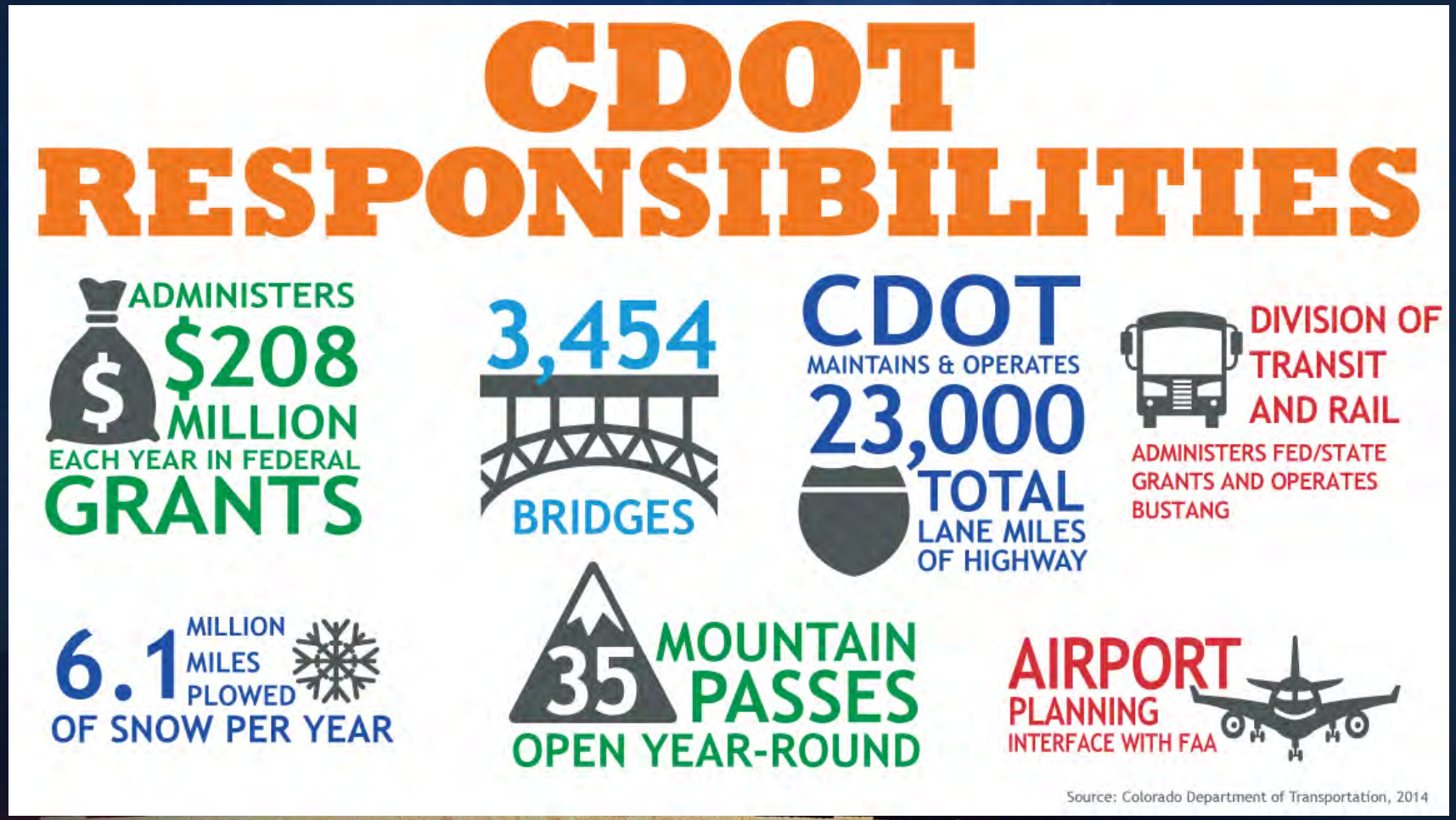
COLORADO
Department of Transportation

Colorado Association of Ski Towns
January 19, 2018

FY 2016-2017 $1.44 Billion Budget



ROAD X
ACCELERATING TECHNOLOGY

Purpose

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

2017

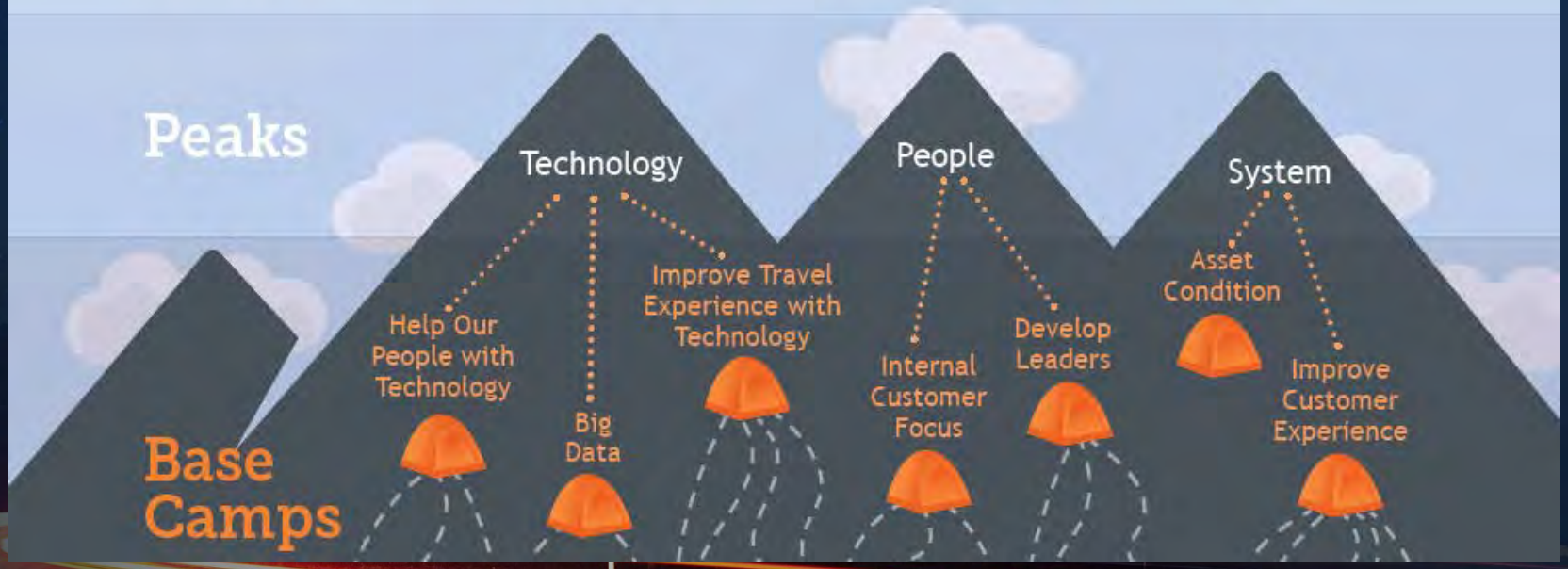
Values

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

OUR CHALLENGE : CONTINUED GROWTH

CDOT | ROADX ACCELERATING TECHNOLOGY

1991	2015	2040
		
3.3 million	5.4 million	7.8 million
		
27.7 billion vehicles miles traveled	**50.5 billion vehicle miles traveled**	**72.3 billion vehicle miles traveled**
$$$$$$$$$$$$$$$$ $$$$$$$$$$$$$$$$ $$$$$$$$$$$$$$$$ $$$$$$$$$$$$$$$$	$$$$$$$$$$$$$$$$ $$$$$$$$$$$$$$$$ $$	$$$$$$$$$$$$$$$$ $$$$
$125.70 spent per person	$68.94 spent per person	$41.16 spent per person

All dollar figures adjusted for inflation

CDOT | ROADX

ACCELERATING TECHNOLOGY

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

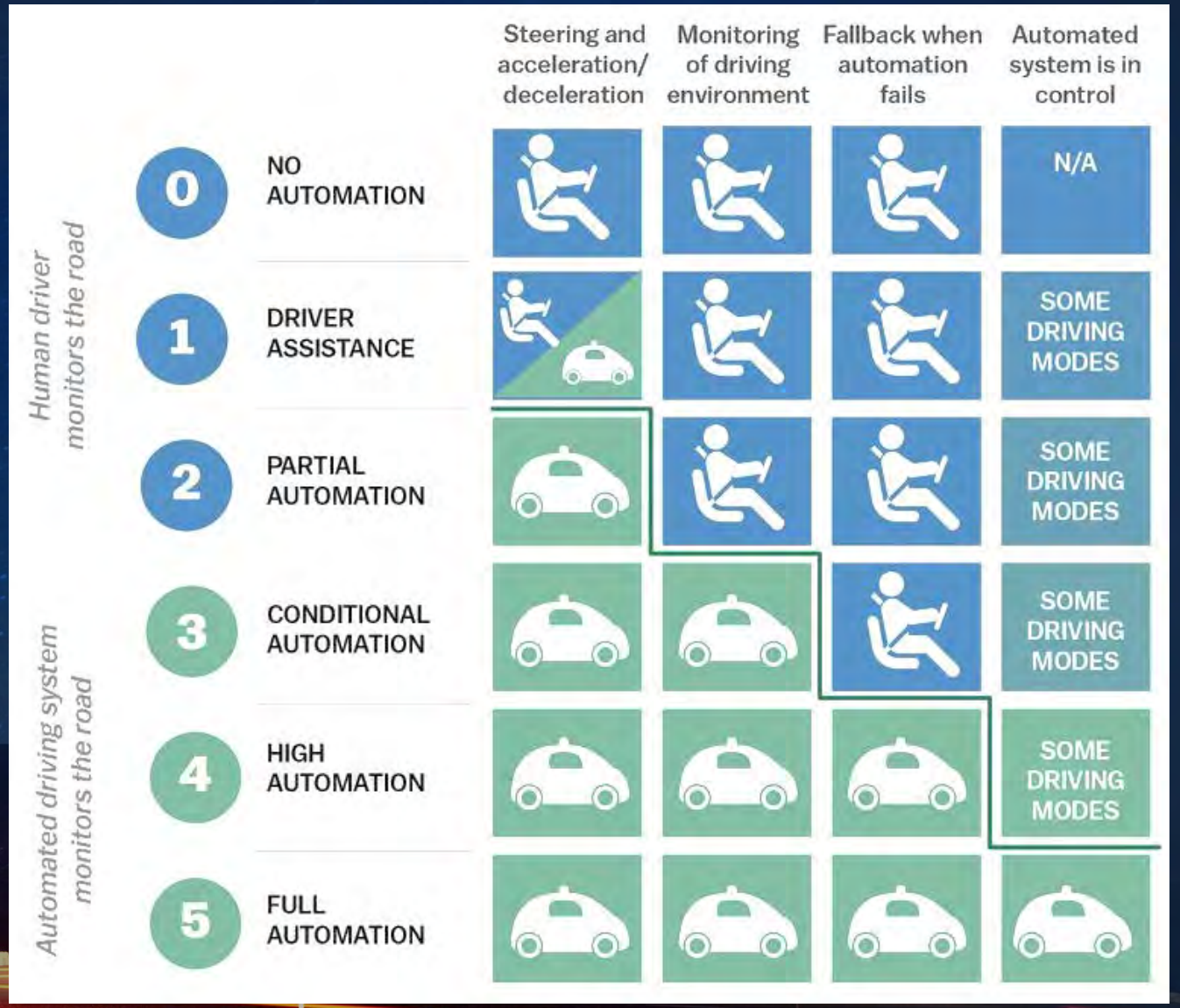
MOBILITY

40 to 400% increase in capacity

5 LEVELS OF DRIVING AUTOMATION

Human driver

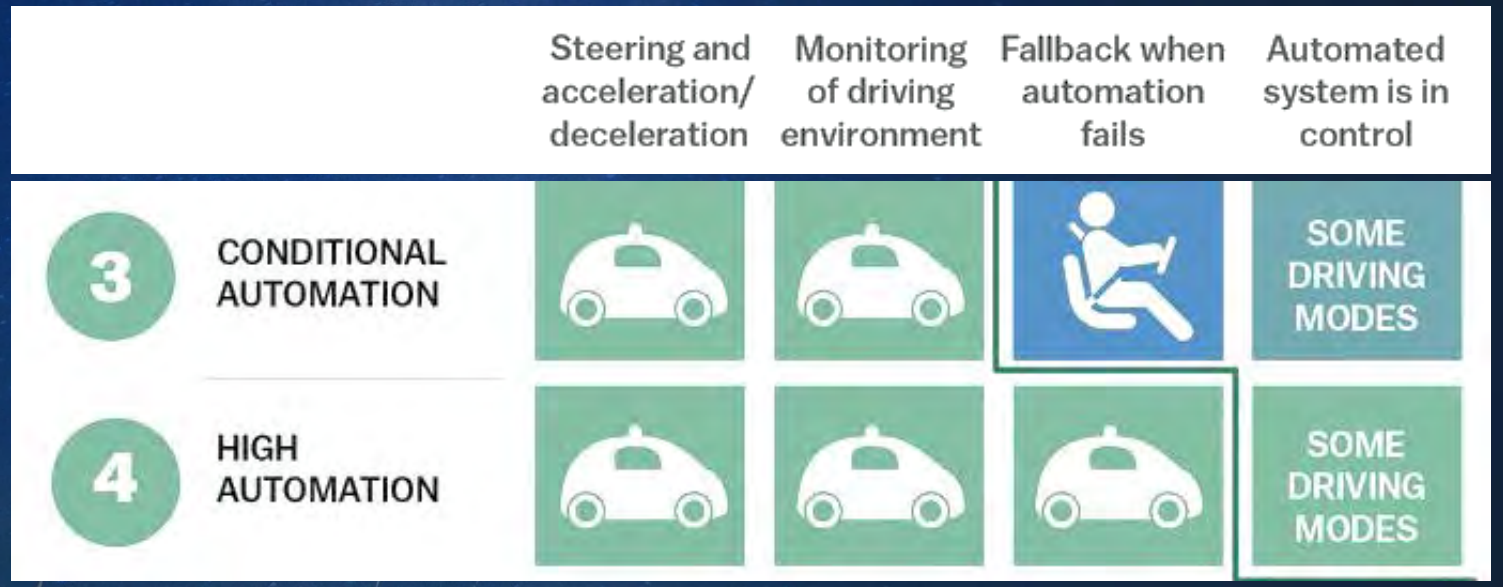
Automated system



Highly Automated Vehicles (HAVs)

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.



