



**COLORADO**

Department of  
Transportation



**ITS Rocky Mountain  
October 5, 2017**

FY 2016-2017  
\$1.44 Billion Budget



# CDOT RESPONSIBILITIES

ADMINISTERS  
**\$208**  
MILLION  
EACH YEAR IN FEDERAL  
**GRANTS**

**3,454**  
  
**BRIDGES**

CDOT  
MAINTAINS & OPERATES  
**23,000**  
  
**TOTAL**  
LANE MILES  
OF HIGHWAY



**DIVISION OF  
TRANSIT  
AND RAIL**  
ADMINISTERS FED/STATE  
GRANTS AND OPERATES  
BUSTANG

**6.1** MILLION  
MILES  
PLOWED  
OF SNOW PER YEAR 

**35** MOUNTAIN  
PASSES  
OPEN YEAR-ROUND 

**AIRPORT  
PLANNING**  
INTERFACE WITH FAA 

Source: Colorado Department of Transportation, 2014

## Purpose

To save lives and make lives better by providing freedom, connection and experience through travel.



## Values

Safety, people, integrity, customer service, excellence and respect are at the heart of all that we do.

## Summit

The best DOT in the country for all customers by focusing on our people, leading-edge technology and a healthy multi-modal system.

## Peaks

## Base Camps

Technology

People

System

Help Our People with Technology

Improve Travel Experience with Technology

Internal Customer Focus

Develop Leaders

Asset Condition

Improve Customer Experience

Big Data

# OUR CHALLENGE

## Continued Growth



1991



3.3 million



27.7 billion  
vehicles miles traveled

\$  
 \$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$  
 \$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$  
 \$\$\$

\$125.70

spent per person

2015



5.4 million



50.5 billion  
vehicle miles traveled

\$  
 \$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$

\$68.94

spent per person

2040



7.8 million



72.3 billion  
vehicle miles traveled

\$

\$41.16

spent per person

*All dollar  
figures  
adjusted  
for inflation*



RoadX **VISION**: Crash-free, Injury-free, Delay-free and Technologically-transformed travel in Colorado.

RoadX **MISSION**: Team with public and industry partners to make Colorado one of the most technologically advanced transportation systems in the nation, and a leader in safety and reliability.

Colorado Is Open For Business – Colorado invites partners to join us in accelerating the adoption and deployment of technological solutions.



## Why do we need to act?

### SAFETY

**80%** reduction in crashes per NHTSA estimates



### MOBILITY

**40 to 400%** increase in capacity





# 5 levels of driving automation

		Steering and acceleration/ deceleration	Monitoring of driving environment	Fallback when automation fails	Automated system is in control
Human driver monitors the road	<b>0</b> NO AUTOMATION				N/A
	<b>1</b> DRIVER ASSISTANCE				SOME DRIVING MODES
	<b>2</b> PARTIAL AUTOMATION				SOME DRIVING MODES
Automated driving system monitors the road	<b>3</b> CONDITIONAL AUTOMATION				SOME DRIVING MODES
	<b>4</b> HIGH AUTOMATION				SOME DRIVING MODES
	<b>5</b> FULL AUTOMATION				









Highly Automated Vehicles (HAVs)

	Human driver
	Automated system

## NHTSA's AV Guidance and ODD

The document identifies **Operational Design Domain (ODD)** as the critical definition of where (such as what roadway types, roadway speeds, etc.) and when (under what conditions, such as day/night, normal or work zone, etc.) an HAV is designed to operate. The importance of communicating the ODD of an HAV to the consumer as part of broader product education is highlighted.

