



## **Connected and Autonomous Technology (CAT) Program**

### **MISSION**

Improve the movement of goods and services throughout Colorado by leveraging the benefits of connected and autonomous mobility technologies while mitigating potential risks

### **PURPOSE**

To accelerate the responsible use of connected and autonomous technologies in Colorado

### **PROBLEMS**

CDOT will use CAT to help address the following transportation problems in Colorado

- **Safety** - One of the primary motivators of the CAT program is to improve roadway safety. By sending timely notifications directly to drivers prior to an accident or hazardous conditions, connected vehicles (CV) can help prevent up to 81% of unimpaired accidents from happening at all. Autonomous vehicles (AV) can remove the human error that contributes to 94% of all vehicle crashes. Both technologies can help Colorado spare lives and avoid costly accidents.
  - 648 people lost their lives on Colorado roadways in 2017, which is the highest total in over a decade and a 55% increase since 2011
- **Congestion** - CAT can improve congestion by safely increasing the capacity of existing roadways. Autonomous vehicles can be used to supplement transit and solve the first-last mile problem, or in ridesharing applications that increase occupancy. CAT will allow real-time notification and faster resolution of accidents, potholes, and traffic that will alleviate non-recurring congestion that causes 55% of traffic in Colorado's urban areas. Other applications like truck platooning, smart signals, freight signal priority, speed harmonization and dedicated connected or autonomous vehicle lanes offer tremendous potential to address recurring congestion as well.
  - Coloradans in the Denver area spent 325,000 person hours/day, the equivalent of \$1.34 billion stuck in traffic in 2014
- **Air quality and climate change** - By reducing congestion and getting people and goods to their destination more quickly, a system of connected vehicles and smart infrastructure can reduce transportation emissions by burning less fuel. Additionally, research suggests that CAT will likely be introduced with plug-in electric or hybrid vehicles, which would provide substantial emissions reduction benefits.



- Transportation is now the country's largest source of greenhouse gas emissions that cause climate change in the United States
- Tailpipes are the leading source of harmful air pollution in Colorado, which is especially important considering Colorado is currently not attaining federal ozone standards designed to protect public health.
- Americans burned 3.1 billion gallons of fuel last year waiting in traffic.
- **Transportation funding** - Building new roads and infrastructure is prohibitively expensive, but CAT will allow CDOT to make digital changes to our roads that will expand their capacity and improve safety for a much lower cost. Additionally, the situational awareness provided by connected vehicle data will allow CDOT to make smarter decisions about deployment of snowplows, incident response, and other CDOT functions that can make roadway operation more efficient in the near-term. Finally, connected vehicles will provide more reliable, robust data than existing ITS solutions that should allow for a reduction of on-road equipment required to deliver better service.
  - For every minute a lane is closed, it takes four minutes for traffic to return to normal. CAT can prevent lane closures by preventing accidents, and it will speed up incident response and removal time.
  - Colorado has a \$1 billion annual budget shortfall, making it difficult to maintain existing infrastructure and nearly impossible to expand without tolling or HOV lanes.
  - CDOT funding is not growing with the pace of Colorado. As Colorado grows rapidly, our transportation needs grow as well. Unless Colorado finds a way to fit more people safely and efficiently onto today's roadways, transportation issues will continue to get worse.

## OBJECTIVES

The following objectives describe how the CAT program will accomplish its mission.

1. **Integrate** CAT into CDOT planning and operations through consultation and education
2. Provide **strategy and direction** for CAT planning, policy, and investment
3. **Facilitate development** of statewide and inter-state CAT infrastructure network
4. **Partner** with industry to accelerate CAT investment and deployment in Colorado
5. **Advocate** for policy and regulation that aligns with program framework
6. **Build public support and enthusiasm** for CAT technology through education and engagement
7. **Partner** with local, regional, and national stakeholders to align efforts



## OUTCOMES

CDOT expects to measure progress toward the program mission against specific outcomes, including but not limited to:

- **Safety**
  - Roadway fatalities
  - Total vehicle accidents
  - Work zone accidents
  - Level of Service of Safety (LOSS)
  - Incidence of unimpaired accidents
- **Mobility**
  - Average daily traffic (ADT)
  - Average annual traffic delay
  - Freight corridor efficiency
  - Recurring congestion
  - Cause of congestion
  - Non-recurring congestion
  - Travel time
  - Vehicle miles traveled (VMT)
  - Modeshare
- **Emissions**
  - Statewide transportation criteria air pollutant emissions
  - Statewide transportation greenhouse gas emissions
- **Cost Savings**
  - Safety improvements
  - Avoided costs from traditional measures
  - Maintenance
  - ITS infrastructure
  - Management
  - Operations

## PRIORITIES

There are several priorities that will drive CDOT's deployment of CAT. In addition to the specific outcomes CDOT will use to measure mission progress, these priorities provide strategic direction to how the CAT program will direct its activities, and it will provide direction to industry stakeholders looking to partner with CDOT.



