested and shown its value in Colorado.

In the late 20th century, Colorado was the site of a telecommunications boom. Several national high-technology and telecommunications companies located their headquarters in Denver and elsewhere in the state. Colorado remained a national leader in the field into the 21st century with the economic recovery.

Colorado's Proving Ground Protocols

How will the testing facilities adhere to state and local laws and federal regulations?

As the safety branches of Colorado's government, CSP and CDOT have had a long history of engaging in innovative transportation methods while complying with federal, state and local laws. The testing areas designated by Colorado (highway corridors and CSP test track) are directly under the government agencies' jurisdiction and provide ample opportunities for innovation through automated vehicles. CSP, CDOT, and DOR, being experts in this area of state regulatory authority, are the best equipped with resources (knowledge, expertise, authority) to ensure the testing areas will comply with all applicable laws.

For the purposes of this application, testing will occur at both a closed track operated by CSP and on designated highway corridors. The test track is continuously monitored by CSP to ensure it is operated in compliance with all applicable laws and regulations. The highway corridors are public roads and will require close coordination with the state agencies to ensure an automated vehicle on a highway corridor is complying with applicable laws.

How will Colorado demonstrate adherence to the primary subject areas outlined in the NHTSA policy for any testing or deployment of L3-L5 systems on public roads, when making use of public roads?

As most of the primary subject areas outlined in the National Highway Traffic Safety Administration (NHTSA) policy applies to manufacturers and other entities, Colorado will respond to the subject area of model state policy recommendations outlined in the NHTSA policy for any testing or deployment of L3-L5 systems on public roads.

Colorado has already met much of what NHTSA recommended as a model state policy. Colorado already has had a Task Force of three agencies with primary authority over transportation and motor vehicles (CDOT, CSP, DOR), working collaboratively over the past year on automated vehicle regulatory issues. CDOT has been the lead agency based on its RoadX initiative. CSP is an integral agency member of the Task Force and is closely involved in the discussion of safety concerns related to automated vehicle technology, and the testing and deployment of automated vehicles. The Task Force has worked

collaboratively with the industry to develop a safety operation plan (World's first automated freight delivery). The Task Force has been reviewing existing Colorado laws over the past year to determine potential obstacles in the legal framework. Through these existing efforts, Colorado has demonstrated that its regulatory framework aligns with NHTSA's state model policy.

How will CDOT track the various test track pilot project successes?

CDOT has demonstrated experience in developing goals and tracking performance metrics for the annual FHWA Stewardship Agreement report and for allocation of funding. Data are gathered from the Colorado Traffic Management Center, DOR and CSP. Data include but are not limited to: injuries, fatalities, reliability-planning time index, road closures, incident clearance time, 511 calls, wildlife hit and roadway maintenance. For each pilot project, a Technical Working Group (TWG) will be developed that represents the Coalition, various stakeholders, partners and participants with the pilot. This TWG will outline performance goals and measures of success for each CAV project. The goals for CAV projects may be to improve mobility, safety, vehicle-to-infrastructure communication, air quality or public information. Metrics can then be assessed before and after project deployment. As just one example, CDOT can track mobility of a corridor before and after the implementation of a CAV project using INRIX.

The TWG will also delegate a Safety Lead and a Public Information Officer to work with all partners for messaging and documentation to the pilot project. Issues to considered and address will include the need for public advertising, the formatting for input data, the results desired based upon pilot goals, the measures of success and the display of the results on a Proving Grounds website.

A critical element of every document resulting from each pilot CAV deployment will be a record of the ideas and approaches that succeeded, did not work or were not carried forward. Safety Plans will also be included. This valuable documentation of lessons learned will equally support the research investment to be made by other states.

How do CDOT and its partners plan to share the data?

The Proving Grounds website, will be a repository for intelligent mobility information and resources, as well as test protocols, goals, safety plans, and results.

To the Proving Grounds website will create an environment that fosters innovation. It will link the university network of academic research around intelligent mobility with industry and agencies. These partnerships provide an incubator for good ideas, barriers are removed, deployment is facilitated, and rapid-start/pilot activities are fostered. This open source environment furthers collaboration, information sharing, innovation and technology development.