CONNECTED ROAD CLASSIFICATION SYSTEM

Level 1

Unpaved and/or non-striped 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 date 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

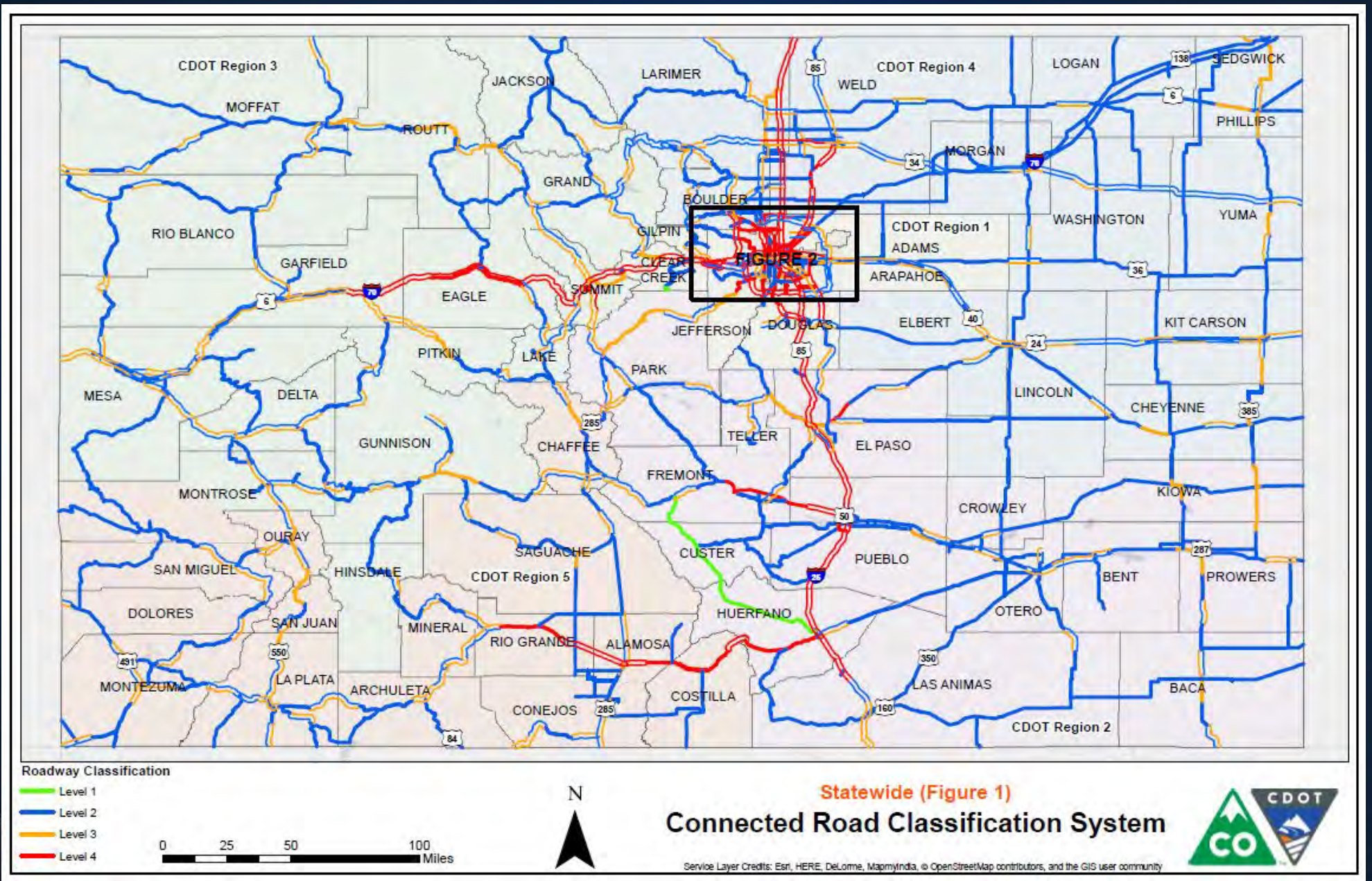
Roadway or specific lane(s) has adaptive ITS equipment (i.e. smart signals hold for vehicles, highway lighting that turn on for vehicles, etc.) with Traffic Operations Center override only, and/or two way data share between DOT/Vehicle/User, and/or lanes designated for vehicle levels 3 & 4 only

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


CDOT Region 3
MOFFAT
ROUTT
JACKSON
LARIMER
CDOT Region 4
WELD
LOGAN
SEDGWICK
PHILLIPS
MORGAN
GRAND
BOULDER
RIO BLANCO
GILPIN
CDOT Region 1
ADAMS
WASHINGTON
YUMA
GARFIELD
CLEAR CREEK
FIGURE 2
ARAPAHOE
EAGLE
SUMMIT
JEFFERSON
DOUGLAS
ELBERT
KIT CARSON
PITKIN
LAKE
PARK
MESA
DELTA
LINCOLN
CHEYENNE
GUNNISON
CHAFFEE
TELLER
EL PASO
FREMONT
MONTROSE
CROWLEY
KIOWA
OURAY
SAGUACHE
CUSTER
PUEBLO
SAN MIGUEL
HINSDALE
CDOT Region 5
BENT
PROWERS
DOLORES
SAN JUAN
MINERAL
HUERFANO
OTERO
RIO GRANDE
ALAMOSA
MONTEZUMA
LA PLATA
ARCHULETA
CONEJOS
COSTILLA
LAS ANIMAS
BACA
CDOT Region 2
Roadway Classification
Level 1
Level 2
Level 3
Level 4
0
25
50
100
Miles
N
Statewide (Figure 1)
Connected Road Classification System
Service Layer Credits: Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community


CDOT
ROADX
ACCELERATING TECHNOLOGY
COMMUTING
SUSTAINABILITY
TRANSPORT
SAFETY
CONNECTION

ROADX PROJECT CLASS (RPC)

Identifying Projects Based on Technology Readiness and Risk

RPC 1
First of Its Kind Projects

35% of Budget

- HYPERLOOP
- SMART POWERED LANES
- PANASONIC
- ETC.

RPC 2
Bringing Proven Tech to Colorado

55% of Budget

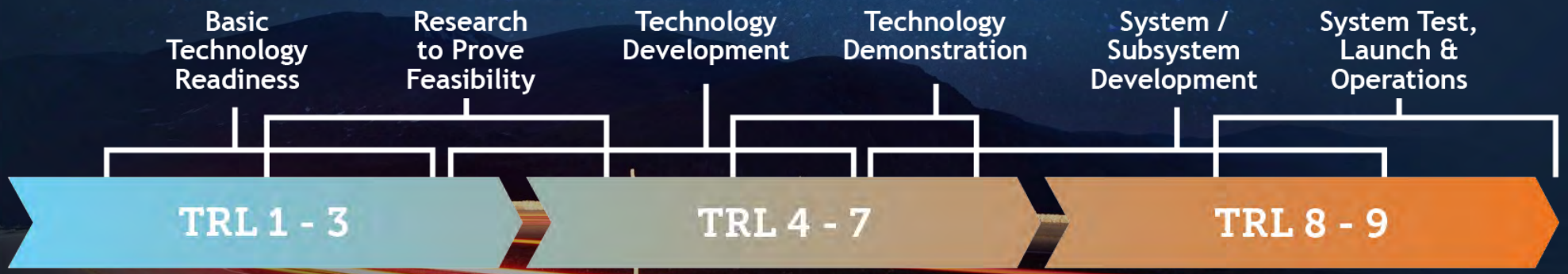
- SMART 25
- SMART 70
- SMART TRUCK PARKING
- ETC.

RPC 3
Supporting Existing Projects to Create the Roads of Tomorrow

10% of Budget

- TRAFFIC SIGNAL UPGRADES
- FIBER EXPANSION
- NORTH I-25
- ETC.

TECHNOLOGY READINESS LEVELS (TRL)



TRANSPORT | TIMING : FALL 2016

CDOT | ROADX ACCELERATING TECHNOLOGY

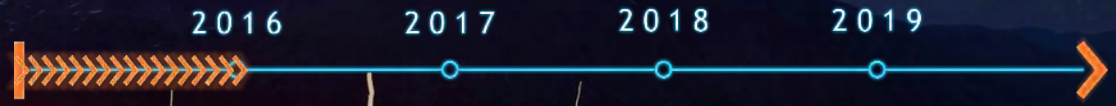
OTTO SELF-DRIVING TRUCK

Colorado (Colorado Department of Transportation, Colorado State Patrol and Department of Revenue) 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

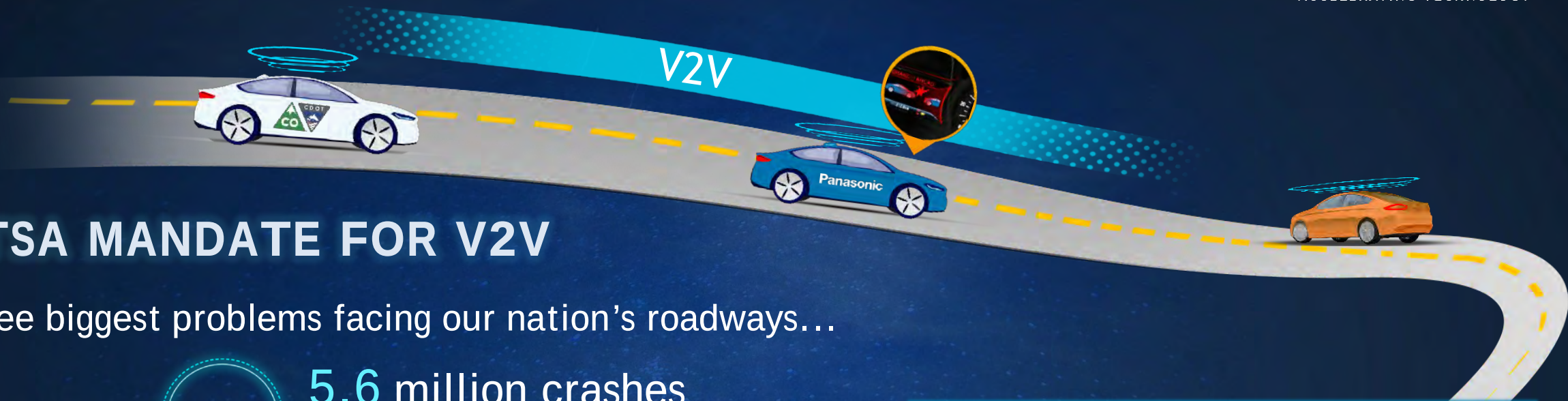
Foster the economic benefits advanced driving technologies are poised to bring to freight delivery and our state.



OTTO

CONNECTION | TIMING : STARTING WINTER 2017

CDOT ROADX ACCELERATING TECHNOLOGY



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 | ROADX ACCELERATING TECHNOLOGY

WHAT DOES V2V UNLOCK?

Potential...

Prevent up to 592,000 crashes

Save 1,000s of lives

Avoid up to 270,000 injury crashes

Using This Data...