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- **Preservation of Roadway Management** - CDOT currently controls physical infrastructure in the rights of way as a means for protecting roadway safety. However, CAT is enabling private companies to influence driver behavior and, therefore, roadway operations through digital communication directly with drivers. Unless steps are taken now to position CDOT as leaders in connected vehicle infrastructure and messaging, the opportunity to accelerate the enhancement of public safety will be forfeited to private companies with little expertise or incentive to improve the safety of Colorado roads.
- **Interoperability and open data** - Deployment of CAT will be done in alignment with federal and industry standards in order to ensure interoperability, and data CDOT collects from connected and autonomous vehicles will be made publicly available in an anonymized, secure format. This will provide transparency and allow access to a robust, real-time transportation dataset useful to researchers, transit agencies, local governments and other stakeholders that can assist in solving our transportation challenges.
- **Mobility Access** - A significant portion of Coloradans have limited mobility options because they cannot drive. Children, low-income, handicapped, and older populations that can't drive themselves lack the quality of life that mobility provides. Autonomous vehicles may give affordable transportation options to people who currently lack the ability to drive themselves, and CDOT wants CAT to maximize mobility access to those populations.
- **Leadership and Innovation** - CDOT will continue to lead in exploring new ideas and innovative methods for employing CAT to solve our transportation challenges. In a space changing so quickly, CDOT must pioneer new technologies and ideas that help shape the market instead of simply reacting to changes that the industry makes.
- **Partnership** - CDOT recognizes the importance of innovating through partnership and collaboration. Whether it's directly with private industry, research institutions, or other governments, CDOT wants CAT to provide a platform for sharing ideas and building solutions together so benefits are realized faster by learning from collective best practices and pitfalls.



## RISKS

The CAT program recognizes that there are inherent risks involved in deployment of connected and autonomous vehicles that need to be actively mitigated in order to realize their full benefit. The program will work to mitigate the following risks identified as CAT is deployed in Colorado.

- **Technology maturity** - Autonomous vehicles offer tremendous safety benefits by removing human error from our roads, but there are also risks in introducing new autonomous driving systems to our roadways before they're ready. Autonomous driving systems are designed to operate within a certain environment and set of operating constraints called an operational design domain, so it is essential that the technology be suited to the proper environment. The CAT program will aim to promote deployment of mature, tested, and safe autonomous vehicle technologies in the proper environments.
- **VMT increases** - The benefits that autonomous vehicles will provide their passengers in the form of convenience, affordability, and access may actually result in more people driving more often. If driving is no longer a hassle or a significant expense, then the factors that limit people from driving more often (congestion, fuel costs, time) will be lowered. Lowering the "cost" of traveling may lead people to live further away from work, driver more often and for longer distances as vehicles become a comfortable extension of home and work.

Additionally, if autonomous vehicles provide mobility for people who don't currently have access to transportation, then our roadways will also have to handle even more users than it does today. If more people are driving more miles, that will create even more significant challenges to mobility in the future.

CDOT recognizes this risk and will work with industry to monitor and minimize VMT as autonomous vehicles hit our roads through policy, partnership, and collaboration.

- **Zero Occupant Vehicle (ZOV)** - Highly autonomous vehicles (Levels 4-5) will have the ability to travel our roads with zero passengers or cargo. This could create a scenario where vehicles are using and degrading our roadways without providing any passenger or freight transport benefit, which would amplify the efficiency issues that single-occupant vehicles create today by furthering congestion and polluting our environment.

Maximizing vehicle occupancy and minimizing ZOVs will be important to realizing the mobility and environmental benefits that CAT can provide the system as a whole.



- **Public Acceptance, Adoption and Trust** - Connected and autonomous cars represent the largest change in transportation since the transition from horses to automobiles. With big changes often comes a transition period where education, outreach, and understanding alleviate concerns and accelerate adoption. Coloradans need to trust and accept CAT before its benefits can be realized, and public opinion polls indicate Americans have significant skepticism, fear, or mistrust of connected and autonomous vehicles.

The CAT program will work to educate Coloradans about connected and autonomous vehicles as they are introduced. Public engagement and communication are essential to aligning CDOT's efforts with public interests and educating Coloradans about how CAT could benefit their lives. Without public support for the technology, adoption and investment in the state will be slow, hampering safety and mobility goals.

- **Cybersecurity** - Connected and autonomous vehicles rely on sensors to interpret their environment, computers to process the information, and networks to communicate with other vehicles, operators, and other services. These systems, and the information they use, are susceptible to cybersecurity threats. Researchers, automakers, tech companies, and policy makers are all working to develop secure communications systems for safe operation of connected and autonomous vehicles.

Though cybersecurity of the vehicles themselves is being handled by the private industry and federal regulators, Cybersecurity in connected and autonomous vehicles is a matter of public safety. CDOT's cybersecurity responsibility in connected and autonomous vehicles resides in network connectivity and preventing hacks before they happen. Specific CDOT responsibilities include:

- Improve and maintain physical security of CDOT devices and network assets
- Build reliable, resilient and redundant fiber and network communications infrastructure
- Reduce CDOT's network attack surface by placing network devices and wireless access points in strategic locations
- Deploy advanced intrusion detection systems to stop hacking attempts before systems are compromised
- Employ continuous cybersecurity training employees working within the connected and autonomous vehicles ecosystem.
- Ensure compliance with federal regulations prior to introduction of autonomous vehicles in Colorado.



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- ***Evolving technology*** - Transportation technology is changing at a dramatic pace, making it difficult to accurately plan long-term strategy and investments. Investments in CAT need to mitigate this risk by avoiding long-term commitments to a specific technology or vendor, leveraging agile procurement mechanisms, and designing flexible systems capable of changing with new information or technology. One example of this is how CDOT is building a connected vehicle platform capable of handling data from either dedicated short range communication (DSRC) or cellular-V2X data. This approach will ensure CDOT can leverage connected vehicle data today and is prepared for tomorrow depending on how market dynamics play out over time.
- ***Modality*** - If autonomous vehicles become more convenient and affordable than other travel modes like bus, bike, or light-rail, people may choose to forgo these other modes in favor of an individual, autonomous vehicle. Any decline in these other modes would put more pressure on our crowded roads.

Instead, connected and autonomous vehicles could be used to increase the convenience of other travel modes, providing information about your nearest transportation options like bikeshare or transit while serving as a connection to those modes. The CAT program will prioritize the use of connected and autonomous vehicles as part of a multi-modal environment.