The website will be a safe and accessible forum for all data and results of any of the test track pilots completed in Colorado. This open-access platform will be available to all interested in advancing their intelligent mobility initiatives.

More traditional distribution methods will be embraced, such as presentations and speakers at local and national conference. Additionally, CDOT will participate in the annual Autonomous Vehicles Symposium, the ITS World Conference, American Association of State Highway and Transportation (AASHTO) Officials, and WTS to discuss the successes of the CAV Proving Ground. In state, CDOT will also present findings at its annual Transportation Summit.

Further, the Coalition will work with the University of Denver's Advanced Mobility Program to affiliate students with projects, for advancement of information.

To participate in the Community of Practice, CDOT will document quarterly project updates through the Proving Grounds website. Through feedback from these outreach efforts, CDOT will develop an educational package and flow chart to help other organizations safely deploy CAV technology in their respective communities.

How will CDOT share its approaches to safety and the safety data generated?

CDOT and the Coalition are committed to sharing Colorado's approach and procedures to improve safety. Safety performance goals will be set and the data will be tracked for each individual project. The Safety Management Plans and After Action Reports will become part of each project's documentation. The core team will

speak as a unified voice about each project's benefits and safety procedures. These will be reported throughout Colorado via the Colorado Motor Carriers Association, the Colorado Freight Advisory Committee, Colorado Contractors Association, universities, and nationally to US DOT, Federal Highway Administration (FHWA), Federal Motor Carrier Safety Administration (FMCSA), other state Departments of Transportation (DOTs) and AASHTO.

For the Proving Grounds' Pilot Projects, CDOT will publish the safety plan, the risk assessment and the risk register of mitigations. This plan along with the findings of the project will be open to public review.

How will Colorado maintain a working relations with the USDOT's other research efforts and contribute to the Community of Practice?

Colorado proposes to use the Proving Grounds website to share its data and to work with other USDOT research efforts. This platform will facilitate both CDOT data sharing on its pilots and other research around the country, including USDOT research efforts.

The Proving Grounds website can be used as the Community of Practice platform for pilot project information sharing.

How is the State of Colorado investing to advance CAV?

Colorado's RoadX Program is investing in the future. Since being launched in October of 2015 the RoadX Program has been allocated approximately $36 million and anticipates being allocated approximately $12 to $15 million per year for the foreseeable future. RoadX is investing these funds in new partnerships and in advancing some of its signature Projects (Smart 25, Smart 70 and Bike & Ped Challenge). In addition to investing in its own projects, the RoadX Program is supporting other large CDOT investments by providing technical assistance – insuring that these major investments are installing the needed infrastructure so more roadways in Colorado are prepared for the inevitably of CAV vehicles.

As more and more CDOT projects are built with embedded technologies, Colorado's portfolio of CAV ready roadways will increase and CAV will operate as designed.