		Steering and acceleration/ deceleration	Monitoring of driving environment	Fallback when automation fails	Automated system is in control
3	CONDITIONAL AUTOMATION				SOME DRIVING MODES
4	HIGH AUTOMATION				SOME DRIVING MODES



# Connected road classification system

Level  
**1**

Unpaved and/or non-stripped roads designed to a minimum level of standard of safety and mobility

Level  
**2**

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 data service may be available

Level  
**3**

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



# Connected road classification system

Level  
**4**

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

Level  
**5**

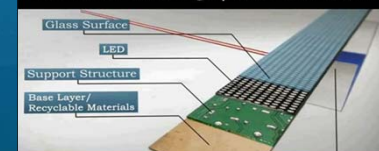
(Advance Guide-way System) roadway or specific lane(s) designed for vehicle level 4 only with additional features that may include inductive charging, advance/enhanced data sharing, etc. Additionally, no roadside signs are needed as all roadway information is direct to vehicles' on-board systems

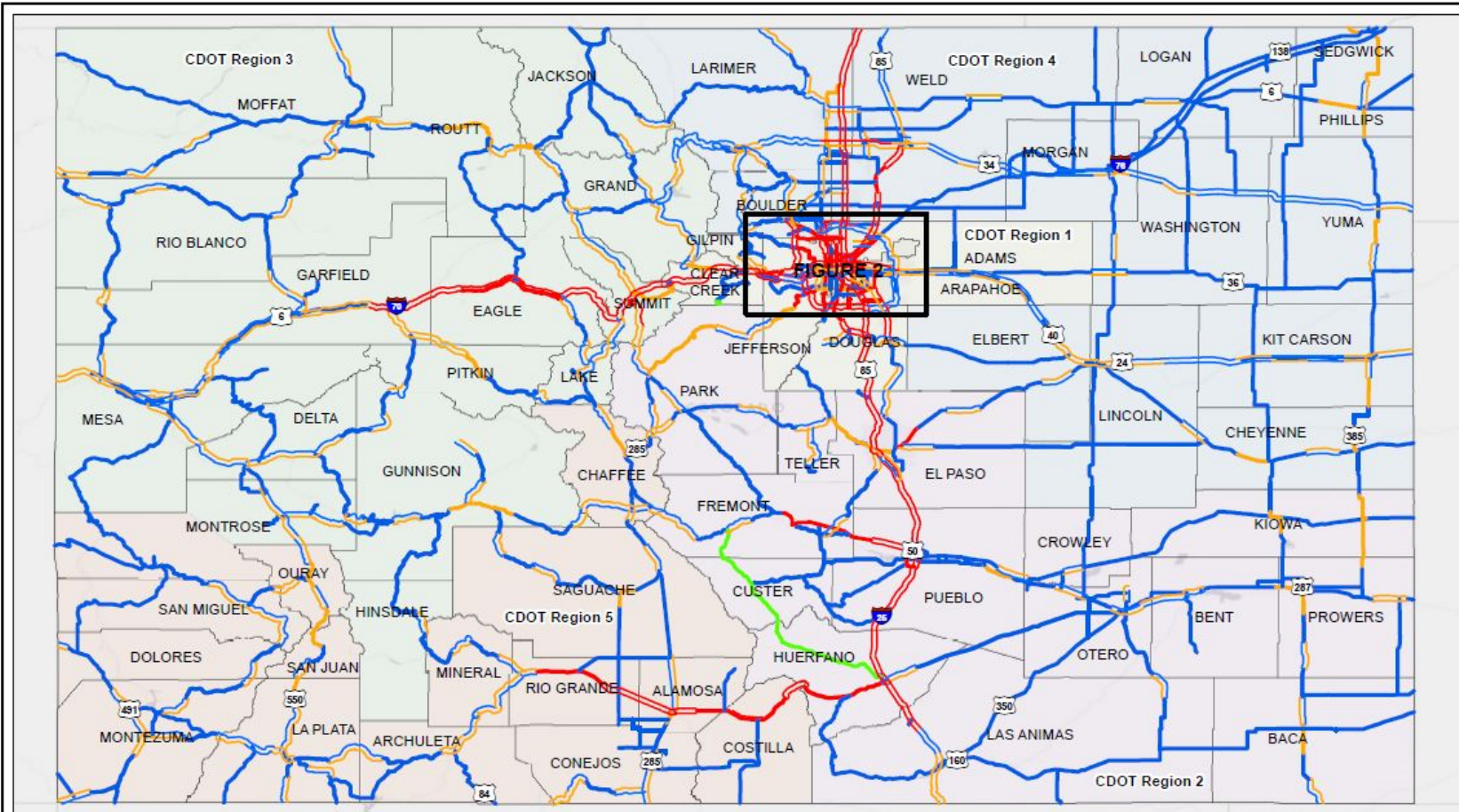
Level  
**6**

All roadway elements designed for only vehicle level 5 systems – no signs, signals, striping... needed



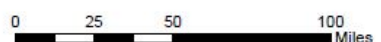
Could solar roadways power our future?





**Roadway Classification**

- Level 1
- Level 2
- Level 3
- Level 4



**Statewide (Figure 1)**  
**Connected Road Classification System**

Service Layer Credits: Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community