Basic Safety Message Core Data	Example Contextual Vehicle CAN Data
Latitude	Steering Wheel Angle Rate
Longitude	Brake Applied Pressure
Elevation	Throttle Position
Positional Accuracy	Wiper Set
Transmission State	Road Friction
Speed	Rain Sensor
Heading	Vehicle Mass
Steering Wheel Angle	Vehicle Type
AccelerationSet4Way	Vehicle Height
Brake System Status	AirBag Status
Vehicle Size	Emergency Alert

To Address The Most Dangerous Crashes....

V2V technology can see where we cannot:

- Queue Warning & Crash Ahead
- Freeway Merge Assist
- Intersection Movement Assist
- Left Turn Assist
- Emergency Electronic Brake Lights
- Wrong Way Driving

V2V technology provides every vehicle with:

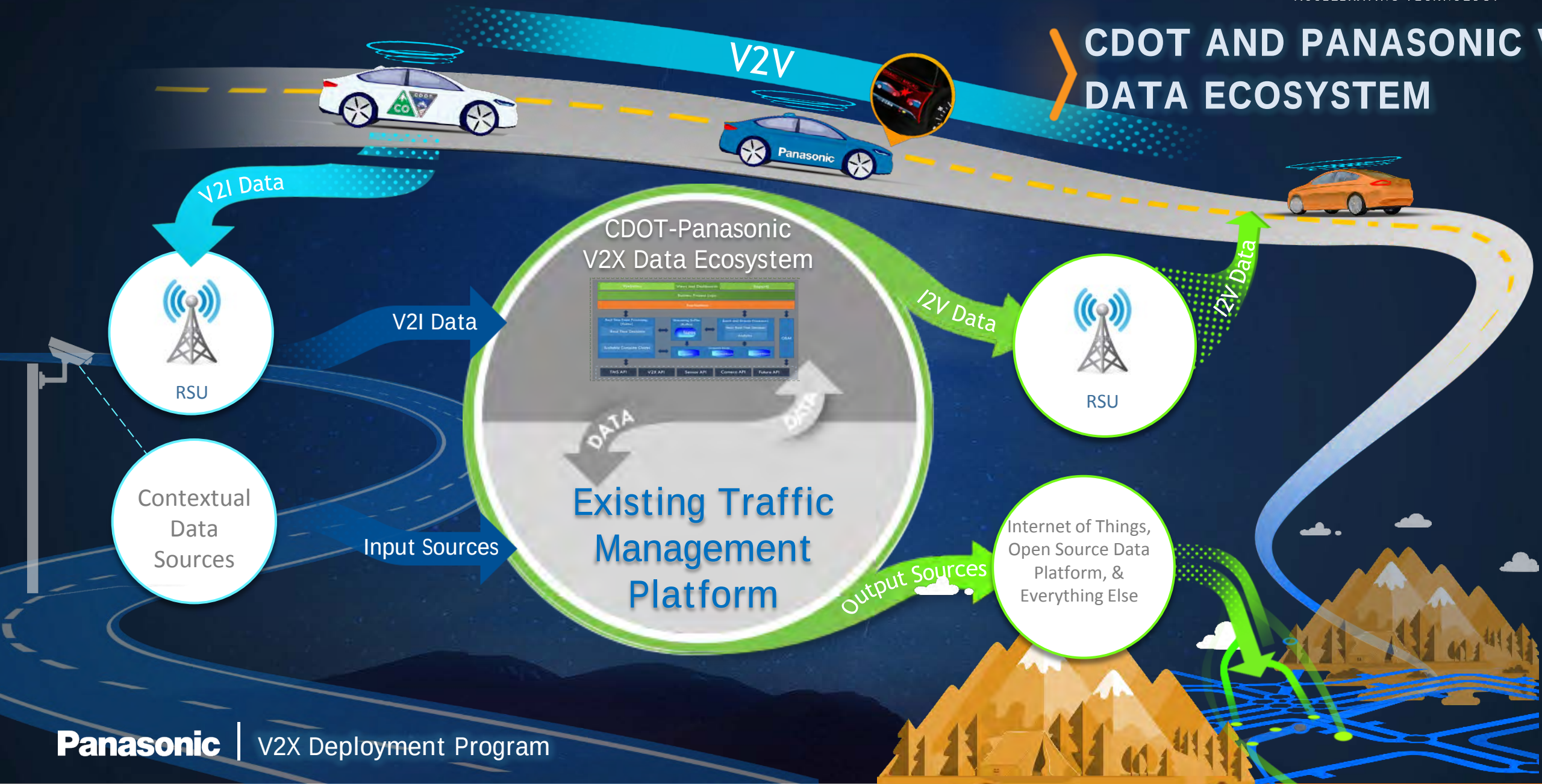
- Real-time situational awareness for:
  - Surrounding vehicles
  - Weather
  - Roadway conditions
- Enhanced, safer driving conditions

[1]http://www.nhtsa.gov/staticfiles/rulemaking/pdf/V2V/Readiness-of-V2V-Technology-for-Application-812014.pdf

CONNECTION | TIMING : STARTING WINTER 2017

ROADX ACCELERATING TECHNOLOGY

CDOT AND PANASONIC V
DATA ECOSYSTEM



Panasonic | V2X Deployment Program

CONNECTION | TIMING : STARTING WINTER 2017

CDOT | ROADX 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

ROADX ACCELERATING TECHNOLOGY

CRITICAL NEED FOR INTEROPERABILITY

We have learned from traffic signal systems and enterprise tolling that interoperability is difficult to achieve as an afterthought.

SAE INTERNATIONAL ISO IEEE 802.11-2012 IEEE 1609 Family SAE J2945 Family ISO 19091 Family SAE J2735 IEEE

V2X is built on standards. With true interoperability, roadway operators could:

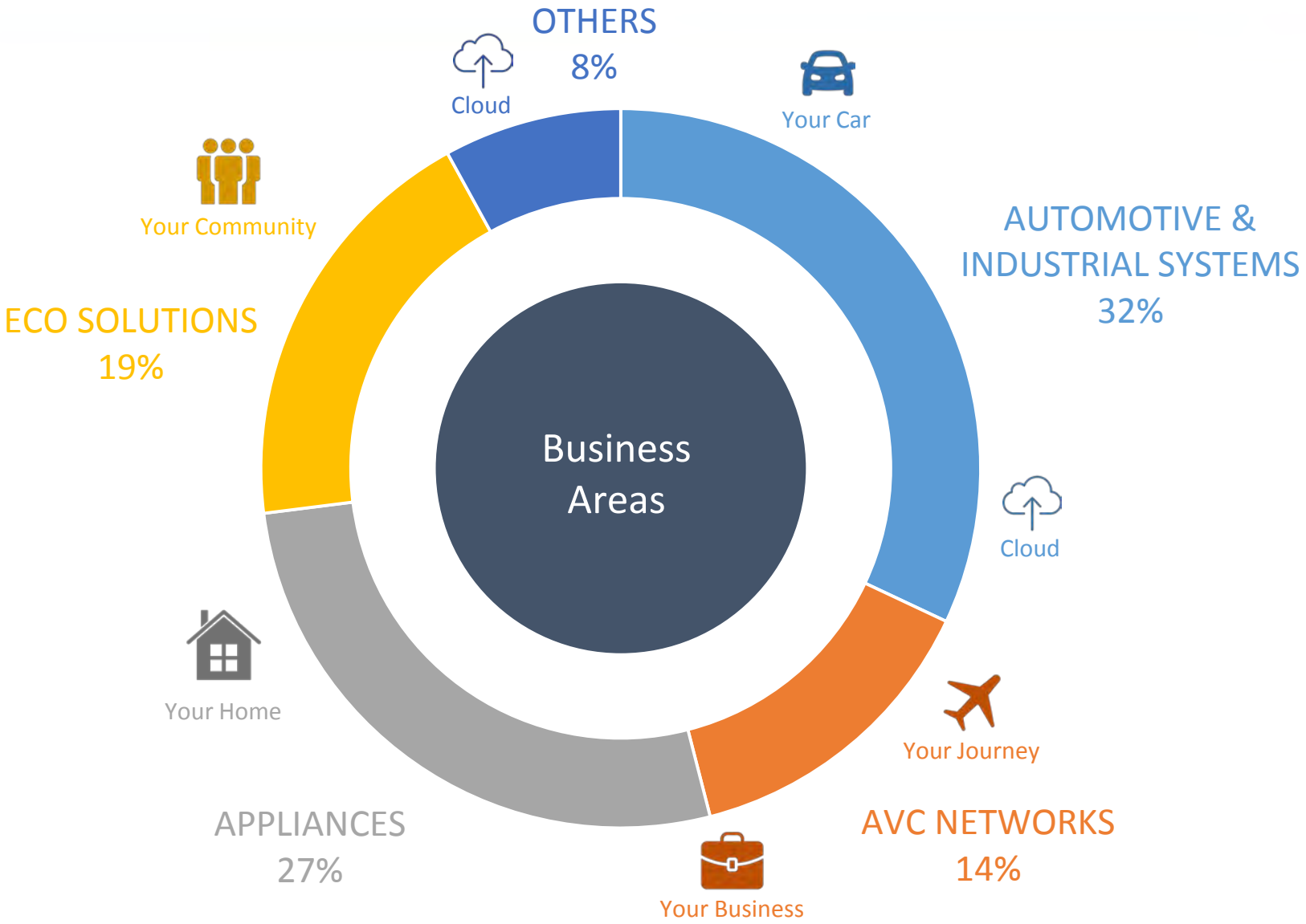
- Manage roadway operations across Municipal, State, and National borders
- Coordinate freight movement of goods from urban center to freeway to parking availability to neighbor states.
- Improve operations from freeway to arterial to local roads for less congested and better traffic flow.
- Send critical, location-specific traveler information to vehicles.
- Coordinate emergency alerts, roadway conditions, and traveler information from Center-to-Center.

Colorado Association of Ski Towns

January 19, 2018

A Better Life … With A Lifetime of Technology

DNA of Consumer Electronics



Smart Cities

Global Experience, Innovation, and Results

Panasonic

Shioashiya

Japan

- Opened 2012
- 400 single-family homes
- 83 condos
- Net-zero energy, net-zero carbon community

Solutions include:

- Residential solar+storage
- Full smart home IoT including appliances and lighting

Tsunashima SST

Japan

- Targeting (vs. 2005) 40% lower CO_2 emissions & 30% lower water use
- >30% energy from solar PV, plus co-gen & fuel cells
- Community Continuity Plan for resilience and emergency services
- Town Energy Center and Smart City Management Center
- Also mobility, security, and wellness solutions

Suntrust Park & The Battery Atlanta

Atlanta, GA

- Mixed-use development district adjacent to new, iconic property (Suntrust Park)

Solutions include:

- Digital experience
- Public safety & security
- Eco & sustainability

Panasonic

Fujisawa SST

Japan

- 47 acres
- Opened spring 2014
- Single-family homes, condos/townhomes, multigenerational living
- 600+ families

-70%

-30%

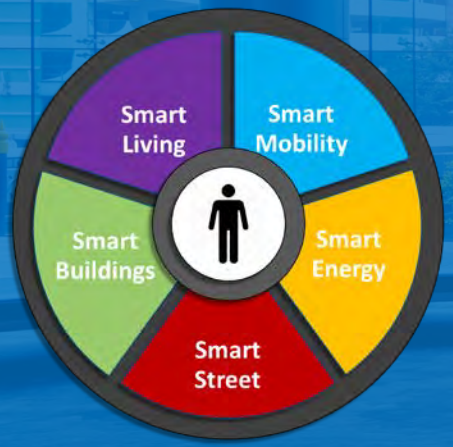
30%

+25%

City & Country of Denver & Mayoral Proclamation

Mayoral Proclamation

- Issued by Michael Hancock, Mayor City and Country of Denver
- Acknowledged by Joseph Taylor, Chairman Panasonic Corp. of N.A.
- Signed 6/3/2015
- Proclamation defines;
  - ✓ 4 pillars and establishment of task forces
    → Evolved to 5 pillars (see below)
  - ✓ the goal of the task forces to find technological and innovative solutions to key priorities and challenges in respective pillars.
    → 18 specific projects for the 4 pillars



City and County of Denver

Proclamation

WHEREAS, *Panasonic Enterprise Solutions Company is establishing its world-class, environmentally-sustainable headquarters in Denver, Colorado, and leading efforts to create a smart and sustainable transit-oriented community; and*

WHEREAS, *Panasonic Corporation of North America ("Panasonic") has identified the State of Colorado and the Denver metropolitan area as region in which to invest additional resources in pursuit of Panasonic's mission and vision; and*

WHEREAS, *the City and County of Denver and Panasonic are aligned in a shared vision of deploying technology and innovative solutions to make Denver smart and sustainable, particularly in the fields of power, water, healthcare and the provision of other public services; and*

WHEREAS, *the opportunity exists for a new model of public–private partnership by which Panasonic, Denver and other stakeholders can develop and implement ground-breaking solutions to challenges facing the region; and*

NOW, THEREFORE, I, MICHAEL B. HANCOCK, MAYOR *of the City and County of Denver, Colorado, by virtue of the authority vested in me, do hereby officially proclaim the following:*

I am directing the immediate creation of four task forces, in the fields of (1) housing and utilities, (2) transportation and mobility, (3) community well-being, and (4) City services and security. I intend to appoint to these task forces representatives from Denver, our sister public agencies, Panasonic, and other key stakeholders. These task forces are to work expeditiously to find technological and innovative solutions to key priorities and challenges in their respective fields. These task forces specifically will build upon the potential solutions identified in Exhibit A to this Proclamation, which is to product of a preliminary ideation session in May 2015.