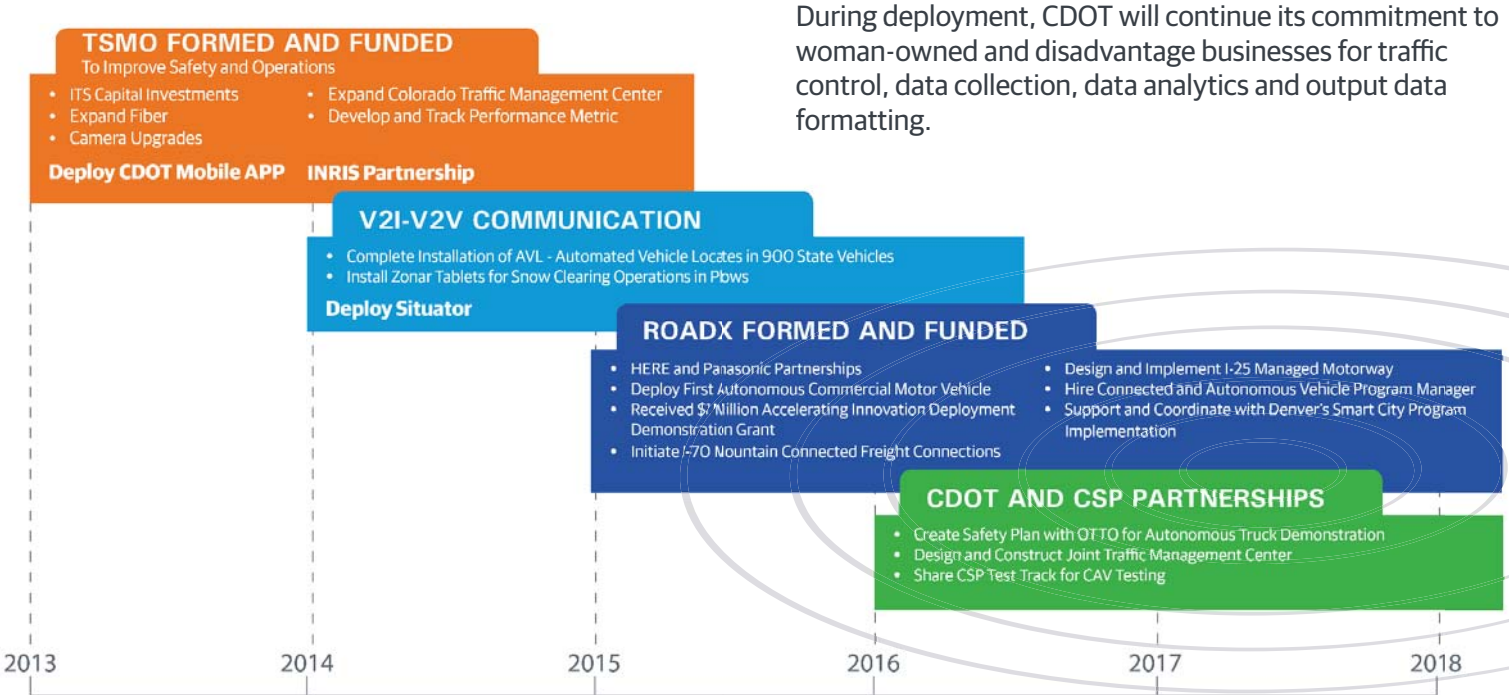
Another focus of the RoadX initiative is building partnerships, entrepreneurial relationships and delivering innovative solutions that will revolutionize our transportation system. No single transportation undertaking in this decade is more important for the long-term economic strength of Colorado and for the quality of life of our residents. While Colorado has the ability to fund and begin individual technology-related pilot projects, we recognize the importance of ensuring that each project has industry input, and each provides an interconnected foundation that builds toward our ultimate transformative vision.

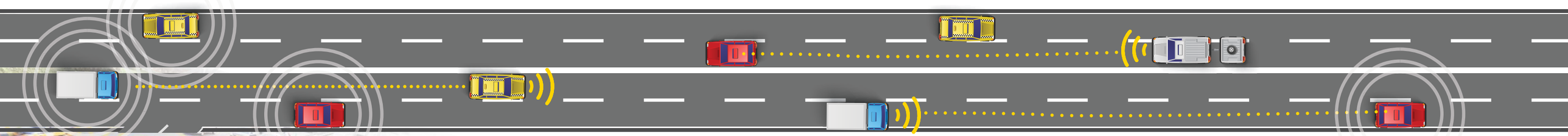
A cornerstone for partnership with industry is the InnoVisers Council, comprised of business leaders from Colorado's top companies, which is tapping public and private industry innovators and advisors from within the state, across the nation and worldwide. Our business proposition is simple: Help Colorado blend technology with transportation, and create the nation's new standard for safety and reliability. To facilitate this transformation, Colorado has committed to:

- Providing industry access to key state assets for statewide transportation technology deployment partnerships.
- Offering an industry-friendly, technology-partnering environment at all levels of public policy.

We have seen great interest in RoadX and our initial projects, from which great partnerships are being created.

During deployment, CDOT will continue its commitment to woman-owned and disadvantage businesses for traffic control, data collection, data analytics and output data formatting.