COMMUTING



SUSTAINABILITY



TRANSPORT



SAFETY

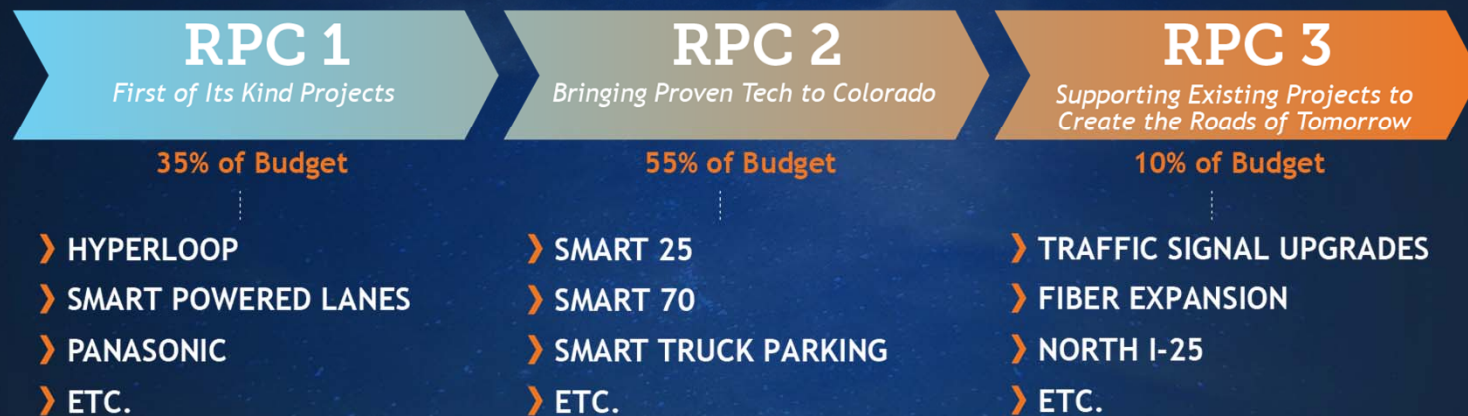


CONNECTION

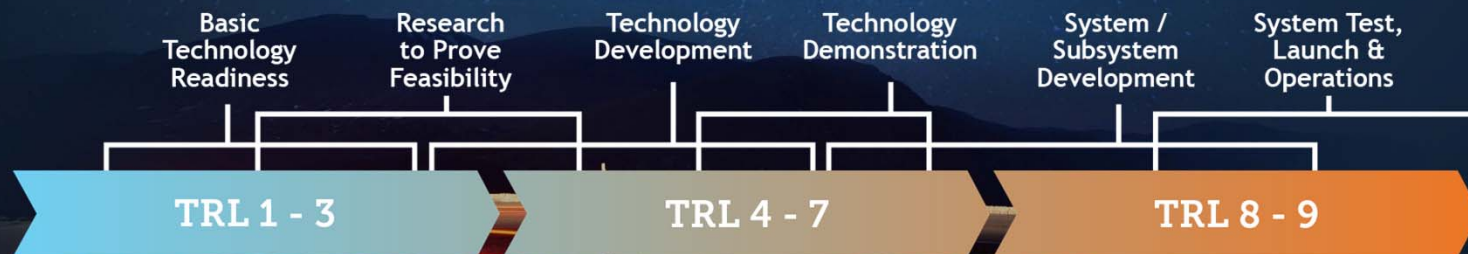


# ROAD X PROJECT CLASS (RPC)

Identifying Projects Based on Technology Readiness and Risk



## TECHNOLOGY READINESS LEVELS (TRL)





TRANSPORT



TIMING : FALL 2016

Colorado partnered with Otto of Uber to complete the world's first commercial 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 towards zero deaths on our roadways. Colorado is enthusiastic about working with Otto and others on:



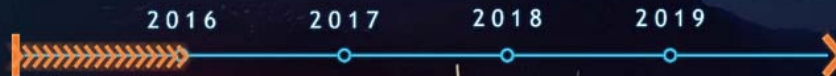
The long-term impacts and benefits of safely deploying this technology to enhance safety



Improve environmental impacts of highway freight



Foster the economic benefits advanced driving technologies are poised to bring to freight delivery and our state.



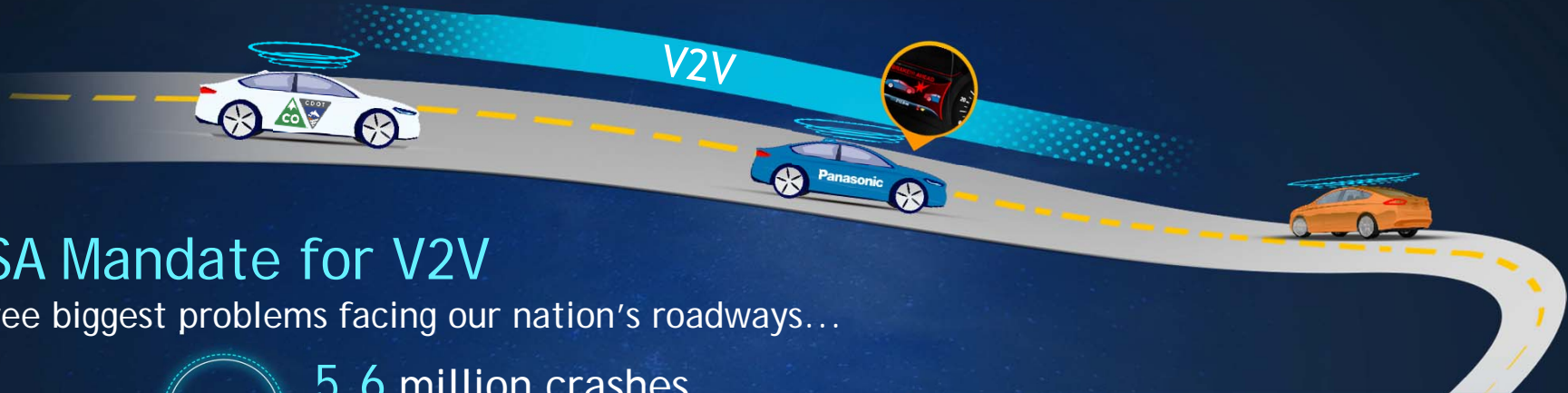
**OTTO**



CONNECTION



TIMING : Starting WINTER 2017



## NHTSA Mandate for V2V

The three biggest problems facing our nation's roadways...

