Advancements in ITS and CV TITS TEXA texite= **Real-World Project Experience and Lessons** Learned **Consor Elliott Heckler**

Outline

- Project Experience
 - Initial Connected Vehicle Deployments
 - Snowplow Signal Priority / Preemption
 - Connected Mobility Strategic Plan
- Practical applications of technology
- Lessons learned

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OBU DNNEXU RSU CONNEXUS

Overview of CV Equipment

- RSU (Road Side Unit)
- OBU (On Board Unit)

• V2X (Vehicle to Everything) Hub



Connected Vehicle Project Lifecycle

Our experience spans all stages of project life cycle – *planning, design, implementation, construction, and operations and maintenance*

- Planning, grant applications, systems engineering, technical guidelines
- Design and procurement
- Implementation (installation, integration, testing)
- Construction management and inspection
- Post-install services





2017 CDOT Project

- 90 miles of mountain corridor
- Basic Safety Messages (BSM)































- Designer-led Design-Build project
- Field work documentation
- Field Deployment Playbook



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ABOUT THIS PLAYBOOK
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JSING THIS PLAYBOOK
ERMS TO KNOW
'LAYS
Play 1: Stakeholder Engagement
Play 2: Identifying Corridors
Play 3: Corridor Assessment
Play 4: Field Inventory
Play 5: Cost Estimating
Play 6: Site Selection
Play 7: FCC Licensing
Play 8: Engineering Design
Play 9: Construction
Play 10: Construction Quality Assurance
Play 11: Testing and Integration
Play 12: Operations & Maintenance
EFERENCE MATERIAL

FIELD DEPLOYMENT PLAYBOOK



I-80 MM 129.89 WB Photos

Held work completed by: Elliott Date: 10/20/2019 Interstate / Highway: 140 Mile Marker: 129.09 Comm Channel / Drog: 2316 / 8 IP Address: 10.202 7.199 Location on Roadway: 🗆 Northbound 🗇 Southbound 🗇 Databound 😒 Westhound 🕒 Median Littitude: 40.724420 Longitude: -111.772920 Ground Elevation: 5048 (ft) Pole / Structure Information Pale / Structure Type:
Discovering Device Pale
SNon-Lowering CCTV Pale
Discovering in the Structure Pale
SNon-Lowering CCTV Pale
Structure Pal 🗆 Small Cell Pole 🗔 Sign Carollever 💷 Traffic Signal Pole 🗔 Other Pole / Structure Color: 🗟 Grey 🗋 Brown 🛄 Other Estimated Pole Height 45(1)) Estimated Pole to Roadway Ground Differential (5(1)) Any obstructions? 🛄 Yes 😳 No Existing pole penetrations for cabling: 🗆 Yes 👘 🖄 No Devices on Structure: 🖾 CCTV Camera Z MD VM8 🗆 VSL RWIS 🗆 Small Cell Equipment C Other: Cabinet Information Cabinet Type or Dimensional Type 554 Cabinet Mounting Ground Available Space in Cabinet: 🛛 Yes 🔤 No 👘 Grounding Present: 🖾 Yes 🔲 No Spore Outliets: 🛛 Yes 👘 No Communication Information Existing Switch: Cisco Is 2000 Si Hugged Comm (8900 Cither: Spare Ports: 🛛 Yes - # 8 🗌 No Maintenance Maintenance Access: D Outside Shoulder D Median D Pull off Area D Interchange D Iane Closure Needed Protection: 🗆 Guardrali 😒 Darrier 💷 Cable Rali 💷 None **Bectrical** 🗆 UPS Bellery Bodup 👘 🗆 Ballery Benk 🔲 Solar Power

Nelco: Cabinet door broken / Cabinet needs shell

I-80 MM 129.89 WB Photos



North of Pole

East of Pole



South of Pole



West of Pole





Back of Cabinet



Switch



Pole





CDOT Snowplow Signal Priority

Project Overview



• Reduce the number of times a snowplow must stop for a red light

*Reduce Route Times *Reduce Emissions *Improve Pavement Conditions *Reduce Yellow Light Decisions

Allocate an early green or extend the green time at the signal when a CDOT snowplow is detected at the intersection.





CDOT Snowplow Signal Priority

Our Role:

 Creating system engineering documents

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- Vendor bench testing & test documentation
- ✓ Pilot project plans & deployment support on 3 signals & 8 snowplows
- Final project plans & deployment
 support for around 21 signals and 18
 snowplows





Bench Test Environment



Test Laptop



Test ATC

CDOT Snowplow Signal Priority

Bench Test Overview

• 4 RSU's tested

•

3 OBU's considered

- Tested interface between RSU and signal controller







Test OBU





MAP file Test

85		Sont CDMs
0		Sent SPATE (UP)
0		Sent SPAIS (US)
0		Sent SPATS
0		Sent RSAS
0		Sent PSMs
0		Sent MAPs (US)
0		Sent MAPs
0		Sent IVIs
0		Sent EVAs
0		Sent DENMs
0		Sent CAM
	5,763	Sent BSM packets
438		Received WSAs
0		Received TIMs
382		Received SSMs
0		Received SRMs
	8,840	Received SPATs (US)
0		Received SPATs
0		Received RSAs
0		Received PSMs
180		Received MAPs (US)
0		Received MAPs
0		Received IVIs
0		Received EVAs
0		Received CAMs
29		Received BSM packet
0		