I further am directing my Chief of Staff and the City Attorney to develop one or more strategies for public-private partnerships to implement the solutions identified by the task forces. These strategies may include traditional procurements by Denver, facilitation by Denver of agreements among Panasonic and our sister public agencies and other stakeholders, and novel forms of P3 arrangements that comply with the City Charter and Code.

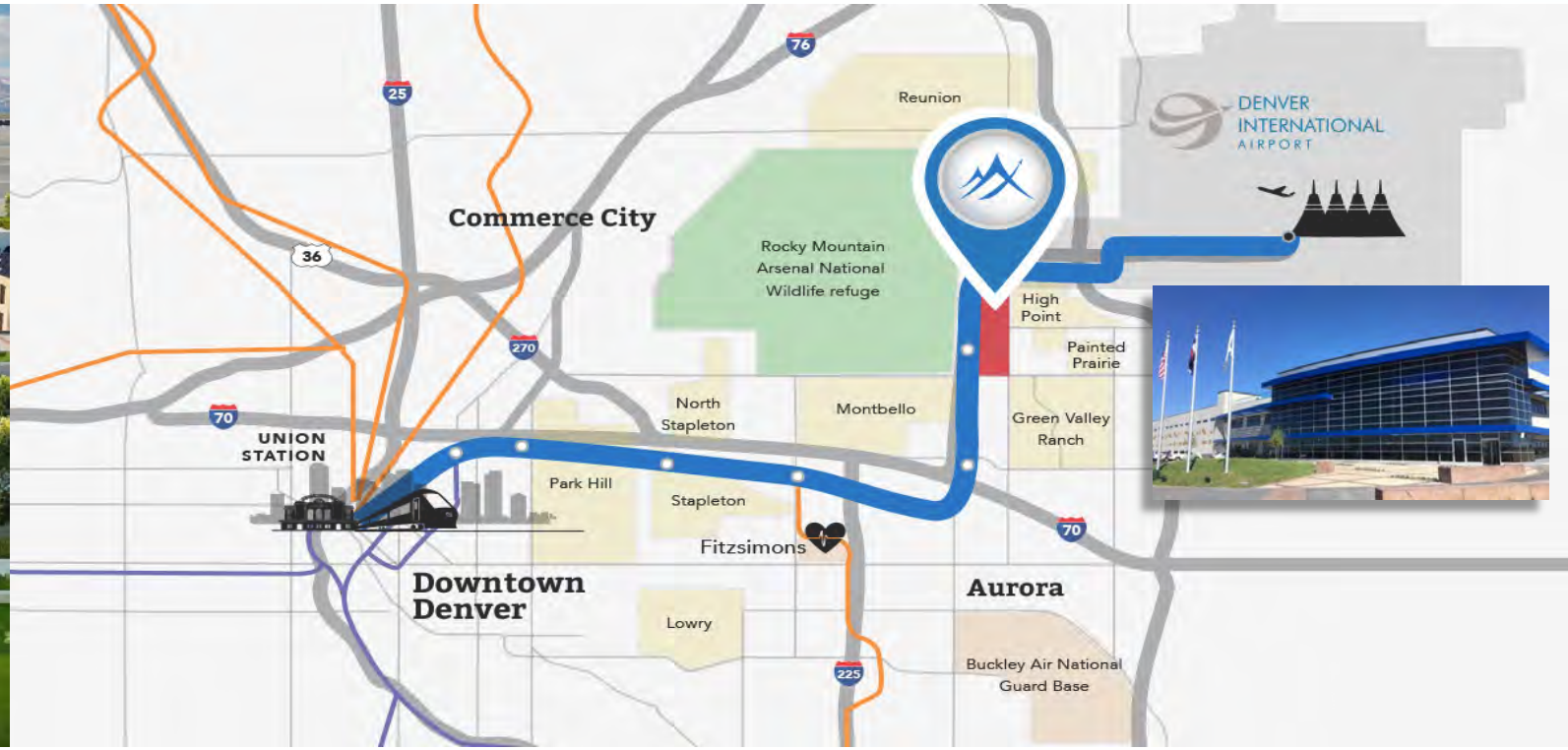
IN WITNESS WHEREOF, *I have hereunto set my hand and caused the official seal of the City and County of Denver to be affixed this 3rd day of June, 2015*

MICHAEL B. HANCOCK
MAYOR

Acknowledged by: *JOE TAYLOR*
PRESIDENT, PANASONIC CORP. NORTH AMERICA

Pena Station NEXT TOD

TOD: **T**ransit **O**riented **D**evelopment



- ✓ 400 acres TOD (35 Tokyo Domes) on RTD's University of Colorado A Line Commuter Rail, one stop from Denver Airport.
- ✓ PESCO being an anchor tenant (Opened on Sep. 12th, 2016)
- ✓ Panasonic invested $2.5M in Pena Station NEXT Phase 1 (154 acres) with LC Fulenwider (Jul. 2016)
- ✓ Exclusive agreement for smart and sustainable products and services (5 year + extensions)

Living lab for the City & County of Denver for the smart city solution before full scale deployment

Colorado Springs

<Colorado Springs>

- ✓ State: Colorado
- ✓ Incorporated: June 19, 1886
- ✓ Elevation: 6,035ft (1,839m)
- ✓ Population: 456,568 (2nd in Colorado)
  *Expected to grow to 0.5 Million by 2025
- ✓ Industry: Defense, High Tech, Tourism
  *Boeing, General Dynamics, Lockheed Martin, Verizon, HP
- ✓ Olympic City USA
  - United States Olympic Training Center
  - HQ United States Olympic Committee
  - HQ for 24 US National Federations for Individual Olympic Sports
- ✓ Mayor: Mr. John William Suthers
  - Member of Republican party
  - Former attorney general of Colorado

Xcel Energy's First Microgrid in CO

2017 Environmental Leader Top Project of the Year Award

2017 Energy Storage North America Innovation Award Finalist

1.6 MW_{dc} carport solar

Anchor load + 259 kW_{dc} rooftop solar

Islanding switch

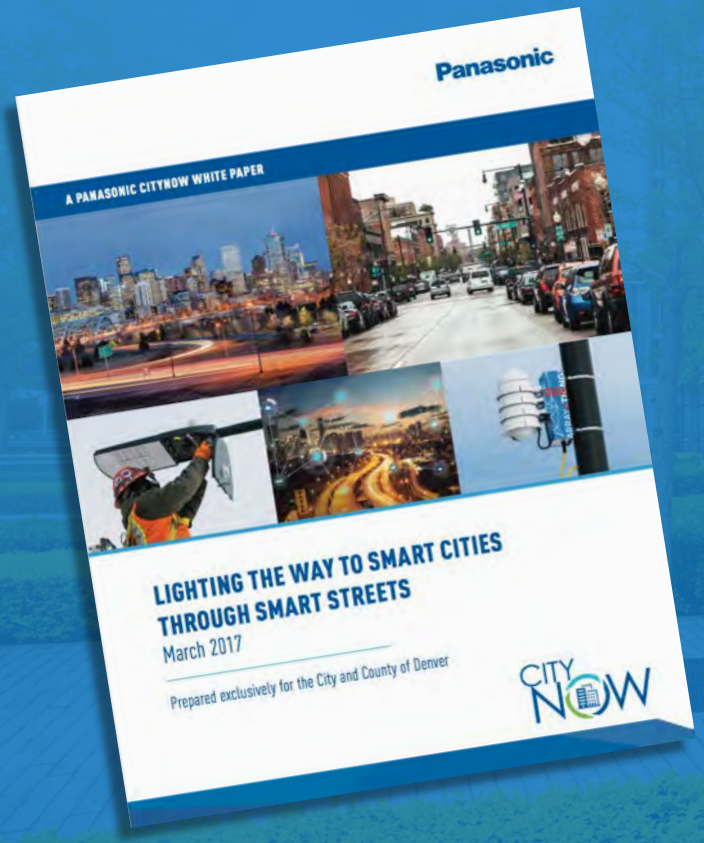
1 MW / 2 MWh battery system

Portfolio of Benefits

- Solar PV Grid Integration (Ramp Rate, Bulk Shift)
- Grid Peak Demand Reduction (Demand Response)
- Frequency Response
- Energy Arbitrage
- Backup Power Resilience

Panasonic

Smart Streets: Lighting the Way to Smart Cities



Panasonic

Carbon-Neutral Energy Planning with NREL

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Xcel Energy℠

Panasonic

Autonomous Electric Shuttles

Solving first/last-mile problems

- 6 seats / 12 passengers
- ~14 hours battery without AC
- ~7 hours battery with AC
- 15 mph transit speed (25 mph top speed)

Panasonic

Dec 4, 2017 – Connected & Autonomous Vehicle Day in CO

State of Colorado

Proclamation

WHEREAS, the Colorado Department of Transportation has launched the Road X program to use technology and ingenuity to solve infrastructure challenges; and

WHEREAS, Colorado is spearheading innovation by launching a first-of-its-kind effort to build a connected vehicle program with Panasonic in which real-time data will be shared across vehicles, infrastructure, and people to improve safety and mobility on the road; and

WHEREAS, Colorado has been a thought leader by advancing proactive legislation to promote connected and autonomous transportation systems while balancing public safety concerns; and

WHEREAS, human error contributes to most crashes and the deployment of connected and autonomous driving systems can reduce fatalities, provide increased options for mobility-challenged residents, and reduce congestion and impacts to the environment; and

WHEREAS, EasyMile, a leader in driverless technology, has announced its North American headquarters in Colorado, and is co-locating their facilities with Panasonic – an international trailblazer in developing smart and sustainable automotive and infrastructure technology solutions; and

WHEREAS, today marks the inaugural demonstration of an autonomous shuttle on city streets, connecting Tower Road to Peña Station, and offering a practical application of first and last mile connections with existing public transit systems; and

WHEREAS, Colorado's reputation as a hub for advanced technologies continues to grow and, with Panasonic and EasyMile as anchors in this sector, allows for the recruitment and development of additional transportation innovators with the goal of creating a mobility center of excellence;

Therefore, I, John W. Hickenlooper, Governor of the State of Colorado, do hereby proclaim, December 4, 2017, as

AUTONOMOUS AND CONNECTED VEHICLE DAY

in the State of Colorado.

GIVEN under my hand and the Executive Seal of the State of Colorado, this fourth day of December, 2017

John W. Hickenlooper
Governor

Colorado-Panasonic Partnership

Five (5) years, $72 Million V2X Deployment Program

1. V2X TOC Data Platform
2. Open Access Framework
3. Production-Grade Deployment on Active, Open Roadways

CDOT — **Launched Jan 2017**

DENVER THE MILE HIGH CITY — **Launching 2018**

Panasonic Automotive Customers

Panasonic Automotive Achievements

Largest Global OEM Systems Integrator

- Global Display Audio
- Infotainment
- Navigation
- EV Battery
- Instrument Panel
- Sensor/Safety
- Connectivity
- ADAS (Advanced Driver Assistance Systems)
- **V2X**