Colorado State Patrol Test Track

Colorado State Patrol Driving Track

The CSP Academy Track is part of the CSP training facility located in Golden, CO. The track consists of 1.4 miles of asphalt paved roadway located on top of South Table Mountain Park Mesa which is fenced and accessed through a gate with a secured code. The track contains three skid-pan areas, three high-speed 65 Mph lane change areas, eight curves ranging from 30-55 Mph, and one off-road recovery area. The rack also includes two uncontrolled intersections and three traffic control signals. The traffic control signals are within the main skid pan and can be individually operated. The traffic control signals are manipulated manually from an enclosed two-story control tower. The control tower provides a 360 degree view of the track as well as radio capabilities. The track facility includes one temperature controlled classroom with a seating capacity for 20, and audio/visual capabilities.

Additional Resources

The CSP Academy Driving Track can be accessed 24-hours-a-day, 7-days-a-week. Access to the CSP Academy Track should be requested in advance from the CSP Academy staff. This State of Colorado owned and operated facility is insured through the State of Colorado liability insurance policy.

Future Upgrade Proposals

The images on the right represent proposed upgrades to the CSP Academy Track.

Conclusion

The CSP is looking forward to partnering with CDOT to advance technologies through the proposed CDOT RoadX AV/CV Proving Grounds Pilot Program to the United States Department of Transportation

Proposed paving of roadways in the center of the existing track. Paving additional roadways will better simulate city streets and proved for improved awareness and advanced training.

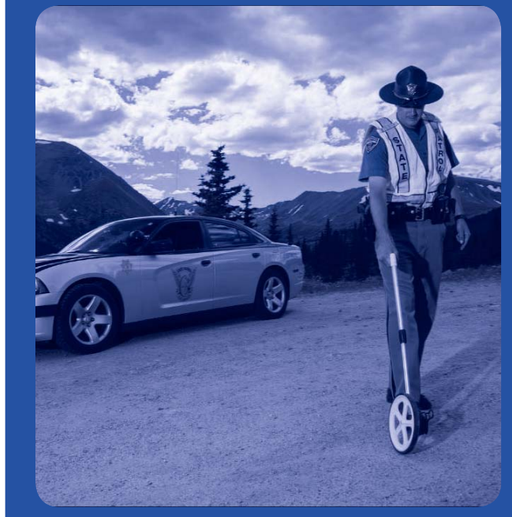
Proposed paving of Quaker Street leading to the track entrance. Paving Quaker Street will allow year-round access during inclement weather and better snow removal.

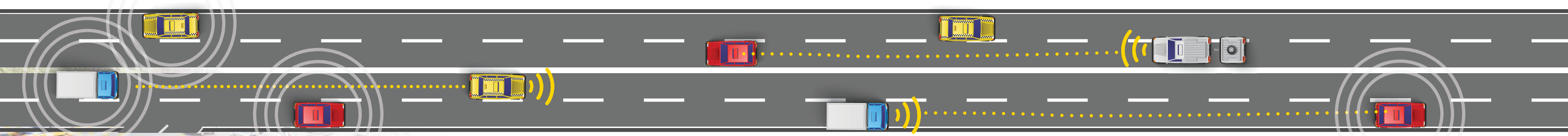
Safety

CSP has partnered with CDOT and the DOR to use its test track to further the safety of Colorado drivers through a complete understanding and testing of AVs and CVs.

Ready and Proven

The test track is available today for the first pilot project in Colorado and CSP will be there ensuring the safety of all.





Highway Corridors Available for Trial Deployment

I-25 New Mexico to Wyoming

The Colorado Task Force partnered with a self-driving truck company to complete the world's first commercial freight delivery by a self-driving truck. This approximately 120-mile demonstration of self-driving technology in the real-world environment of Colorado is a monumental next step in advancing safety solutions that will help Colorado move toward zero deaths on our roadways. Colorado is enthusiastic about working with CAV manufacturers and innovators in the CAV field on:

- The long-term benefits of deploying this technology are understanding the safety and mobility improvements, as well as the possible reductions in environmental impacts of highway freight.
- Fostering the economic benefits advanced driving technologies are poised to bring to freight delivery and our state.

As a test track, I-25 offers reasonable grades on a relatively straight route for CAV testing. Through all of Colorado's largest cities, Fort Collins, Denver, Colorado Springs and Pueblo, I-25 is the backbone of north-south transportation in Colorado. This corridor is ideal to examine the feasibility of new CAV technology.