SAFETY



5.6 million crashes  
32,719 deaths

MOBILITY



6.9 billion hours in traffic

ENVIRONMENT



3.1 billion gallons wasted

“The safety benefit of V2V is undeniable. It will save lives, and everybody knows that. A delay in rolling out V2V will cost lives, and that’s a tragedy.”  
- Harry Lightsey, General Motors

Panasonic

V2X Deployment Program



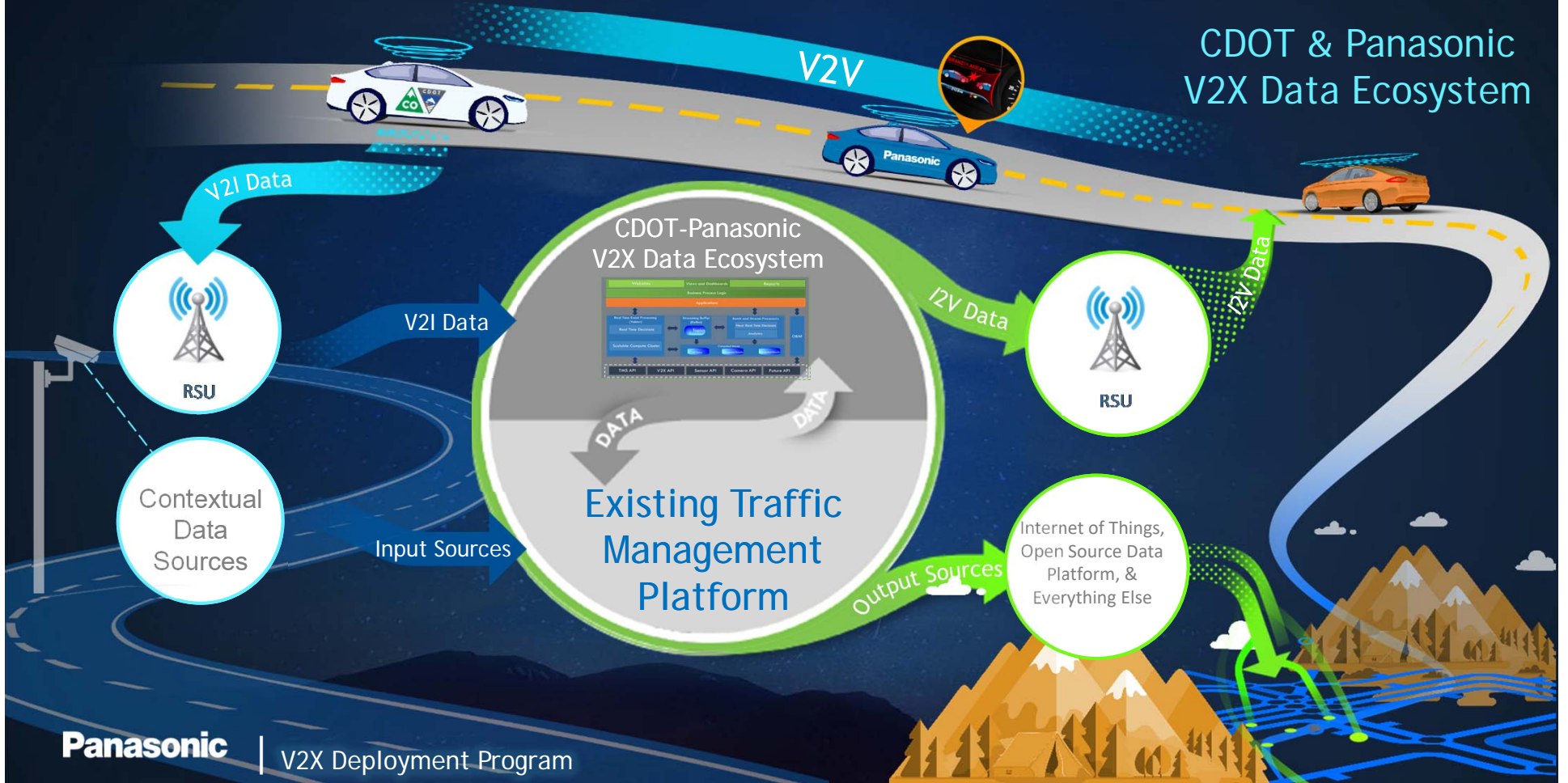
CONNECTION



TIMING : Starting WINTER 2017



# CDOT & Panasonic V2X Data Ecosystem







CONNECTION



TIMING : Starting WINTER 2017



ACCELERATING TECHNOLOGY

# The V2X Ecosystem Unlocks More Than Just V2V

SAFETY



Prevent **419,000** additional crashes  
Save **5,000** more lives  
Avoid **5,000** more fatal crashes