Industry Awards

IHS #1 Global Display Audio Supplier

IHS #1 NA Infotainment Supplier

IHS #3 Global Navigation Supplier

LUX Research #1 Global Battery Supplier

Customer Awards

2015 GM Supplier of the Year

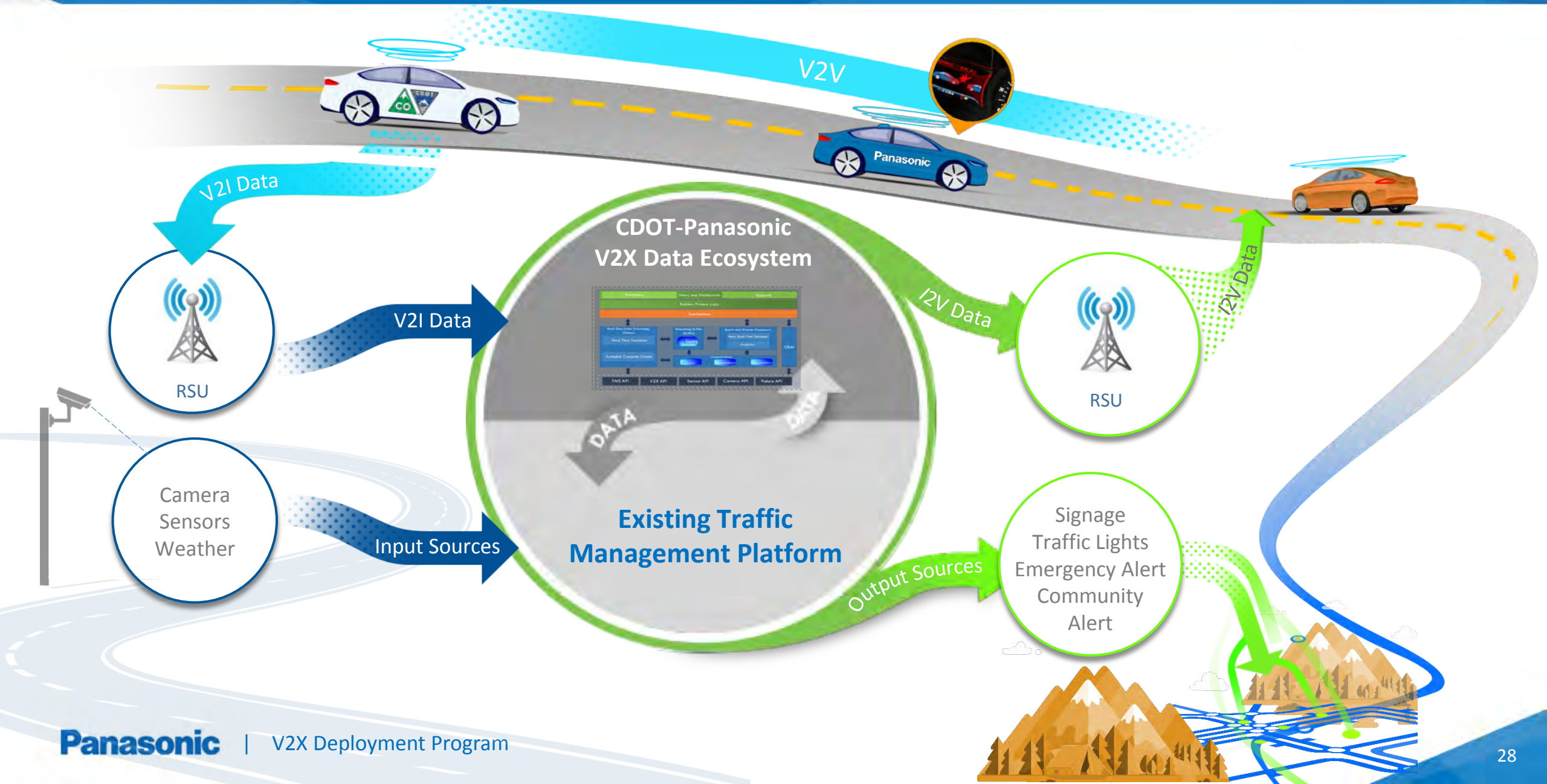
2015 FCA Electrical Supplier Qualitas Award

2016 Honda Innovation, Value and QDV Awards

2014 Toyota Global Contribution Award

2015 Lexus Executive Partnership Award

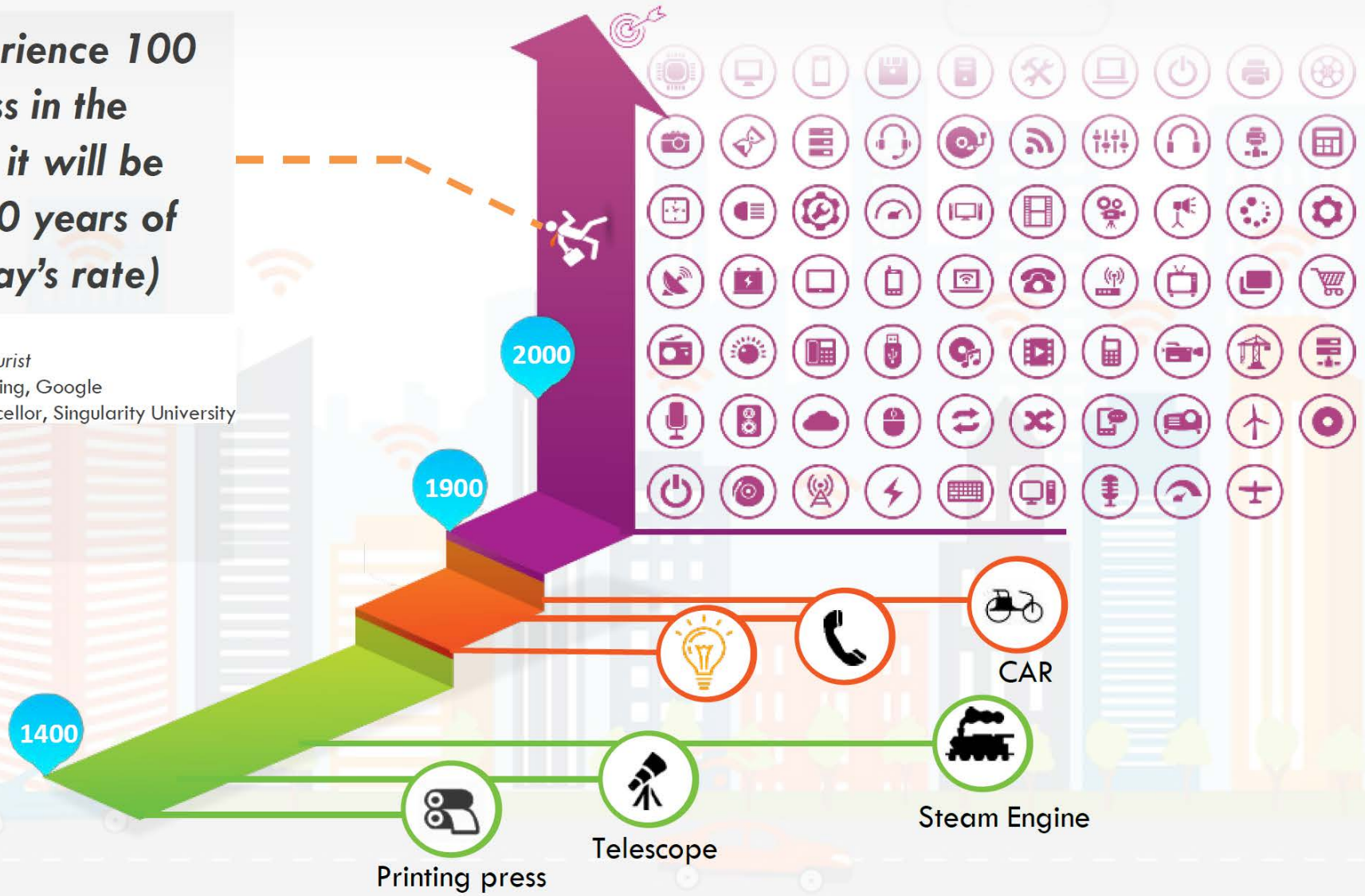
2016 Ford World Excellence Green Brand Pillar Award


V2V
V2I Data
RSU
V2I Data
CDOT-Panasonic
V2X Data Ecosystem
DATA
DATA
Existing Traffic
Management Platform
I2V Data
RSU
I2V Data
Camera
Sensors
Weather
Input Sources
Output Sources
Signage
Traffic Lights
Emergency Alert
Community
Alert

Technology Trends

"We won't experience 100 years of progress in the 21st century — it will be more like 20,000 years of progress (at today's rate)

Ray Kurzweil
Inventor, author, Futurist
Director of Engineering, Google
Co-founder & Chancellor, Singularity University



Rapid Changes to Mobility Trends

AUTOMATED DRIVE

Fully Autonomous >>> **2030**

15% of new cars sold in 2030 could be fully autonomous (McKinsey & Co. Report, Jan 2016)

OEM's changing business focus

Strategic partnerships and investments are rolling out in the race to commercialize an automated vehicle.

Ford + In house software development

CUSTOMERS

ADAS Proliferation

Consumers are willing to pay for driver safety systems more than any other feature.

US government decides **"car is driver"** when in autonomous mode.

Regulation Changes

Shifting Ownership

Owning less will push beyond entertainment and into transportation.

