CONNECTED AND AUTONOMOUS VEHICLES

TYLER SVITAK
CONNECTED AND AUTONOMOUS TECH PROGRAM MANAGER
CDOT INTELLIGENT TRANSPORTATION SYSTEMS (ITS)
CHALLENGES

Safety
Congestion
Air Quality
Cost

Colorado Traffic Fatalities

<table>
<thead>
<tr>
<th>Year</th>
<th>Fatalities</th>
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</thead>
<tbody>
<tr>
<td>2011</td>
<td>450</td>
</tr>
<tr>
<td>2012</td>
<td>470</td>
</tr>
<tr>
<td>2013</td>
<td>480</td>
</tr>
<tr>
<td>2014</td>
<td>490</td>
</tr>
<tr>
<td>2015</td>
<td>500</td>
</tr>
<tr>
<td>2016</td>
<td>510</td>
</tr>
<tr>
<td>2017</td>
<td>520</td>
</tr>
</tbody>
</table>

Population

- 2012: 5,188,683
- 2025: 6,449,955
- 2040: 7,772,467
Geometry

Physical = Expensive

Static, irrelevant

Problem is growing
LEVERAGING CHANGE

New Tools

CDOT GOALS

Awareness
Prevention
Response
CONNECTED VEHICLES (cv)
CVs TALK and LISTEN

Vehicle to Infrastructure (V2I)

Infrastructure to Vehicle (I2V)

Vehicle to Vehicle (V2V)
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latitude</td>
<td>SteeringWheelAngleRate</td>
</tr>
<tr>
<td>Longitude</td>
<td>BrakeAppliedPressure</td>
</tr>
<tr>
<td>Elevation</td>
<td>ThrottlePosition</td>
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<tr>
<td>PositionalAccuracy</td>
<td>WiperSet</td>
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<tr>
<td>TransmissionState</td>
<td>RoadFriction</td>
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<tr>
<td>Speed</td>
<td>RainSensor</td>
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<tr>
<td>Heading</td>
<td>VehicleMass</td>
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<tr>
<td>SteeringWheelAngle</td>
<td>VehicleType</td>
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<tr>
<td>AccelerationSet4Way</td>
<td>VehicleHeight</td>
</tr>
<tr>
<td>BrakeSystemStatus</td>
<td>AirBagStatus</td>
</tr>
<tr>
<td>VehicleSize</td>
<td>EmergencyAlert</td>
</tr>
</tbody>
</table>

10 times/second
CV TOOLS = DATA

Situational Awareness
- Road condition (Ice, potholes)
- Queuing
- Weather
- Travel time
- Crashes
- Hazards
- Lane Occupancy

CDOT Operations
- 511
- COTrip
- VMS
- Traffic Management Center
- Maintenance
- Snowplows
- Signal Timing
- Fiber Planning
- Infrastructure Planning
CV TOOLS = NOTIFICATIONS

VEHICLE to VEHICLE
- Collision warnings
- Do not pass
- Intersection assist
- Platooning

CDOT to Vehicle
- Work zone/emergency ahead
- Curve speed warning
- Red light warning
- Icy corner
- Alternate route
- Signal phasing and timing
- Speed harmonization

Customized – Relevant - Instantaneous
CV DEPLOYMENT

65,000+ DSRC devices

2017 Cadillac CTS Sedans (DSRC)

Toyota = 2021

Coming soon at scale
CDOT and PANASONIC

$72 million Partnership

Not a pilot or test

90 MILES OF I-70

2,500+ VEHICLES

Foundational - iOS

C-V2X, DSRC neutral

Phase 0: Planning
Phase 1: V2I
Phase 2: I2V
Phase ¾: V2V, Analytics
Phase 5: System integration

2.12 billion messages/hr
592.3 GB/hr
COMING to COLORADO FIRST

Three Fortune 125 companies working with us

They need us

We need them

Panasonic
Qualcomm
Ford
V2X DATA ECOSYSTEM (vde)

Operating system for CVs - plug and play

100% of roadways, vehicles

True partnership - leverages market potential

Not open source - SDK, APIs

Standards and interoperability

Commercial grade coding

DSRC, C-V2X neutral
STAGE 0

Funded

Managed Lanes, Panasonic

I-70 W
I-70 Central
I-25 N (sect 7-8)
I-25 S Gap
C-470
Panasonic = CV Foundation

How do we build a meaningful CV network at a scale that begins solving problems?
INTERNET of ROADWAYS (IoR)
CDOT is building a new digital infrastructure from scratch

Transportation systems are becoming information systems

Roadways of the near-future will be influenced by digital messages, not just physical infrastructure

To maintain our ability to influence and improve roadway conditions, we need to adapt

Build where the problems are

Deploy holistic network, not piecemeal

1,000 miles
IoR FACTORS

Safety
Mobility
Freight
IoR FACTORS

- Fiber
- Air Quality
- Regional Coverage
- Interstate Corridors
AUTONOMOUS VEHICLES (av)
Uber autonomous freight

First commercial AV without driver

45,000 Budweiser beer cans

120 miles on I-25
1. Permits highly autonomous systems, with or without a driver, on Colorado roads IF they meet all state, federal laws

2. Establishes a process for evaluating proposals if they do not comply with existing laws (Autonomous Mobility Task Force)

3. Establishes exclusive State regulatory authority
Directed CDOT and Colorado State Patrol to approve of highly autonomous driving systems

State created Autonomous Mobility Task Force to develop process for evaluating and approving ADS

Established charter, finalizing checklist and inspection process

Colorado State Patrol, Department of Revenue, CDOT
Leader-follower autonomous system

Successfully tested on public roads summer 2017

Set to become first ADS approved for normal operations in CO later this spring

Pooled Fund Study

Plans to expand fleet
Easy Mile HQ in Denver

Low-speed autonomous EV shuttle (12 person)

First-last mile application connecting bus and transit

Deployment goal Fall 2018

High potential, low-risk, deployable now
AV STRATEGY

Open door to partnership

Establish clear goals, strategy, risks to steer deployment

Study, test, deploy infrastructure to help ADS

Connect our roadways

OPEN QUESTIONS

Does roadside infrastructure need to change?

What and where is a safe operational domain?

How do we plan for a changing landscape?

How can CDOT use autonomy to further our goals?

How do we mitigate risks while advancing benefits?
Tyler Svitak

Connected and Autonomous Technology Program Manager
Tyler.svitak@state.co.us
303-512-5824