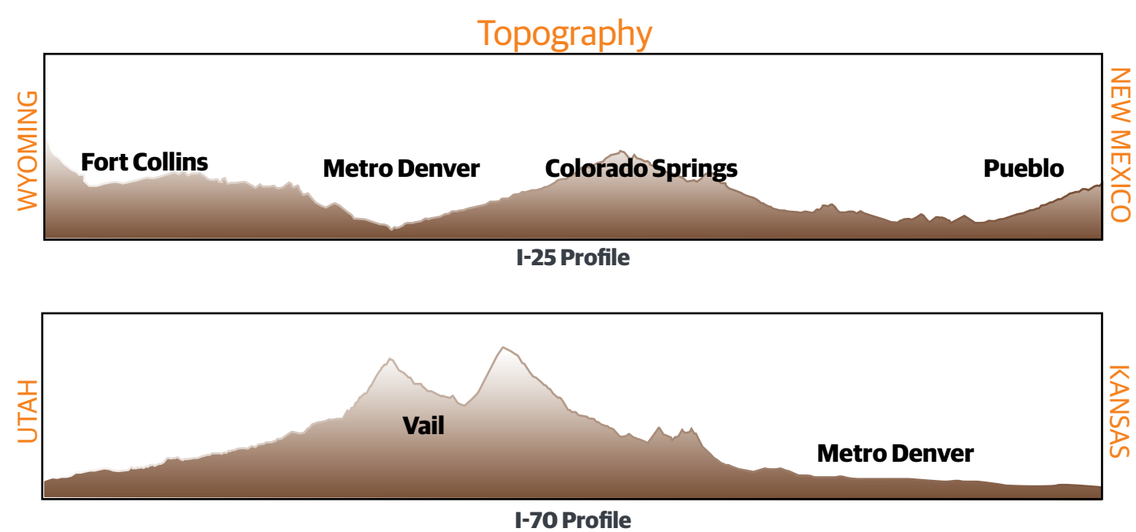
I-70 Utah to Kansas

As a test track I-70 will provide terrain from the mountains to the plains. The distribution of goods to cities and towns throughout rural Colorado would prove to be excellent testing grounds for autonomous trucks. Beyond the straight and flat, I-70 offers testing grounds for steep grades, quickly changing weather conditions, emergency truck parking and last-mile delivery challenges.

Stakeholders on the I-70 corridor have been active participants in two of the state's largest planning efforts: the I-70 Mountain Corridor and the Central 70. This corridor is ready to prove CAV technology over the mountains and through the plains.

For the I-70 Mountain Corridor Environmental Impact Statement (EIS), a planning document for 150 miles of mountain highways with tunnels, mountain passes and access to world-class ski resorts. Through stakeholder meetings, technical teams and personal one-on-one conversations, CDOT has built a partnership with the towns, the resorts, the truckers and the residents that remains strong today. Stakeholders will support the use of I-70 as a test track for innovation in a unique environment.

Through the core of the City and County of Denver, I-70 carries hundreds of thousands of vehicles every day. The renovation of this segment of highway has been planned for years and, again, CDOT has built a network of groups, stakeholders and supporters who have expressed their interest in advanced technologies and how this is the future of transportation. Support for the use of I-70 through the center of Denver exists today to examine new technology.



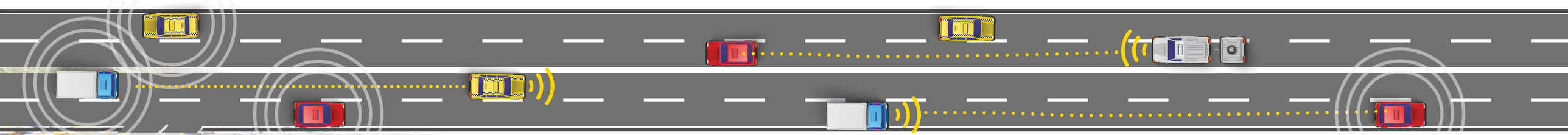
Safety

For both the I-70 and I-25 Test Track projects, Peter Kozinski will assemble a Safety First Team to include Captain Anasari / CSP and appropriate local law enforcement and emergency providers. This core team will discuss other members needed to ensure the absolute safety and protection of Colorado's citizens and travelers. The team will detail the project specifics from which a risk register will be developed. Each identified risk will have a defined mitigation, and unanimous agreement upon the plan will be the first step to begin the project.