Shared Economy

AT&T Next

Automakers pair up with use based service providers

Millennial Rise

$200 Billion Spending

80 Million MILLENNIALS

END USERS

ON-DEMAND MENTALITY

Applied Robotics

Safer decisions

IOT everywhere

TECHNOLOGY

Delivery and logistic intelligence

Low Cost Manufacturing

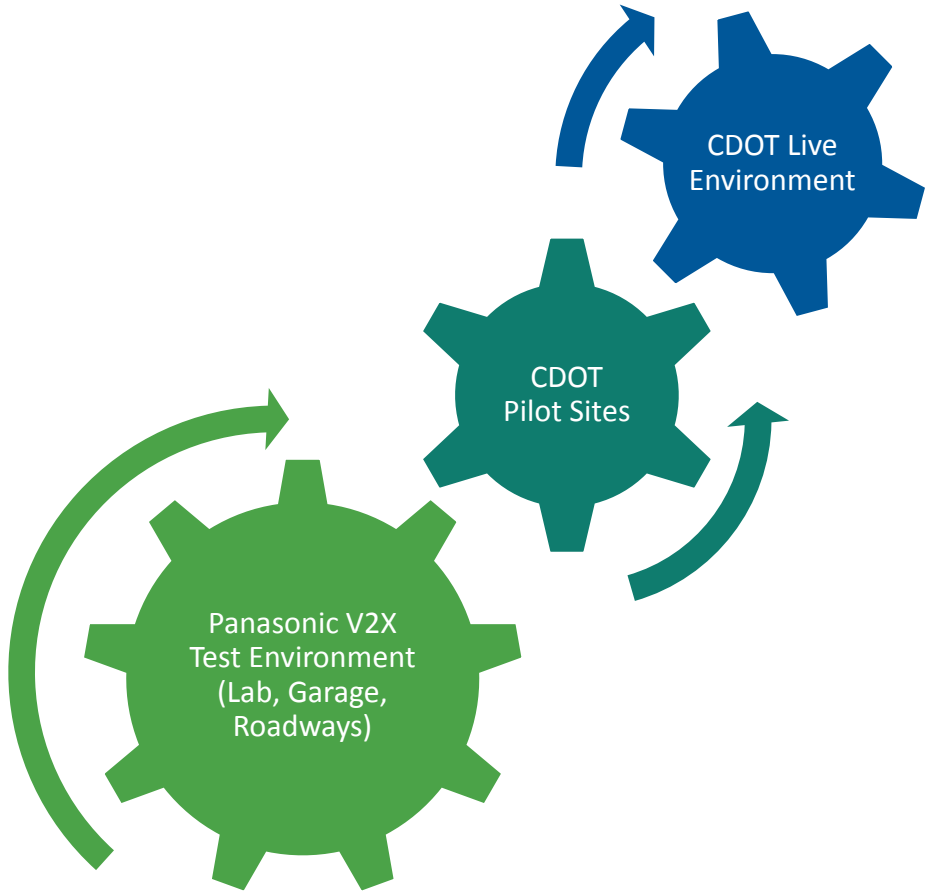
CDOT-Panasonic Partnership

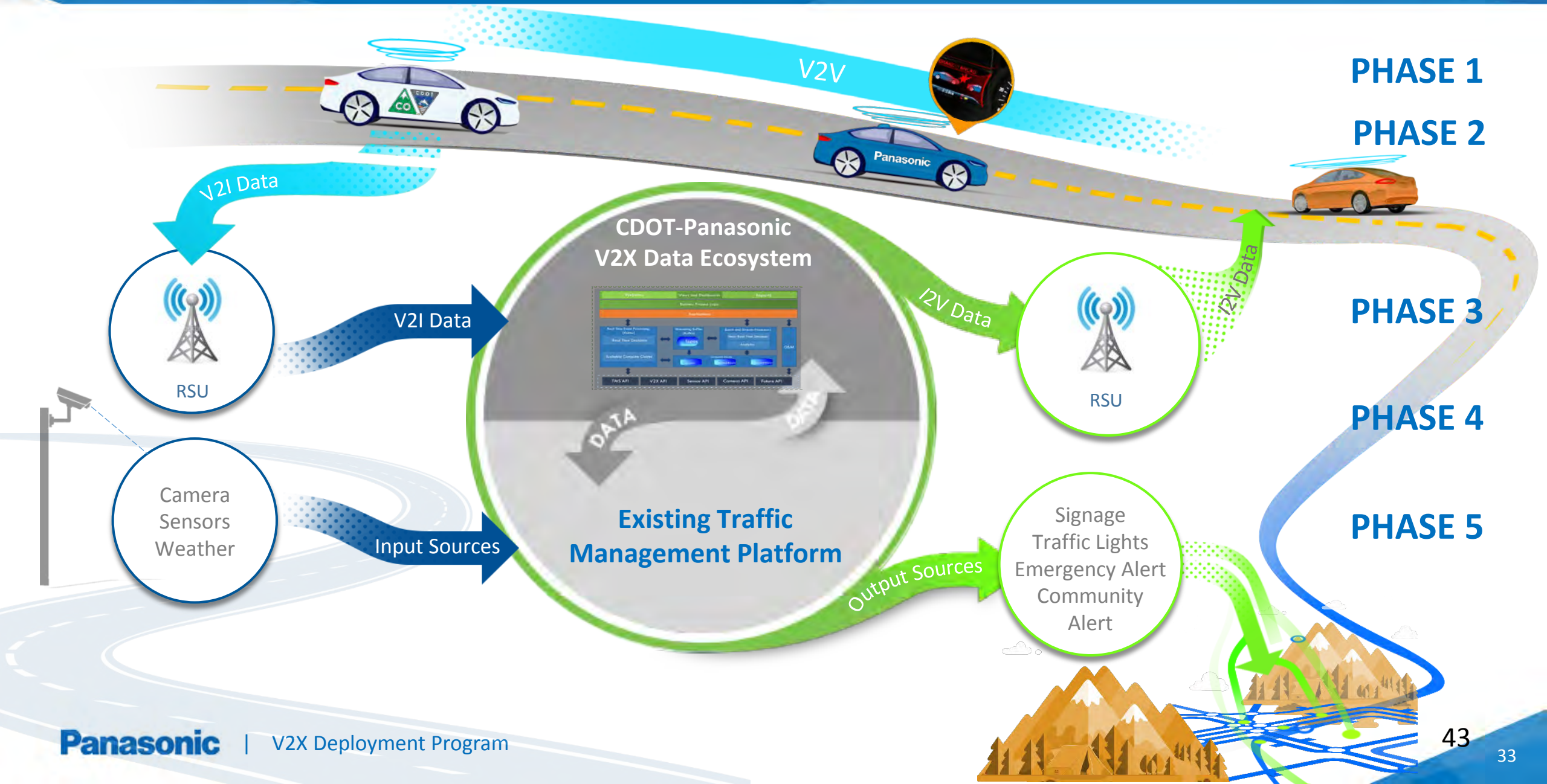
CDOT-Panasonic V2X Deployment Program

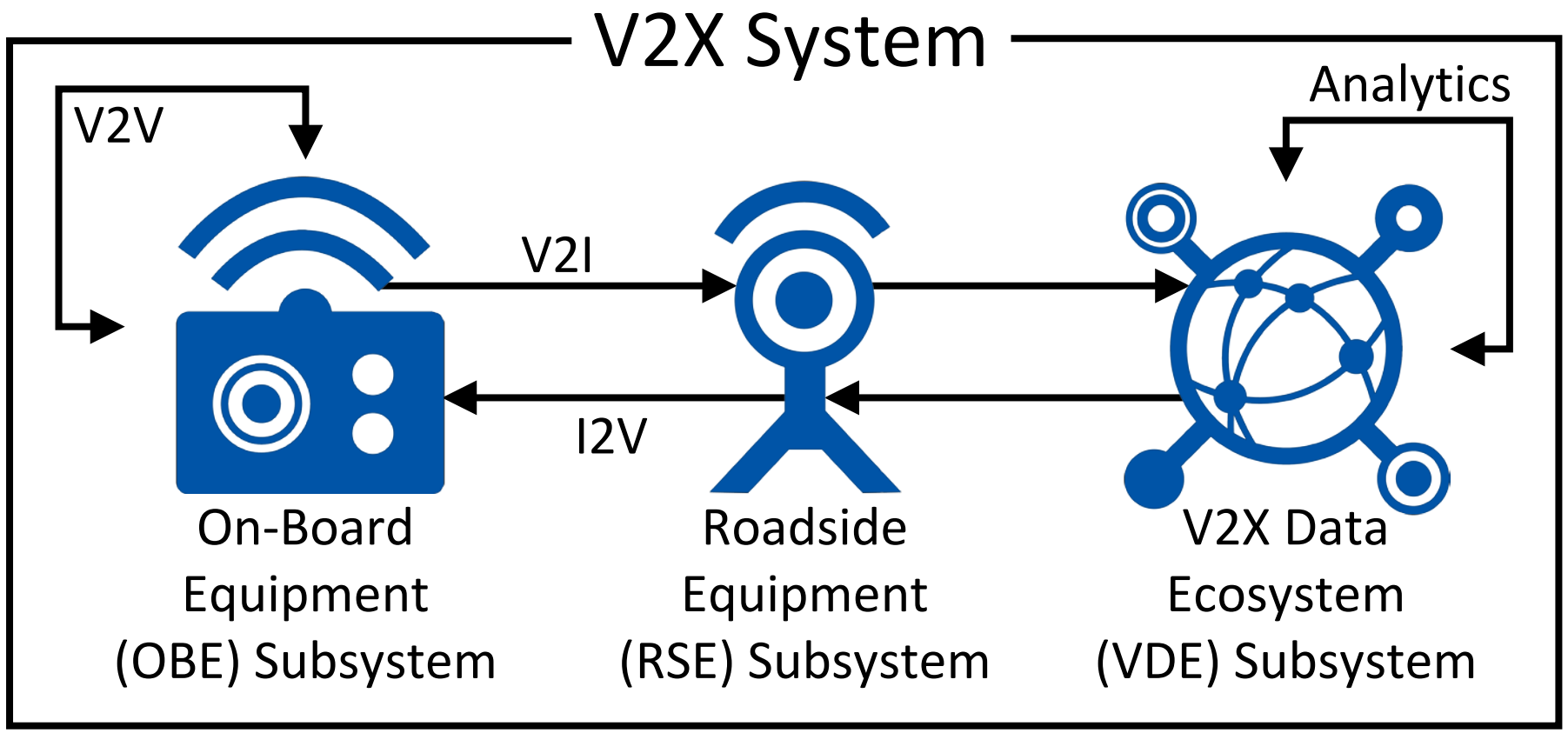
Phased Deployment Approach

Phase 0	Project Plan & System Design • Develop Phase 0 Baseline Schedule • Define & Initiate Program Management • Complete Systems Engineering Planning • Select Project Vendors & Partners • **Build CDOT-Panasonic V2X Test Environment** • Develop Phase 1-5 Preliminary Schedule • Develop Phase 0 Final Report defining Phases 1-5
Phase 1	Vehicle-to-Infrastructure (V2I) Communications – Collect Data
Phase 2	Infrastructure-to-Vehicle (I2V) Communications – Disseminate Data
Phase 3	Vehicle-to-Vehicle Communications (V2V)
Phase 4	Enhanced Data Analytics
Phase 5	End-to-End System Deployment on I-70

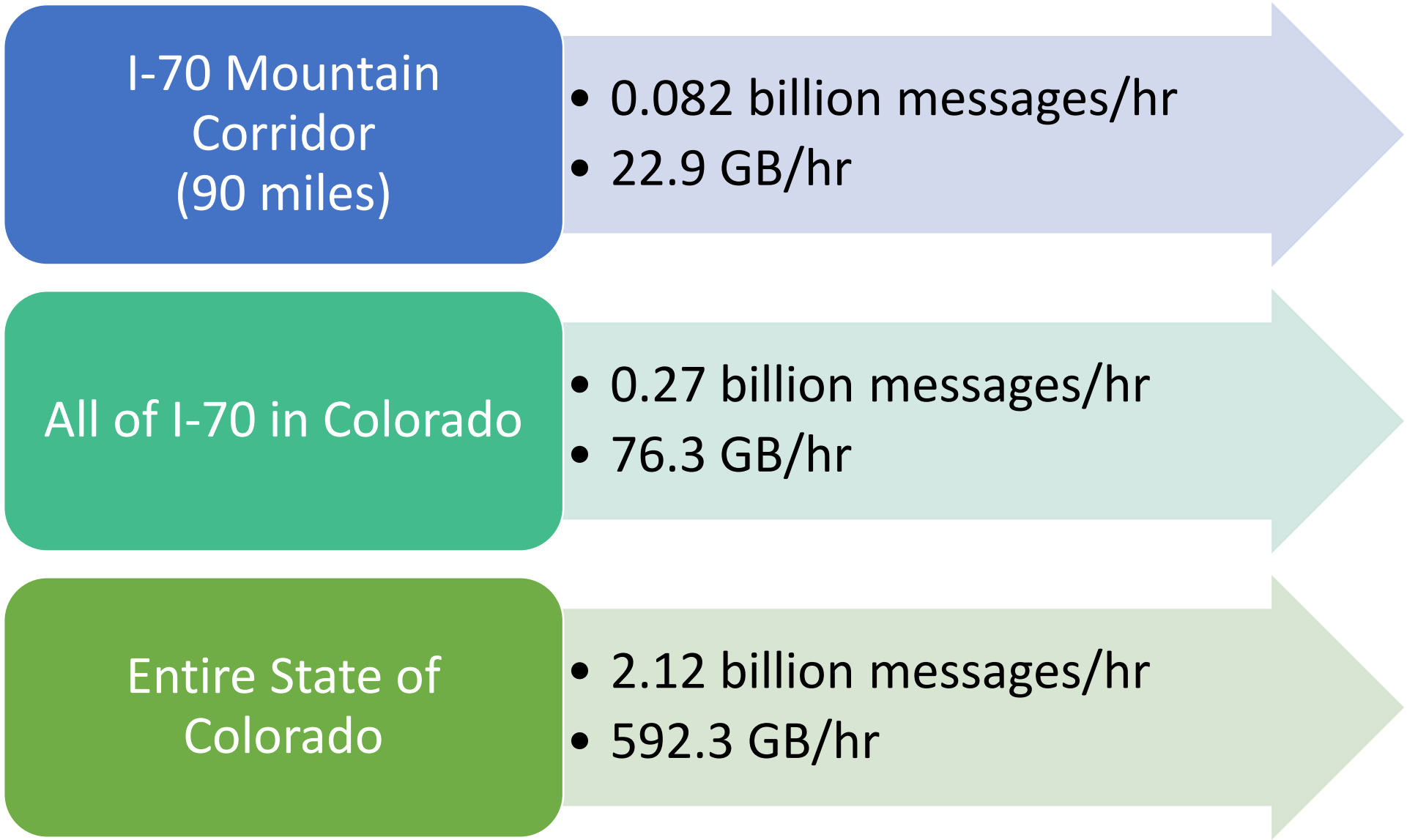
Agile, Iterative Delivery




V2V
V2I Data
V2I Data
RSU
Camera
Sensors
Weather
Input Sources
CDOT-Panasonic
V2X Data Ecosystem
DATA
DATA
Existing Traffic
Management Platform
I2V Data
RSU
I2V Data
Output Sources
Signage
Traffic Lights
Emergency Alert
Community
Alert
PHASE 1
PHASE 2
PHASE 3
PHASE 4
PHASE 5

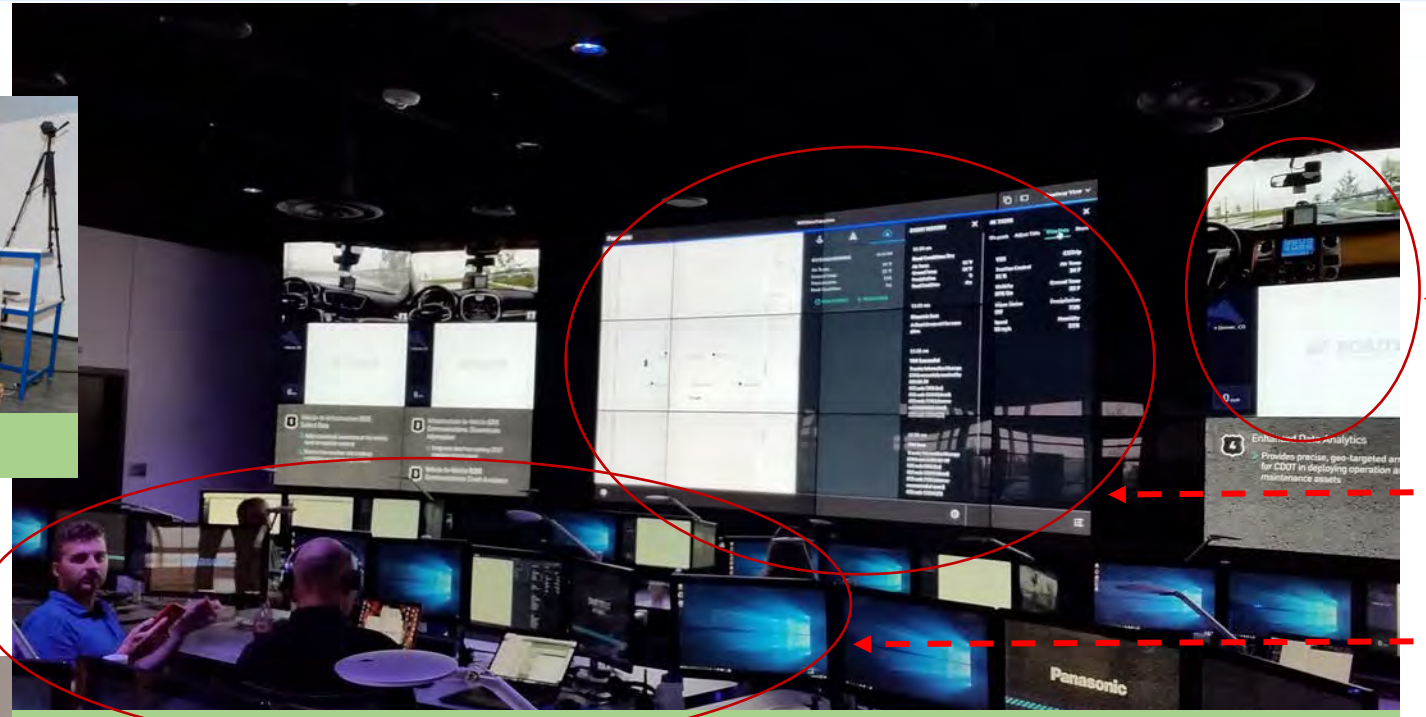


1. **On-Board Equipment (OBE)** – V2X equipment inside vehicles that transmits and receives data between vehicles and to the infrastructure.
2. **Roadside Equipment (RSE)** – V2X equipment installed on the infrastructure that transmits and receives data to and from vehicles.
3. **V2X Data Ecosystem (VDE)** – V2X Data Environment and Open Development Platform


I-70 Mountain Corridor (90 miles)
• 0.082 billion messages/hr
• 22.9 GB/hr
All of I-70 in Colorado
• 0.27 billion messages/hr
• 76.3 GB/hr
Entire State of Colorado
• 2.12 billion messages/hr
• 592.3 GB/hr

First Demo Successful 8/7! (Big demos Today and Thursday!)