MOBILITY



Improve freeway travel times by **42** percent  
Improve arterial travel times by **27** percent  
Reduce poor weather incidents by **25** percent

ENVIRONMENT



Improve fuel savings by **22** percent  
Reduce VMT by **20** percent  
Improve freeway travel times by **42** percent

V2X ecosystem gives roadway operators the ultimate situational awareness of all roadways, providing:

- Highly accurate, geo-located traveler information
- Highly accurate, localized weather data
- Faster emergency response times
- Improved incident management
- More intelligent, coordinated traffic signal systems
- Improved truck parking information/availability
- Enhanced maintenance decision support systems (e.g., snow plow operations)
- Improved infrastructure diagnostics (e.g., pothole identification, roadway friction)

Benefit to DOTs:

1. Empowers DOTs with data ownership and delivers open data for the world.
2. Prepares DOTs for autonomous vehicles



Panasonic

V2X Deployment Program

<https://www.its.dot.gov/factsheets/pdf/ConnectedVehicleBenefits.pdf>



CONNECTION



TIMING : WINTER 2017



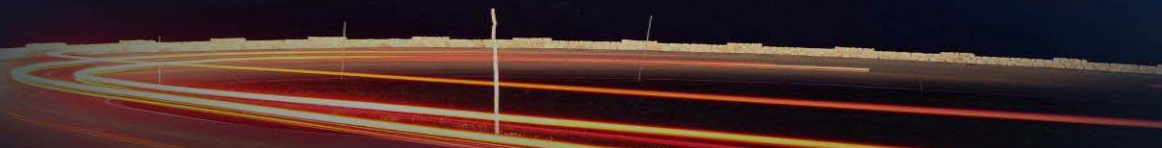
## Smart 70 - Golden to Vail

CDOT has partnered with HERE, a leader in mapping and location technology, to create a connected vehicle environment to provide the most real-time data possible to drivers traveling through the I-70 Mountain Corridor. By using the new "RoadX" app, drivers will receive accurate travel alerts and safety warnings about potential hazards, such as traffic delays, icy conditions and crashes.

CDOT currently has a 50-person pilot testing how accurately and quickly information can be transferred using cellular networks. The ultimate goal is to eventually use the connected vehicle system to inform self-driving cars.



here





COMMUTING



TIMING : FALL 2017

## SMART 25 - RIDGEGATE TO UNIVERSITY

Colorado will be doing a significant software and traffic sensor upgrade to the aging traffic management and ramp metering systems on the highway. This hyper-smart system will help to better manage the flow with vehicles, which could have the result of effectively adding a new lane on I-25 at a fraction of the cost.

The anticipated results are:

- More reliable trips and travel times
- Fewer crashes
- Reduction in stop-and-go traffic
- More efficient flow of traffic without expanding the roadway