Ready and Proven

I-25 has already been used to test a fully automated 18-wheeler over 120 miles of travel. This nationally celebrated accomplishment proves I-25 and the State of Colorado are ready to be designated the Automated Vehicle Proving Grounds of the West.

I-70 is ready as a living laboratory with stakeholder interest and support to test the next generation of autonomous vehicles.



Cities and Urban Cores

Arterial Improvements on Urban Corridor to Demonstrate the Internet of Things

CREATE A MOBILITY MANAGEMENT HUB (MMH)
The cloud-based open data sharing concept includes V2I data from the street to optimize traffic flow, conduct real-time and predictive analytics and disseminate information to CAVs. Private sector partners are able to provide tools for the creation of the most advanced Azure cloud-based mobility management big data application envisioned for the mobility industry. All data flow into the hub from vehicles, mobile apps, sensors and machine-to-machine Internet of Things implementations as well as the traffic signal and ramp metering systems. The MMH is envisioned to facilitate seamless personal communication and mobility experiences for drivers. For example, drivers can exchange calendar entries containing location with the navigation system in a vehicle.

SMART RAMP METERING CONTROLLER AND DATA DETECTION
Upgrades for the I-25 and Corridor Interchange to collect traffic flow.

DEMONSTRATE VEHICLE -TO-VEHICLE (V2V) CAPABILITIES
including collision avoidance and semi-autonomous safety features.

VEHICLE-TO-PEDESTRIAN PHONE (V2P)
Safety application demonstrating AV/CAV collision and signal preemption for pedestrians.

VEHICLE-TO-INFRASTRUCTURE (V2I)
Demonstrating how vehicle data are collected, stored in a cloud and are used to enhance driving experiences for auto alliances.

OPEN REGIONAL DATA SHARING
Cloud-based analytics and messaging from big data mobile applications.

CONSTRUCTION MONITORING AND ADVISORIES
I-25 & Arapahoe Interchange Construction work zone information sent to AV/CAV heads-up displays.

UPGRADE SIGNAL CONTROLLERS
Upgrade key intersections to Econolite Cobalt CAV-capable controllers for enhanced traffic signal timing and data processing, open-source data and real-time analytics for V2I communications.

Colorado's Planned Demonstration Corridor and Mobility Management Hub provide a tangible system that improves safety, provides options to motorists, supports multimodal integration and connects travelers. This system will leverage private sector investments to maximize public dollars and provide a scalable, flexible and easily replicated model that can be used as an innovative showcase for future demonstrations.

AV Test Track on Highway Corridors

Part of Colorado's vision is to develop a CAV test track on a congested corridor in the Denver Metro area to showcase AV compatibility and their interface with other mobility options (vehicles, pedestrians, bicyclists and transit). This project will be a first-of-its-kind collaboration comprised of diverse partnership and technological applications. The demonstration corridor will be equipped to safely deploy AV using key communications mediums: Vehicle-to-Vehicle (V2V), Vehicle-to-Infrastructure (V2I), Vehicle-to-Cloud (V2X), Vehicle-to- Pedestrian (V2P), and Vehicle-to-Bicycle (V2B).

To realize this vision, vested private sector partners including Econolite, Microsoft, Savari Networks, Cisco, and Qualcomm will be engaged to make this vision possible. An advanced ITS design including technologies such as Cobolt CAV-capable signal controllers, DSRC and Bluetooth radios and encryption, enhanced roadside sensors and aftermarket onboard units will be utilized to collect, process and analyze data from test vehicles along the corridor.

It is envisioned this demonstration corridor will be supported by a Mobility Management Hub (MMH) with an Azure cloud-computing based, open-source platform to collect, process, analyze and disseminate data and information to motorists, demonstration vehicles and infrastructure managers. The MMH will integrate data from the enhanced infrastructure, test vehicles and traffic data sources (e.g., INRIX) across a fully inter-operable, open-source data platform that can collect, process and share information between CDOT Traffic Management Centers (TMCs) and those of other municipalities. This advanced test track set on a congested corridor spanning multiple agency jurisdictions is the exact type of AV testing needed to prove and advance current understanding of how AV technology should be deployed and operated.

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