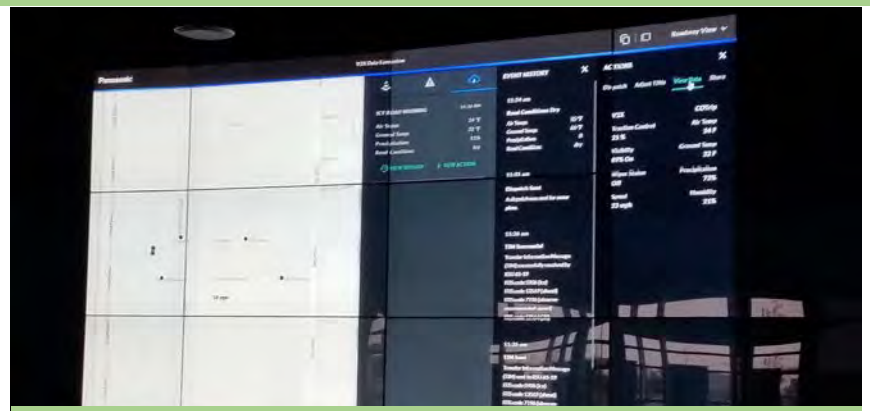
Buck and VR/AR Demo



Our Network Operations Center (NOC)

- 4 Vehicle HMIs and live video
- Traffic Management Center view
- TMC operations

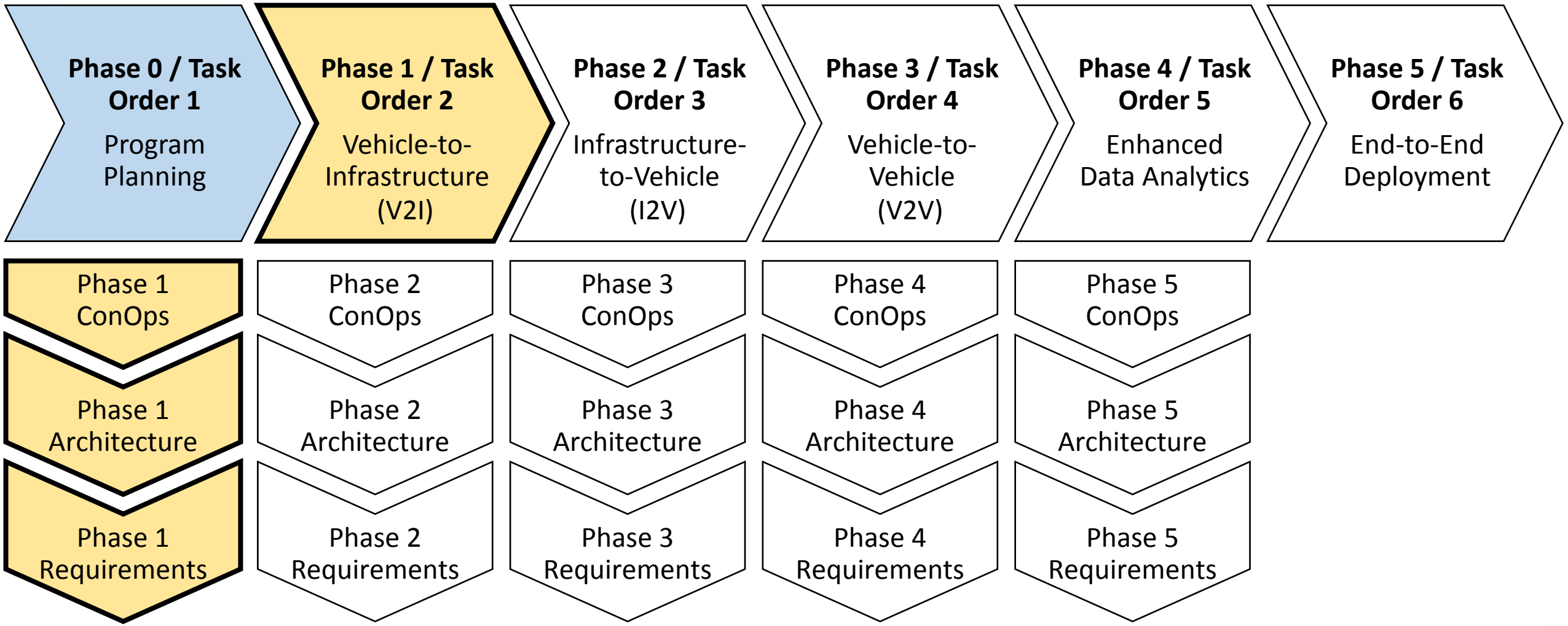
CDOT Executive Director **Shailen P. Bhatt** playing with the VR/AR demo



TMC Close-up

The TEAM behind it

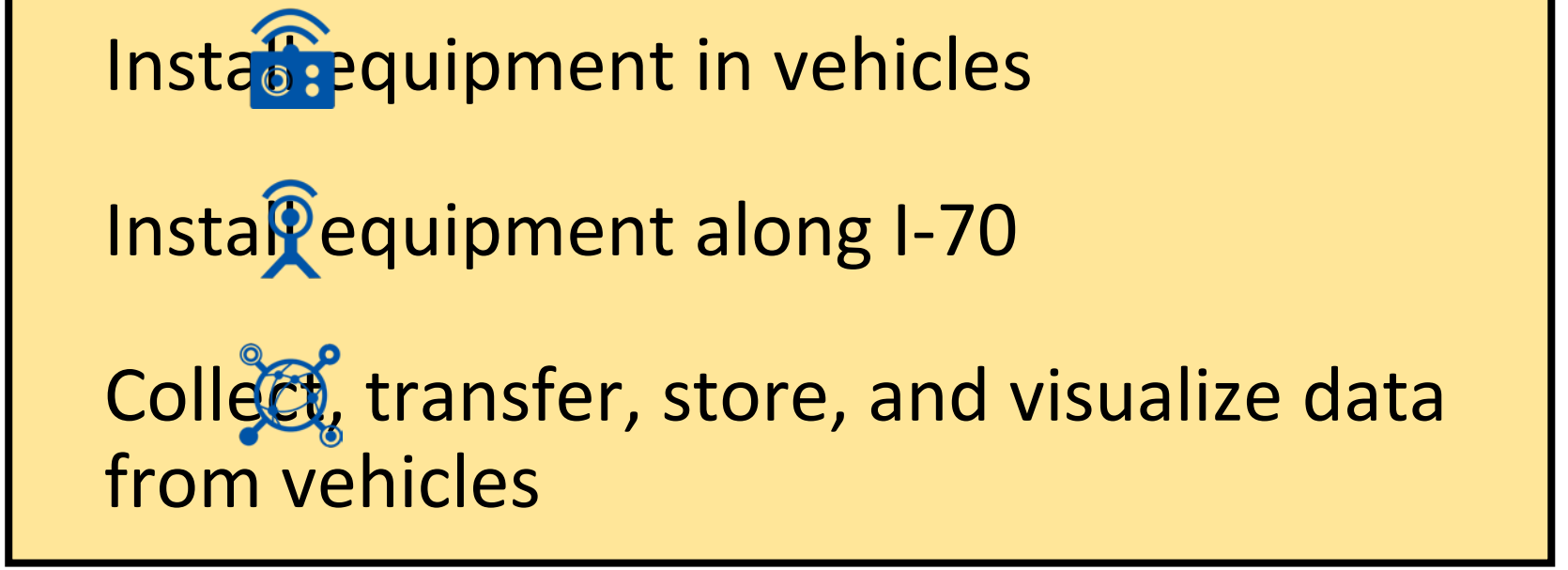
V2X Deployment Program Status



Phase 1 Scope

Overall Goals: (1) Build a statewide V2X Data Ecosystem and (2) launch an initial footprint of V2X technology deployment

Phase 0 / Task Order 1	Phase 1 / Task Order 2	Phase 2 / Task Order 3	Phase 3 / Task Order 4	Phase 4 / Task Order 5	Phase 5 / Task Order 6
Program Planning	Vehicle-to-Infrastructure (V2I)	Infrastructure-to-Vehicle (I2V)	Vehicle-to-Vehicle (V2V)	Enhanced Data Analytics	End-to-End Deployment



CONNECTION | TIMING : WINTER 2017

CDOT ROADX ACCELERATING TECHNOLOGY

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

2016 2017 2018 2019

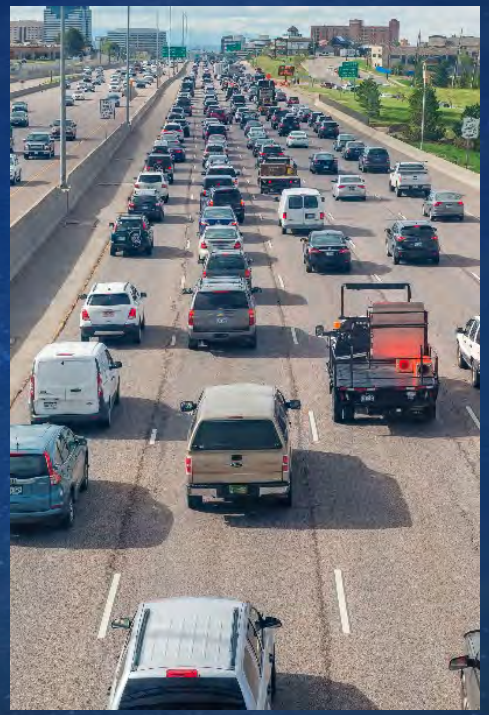
CDOT | ROADX
ACCELERATING TECHNOLOGY

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



2016 2017 2018 2019

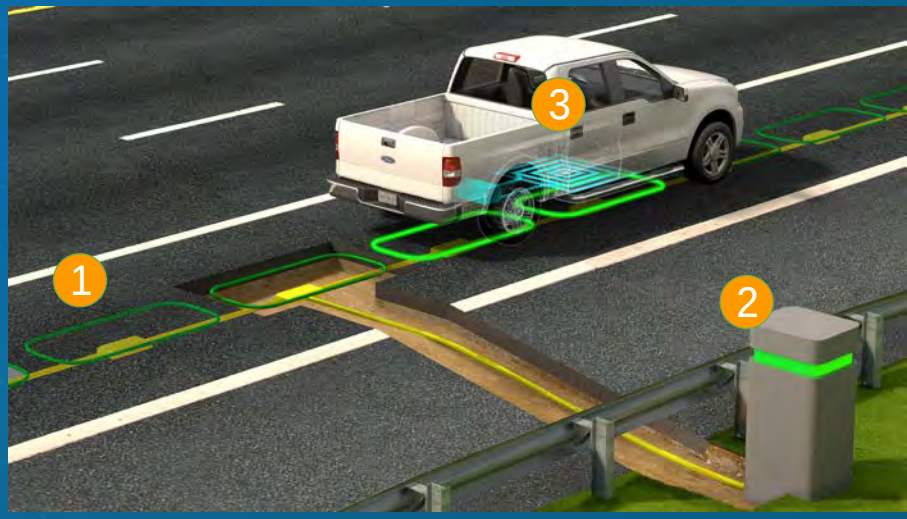
SUSTAINABILITY | TIMING : SUMMER / FALL 2017

CDOT | ROADX ACCELERATING TECHNOLOGY

SMART POWERED LANES

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 – 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.