SUSTAINABILITY



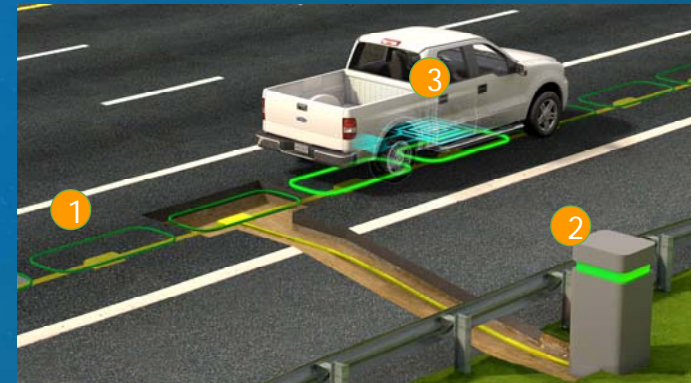
TIMING : SUMMER / Fall 2017



CDOT is looking partner with interested parties to embed power sources into Colorado's roadways that can wirelessly charge electric batteries in freight trucks while they are driving. The Smart Powered Lanes project desires to deploy this technology in live traffic for the first time in the United States. An open forum for business owners and fleet operators will be held on June 7<sup>th</sup> - join us to learn more!



- 1 Power source embedded into the roadway wirelessly transfers energy to vehicles while in motion.
- 2 Roadside equipment efficiently connects to the utility grid and distributes power to the roadway.
- 3 Minimal power storage needed within the vehicle because the batteries receive power from the roadway on the go, allowing longer trips and less battery storage.





TRANSPORT



TIMING : WINTER 2016

## PHASE 1 - SMART TRUCK PARKING (PRE-PASS, CELLULAR AND DSRC)

Using detection and cloud-based software that understands and can report available parking spots to truckers, improving:

- Truckers wasted time and fuel
- Excess wear and tear on Colorado's roadways
- Excess pollution

The first phase of this project will integrate six existing parking facilities into the Smart Truck Parking System.



# SUPPORTING ROADX



**POLICY**



**PEOPLE**



**PLANNING**

# galvanize

The Learning Community For Technology



Galvanize is a dynamic learning community for technology. Their community is where people and companies with the guts and smarts to create real-world change congregate and inspire each other. Their goal is to make opportunities in technology available to all those with the aptitude, determination and drive.



The CDOT & Galvanize partnership will be mutually beneficial in three areas:

- Access to Talent

Giving CDOT access to Galvanize Experts in the areas of Data Science, Data Engineering and Full-Stack Software Engineering - to assist CDOT with any of our Project.

- Training

Galvanize will tailor training to CDOT employees, to first level set select employees in the areas of Data Science, Data Engineering and Full-Stack Software Engineering and second explore with CDOT sending employees through a Galvanize immersive program as part of the CDOT workforce of the future initiative

- Promotion of RoadX

CDOT will seek to include Galvanize in advancing RoadX initiatives and make use of Galvanize campuses that provide a unique hub of activities that bring together entrepreneurial members, large industry partners, stat-ups, students and the greater public

A MOU around this partnership was signed in Q4 of 2016

Submitted:  
Hyperloop One

**AECOM**  
Built to deliver a better world

IN PARTNERSHIP WITH:  
Colorado Department of Transportation  
City and County of Denver  
Denver International Airport (DEN)  
City of Greeley

# ROCKY MOUNTAIN HYPERLOOP

Global Challenge

October 20 16



# BICYCLE & PEDESTRIAN CHALLENGE

## Autonomous Mobility Policy White Paper

Colorado Department of Transportation  
Colorado Department of Revenue  
Colorado Department of Safety

DRAFT 08/2016







TRANSPORT



TIMING : SUMMER 2017

Hyperloop is a new way to move people and freight using a custom electric motor to accelerate and decelerate levitated sleds through a low-pressure tube at speeds up to 700 mph.

- The Rocky Mountain Hyperloop team (CDOT, AECOM, Denver, Greeley and the Denver International Airport (DEN)) was selected as one of 35 worldwide semifinalists to build a 40-mile Hyperloop system between DEN and Greeley
- Three finalists will be selected by late summer of 2017



## NEXT STEPS



**People**  
Educate public



**ROI**  
Invest now in  
technology platforms



**Privacy**  
Address security  
issues



**Technology & Planning**  
Plan and model  
for rapid change



**Regulation**  
Establish consistent policy  
direction that supports  
autonomous future

# QUESTIONS?