OBU Message Statistics

Bench Test Results

MAP+SPaT Test



Operational Event Logs

Entry		De
8	12/14/20 13:10:33 Prioritor 1 active	
9	12/14/20 13:09:45 Prioritor 1 active	
10	12/14/20 13:08:57 Prioritor 1 active	
11	12/14/20 13:08:09 Prioritor 1 active	
12	12/14/20 13:07:21 Prioritor 1 active	
13	12/14/20 13:06:33 Prioritor 1 active	
14	12/14/20 13:05:45 Prioritor 1 active	
15	12/14/20 13:04:57 Prioritor 1 active	
16	12/14/20 13:04:09 Prioritor 1 active	
17	12/14/20 13:03:21 Prioritor 1 active	
18	12/14/20 13:02:33 Prioritor 1 active	
19	12/14/20 13:01:45 Prioritor 1 active	
20	12/14/20 13:00:57 Prioritor 1 active	
21	12/14/20 13:00:09 Prioritor 1 active	

ATC Logs from Signal Priority testing



Connected Mobility Planning



Connected Mobility Strategic Plan City and County of Denver, Colorado

- Development of a **strategic plan** for development and deployment of connected mobility solutions
 - Documentation of existing conditions, definition of desired future state, and gap analysis to identify improvements/investments
 - Roadmap outlining and prioritizing steps
 - Evaluation plan with KPIs and other measures to assess effectiveness over time



Methodology





Existing Conditions





Desired Future State





Gap Analysis

	<u>oficial Elements</u>					
	V2X Use Cases	Organizational	V2X Infrastructure	Supporting Infrastructure	Digital	
	EVP Snowplow VRUs Future	CM Team Internal Collab External Collab Outreach Policy Funding	RSUs OBUs	EVP Snowplow VRUs Future	Data Cybersecurity	
Infrastructure & Resources						
Operations & Maintenance						
Institutional						
Owners						
Dependencies						
Costs						
Technological						

System Elements

Assessment Categories



Recommendations

59 Total Recommendations

Three types:

- Projects
- Infrastructure Upgrades
- Considerations



Ten categories:

- Staff Development & Organizational
- Infrastructure & Devices
- Standards & Specifications
- Maintenance
- Data & Security
- Emergency Vehicle Preemption
- Snowplow Preemption
- Vulnerable Road Users
- Communications & Outreach
- Future Considerations





Recommendations

Example Category:



City and County of Denver Connected Mobility Strategic Plan

5.1 Staff Development & Organizational

For the strategic plan goals to be met, staffing is key. One of the first steps is to develop the current CCD groups to support the CM system. Program management, project management, engineering, data analysis/engineering, and signal technical work are some of the workforce needs in the CM system.

Previously, Denver's CM work has been done in a silo without internal and external knowledge sharing or partnerships. The CM/ SysOps group aims to work closely with TS, Design, Planning, and other groups throughout CCD, similar to how other peer agencies function, allowing for a secure, robust, and impactful CM system. The groups would be unified in a common Advanced Mobility Program. These recommendations will detail the staff development and organizational pieces to support a successful CM program.

The recommendations include:

- C01 Develop Advanced Mobility Program
- C02 Allot an Annual City Budget to CM Program
- C03 Build Up Current Teams to Support CM Program
- C04 Supply Connected Mobility Support Vehicles & Resources
- C05 Establish Workstations for New CM Team Staff
- C06 Identify High Leverage Activities that Should be Performed Internally
- C07 Periodically Reassess the CM Team's Knowledge, Skills, and Abilities
- C08 Collaborate with Other CCD Groups and Departments
- C09 Collaborate Internally on Grant Efforts
- C10 Utilize Consultants, Contractors, and Vendors When Needed
- P01 Develop Processes for Documenting Organizational Knowledge Related to CM

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Recommendations

Example Recommendation:



City and County of Denver Connected Mobility Strategic Plan

SNOWPLOW	P20 - Develop Snowplow Preemption Concept of
PRIORITY	Operations

DESCRIPTION:

Development of a document outlining operational considerations associated with Denver's Snowplow Preemption system. This includes an overview of system elements that allow the system to operate safely and effectively, a description of stakeholder roles and responsibilities, and operational scenarios outlining how the system will function under different circumstances.

VALUE ADDED:

- Provides a framework for the operation of the snowplow preemption system to help ensure it operates safely and efficiently.
- Clarifies roles and responsibilities, ensuring all stakeholders understand their role in the system.
- Fulfills FHWA requirements for transportation technology deployments.
- Serves as a steppingstone toward the development of standard operating procedures.

GAPS ADDRESSED:

G2.4 – Snowplow Preemption Standardization