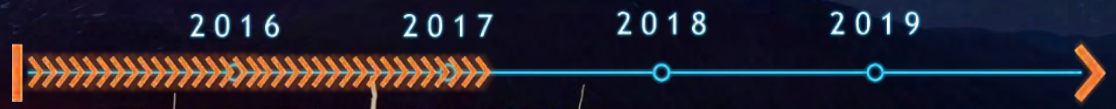
ROADX ACCELERATING TECHNOLOGY

PHASE - 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.



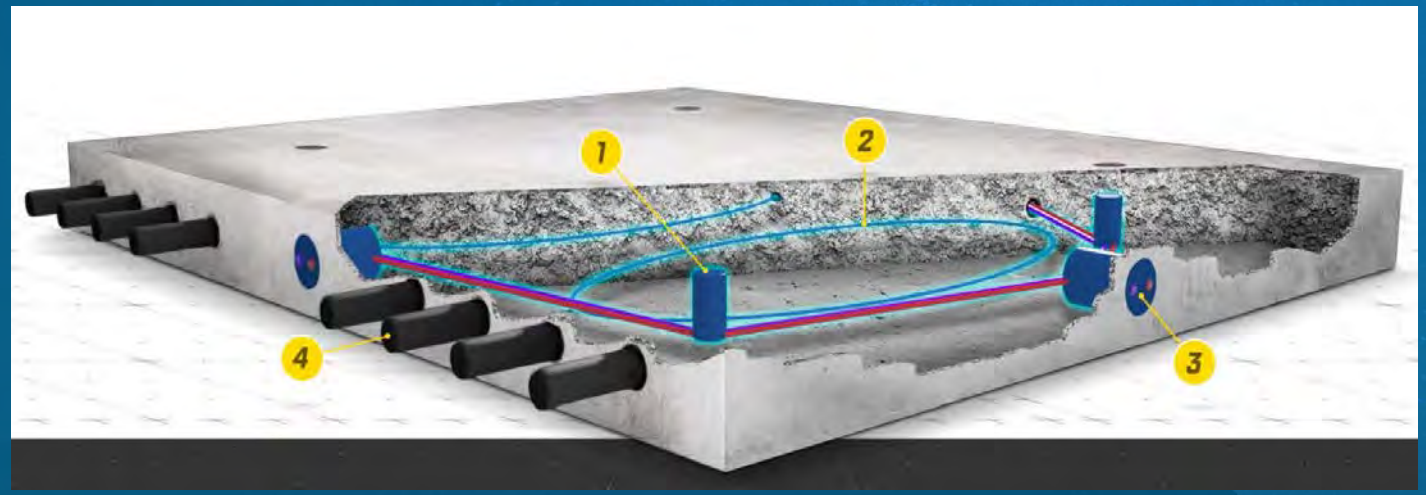
TRANSPORT | TIMING : SUMMER / FALL 2018

CDOT | ROADX ACCELERATING TECHNOLOGY

SMART 285 PAVEMENT

Turning existing roadways into a smart, digitally connected network that and can provide weather, pavement conditions and relay possible safety concerns to the responding agencies.

- 0.8 km segment to be constructed at US 285 - Red Mountain Pass
- Immediate alerts to first responders if a vehicle leaves the roadway
- Future capabilities include inductive charging



1. Expansion ports for new features
2. Fiber Optic Sensing cable makes the road "touch sensitive"
3. Data and power connections at the edge
4. Contained within a prefab concrete slab compliant with standard pavement design specifications

TRANSPORT | TIMING : SUMMER 2017

ROADX ACCELERATING TECHNOLOGY

HYPERLOOP

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.

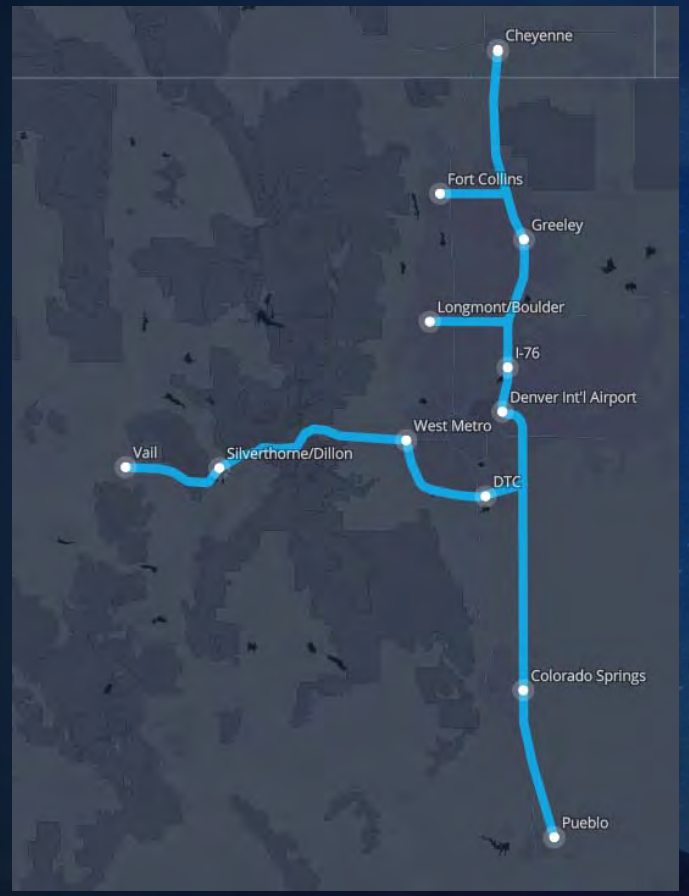
- The Rocky Mountain Hyperloop team (CDOT, AECOM, Denver, Greeley and the Denver International Airport (DEN)) was selected as one of 10 worldwide winners.
- P3 between CDOT & HL1 underway to refine Initial application and define next steps
- Rocky Mountain Hyperloop Feasibility Study / Next Steps done July 1, 2018.

2016 2017 2018 2019

hyperloop one

TRANSPORT | TIMING : SUMMER 2017

CDOT | ROADX ACCELERATING TECHNOLOGY



UNITED STATES

CHEYENNE - DENVER - PUEBLO

TEAM: Rocky Mountain Hyperloop

Colorado's population growth and emerging industry sectors would benefit immensely from a Hyperloop connection along the Front Range. A high-speed link would be beneficial for the state's tourism industry, link high value-added sectors such as biotechnology, technology and aerospace, and help alleviate intercity congestion.

Denver - Greeley: 64km, 6 min
Denver - Fort Collins: 129km, 9 min
Denver - Vail: 121 km, 9 min
Denver - Colorado Springs: 118 km, 9 min
Colorado Springs - Pueblo: 65 km, 6 min
Total Route Length: 580 km

2016 2017 2018 2019

hyperloop one

COMMUTING | TIMING : 2018 FORWARD

CDOT ROADX ACCELERATING TECHNOLOGY

ARRIVO

Arrivo is a new take on a regional transportation system that aims to be safe, fast and clean. The Arrivo system propels four models of vehicles through an enclosed, electromagnetic superhighway, using magnetic levitation to float the vehicles and an all-electric linear motor to push them forward at speeds up to 200 mph with zero emissions.

ARRIVO'S INVOLVEMENT IN COLORADO INCLUDES:

- Development of a full system test track adjacent to E-470
- The creation of 200+ jobs in the Denver metro area by 2020 along with a Arrivo Engineering and Technology Center
- Arrival at DEN in under 20 minutes from anywhere in the Denver metro area

2016 2017 2018 2019

CDOT | ROADX
ACCELERATING TECHNOLOGY

SUPPORTING ROADX

POLICY

PEOPLE

PLANNING

galvanize The Learning Community For Technology

CDOT | ROADX ACCELERATING 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

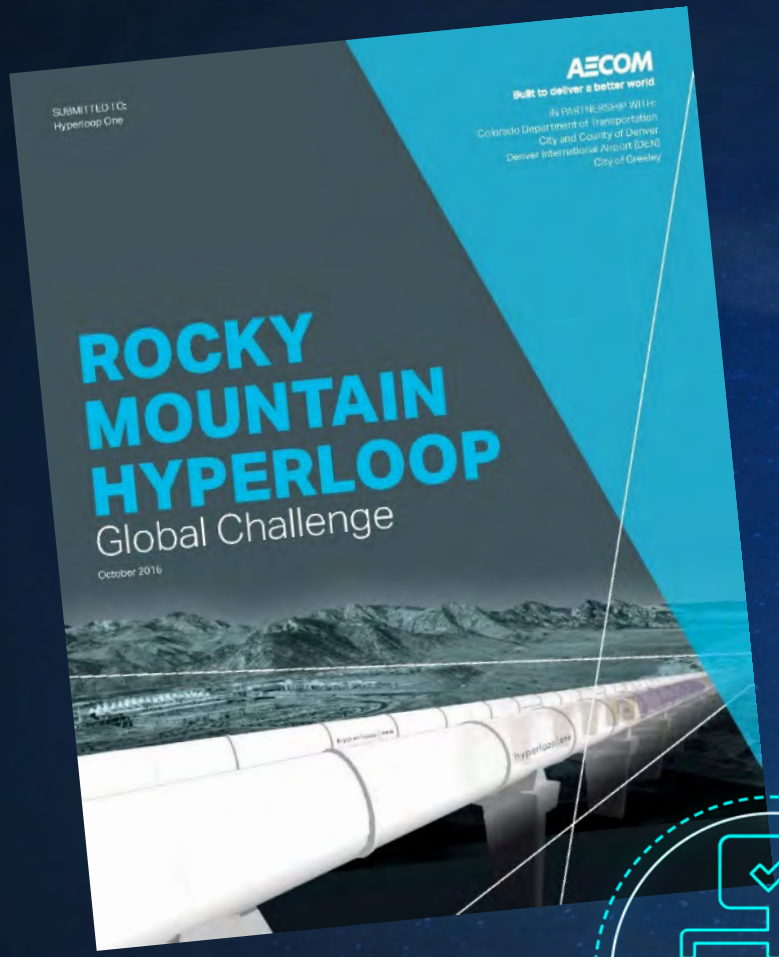
Promotion of RoadX

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

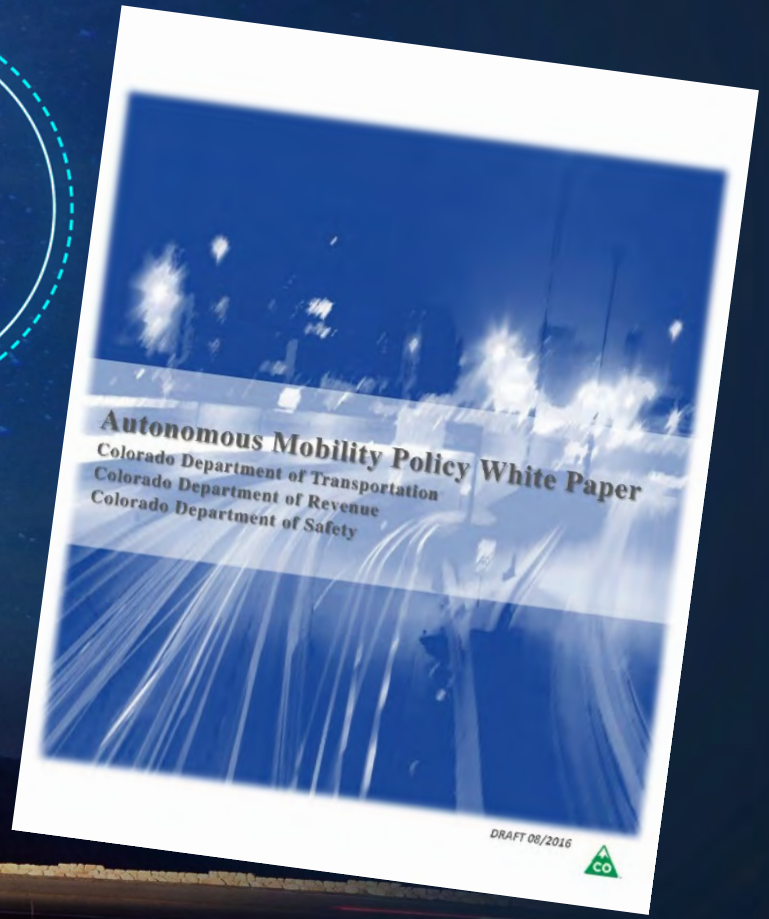
CDOT | ROADX
ACCELERATING TECHNOLOGY

BICYCLE & PEDESTRIAN CHALLENGE



POLICY

PLANNING



CDOT | ROADX
ACCELERATING TECHNOLOGY

NEXT STEPS

Privacy
Address security issues

People
Educate public

Technology & Planning
Plan and model for rapid change

ROI
Invest now in technology platforms

Regulation
Establish consistent policy direction that supports autonomous future

QUESTIONS?