

Autonomous TMA Truck (ATMA)

CDOT Evaluation and Performance Verification



Developed By

KRATOS
UNMANNED SYSTEMS DIVISION

Royal
TRUCK & EQUIPMENT INC.



SCOM 2018 – Charlotte, NC

Project Vision



Project Vision



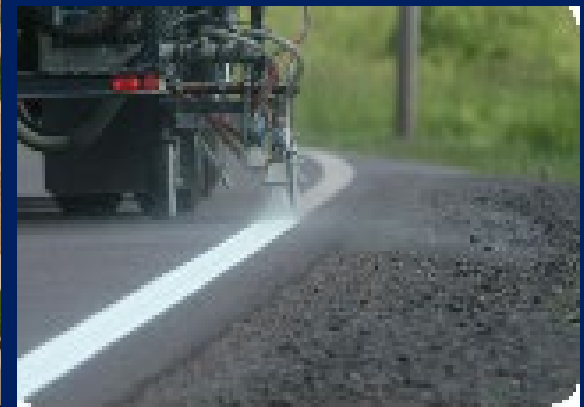
- Remove driver from TMA truck
- Decrease risk of operations
- Increase efficiency of operations
- Pursue cutting-edge technology to improve highway management



Project Goals



1. Installation of system on CDOT piece of equipment
2. Identification of limitations and anomalies in track setting
3. Log open highway miles in striping operation
4. Interchangeability of lead vehicle – sweeper or mower



How it Works



- ATMA will autonomously follow a leader vehicle
 - Leader transmits position, speed, heading
 - Follower matches leader's movements using steering, throttle, brake actuators



Installation of System

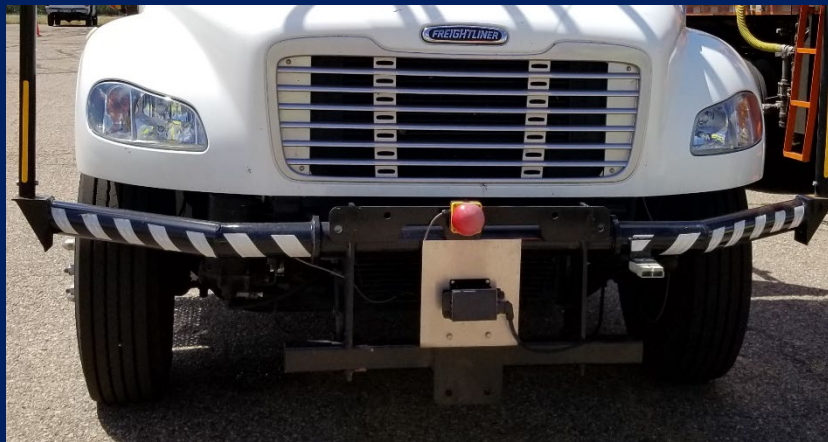


- Follower systems pre-installed
 - Can be retrofitted to existing trucks
- Retrofit leader vehicle with
 - Antennas
 - Navigation module
 - Communications module
- CDOT striping truck completed in ½ day

How it Works



- Front mounted radar on follower provides obstacle detection
 - Only reacts to obstacles in the path between leader and follower
 - Emergency stops upon obstacle detection



Performance Evaluation



- CDOT developed a set of scenarios to verify the capabilities
- First week of performance evaluation conducted on closed track – June 26-30, 2017



Performance Evaluation



- Team from Kratos and Royal Truck and Equipment were on site.
- Tests were downloaded with equipment and GPS data



Lane Accuracy

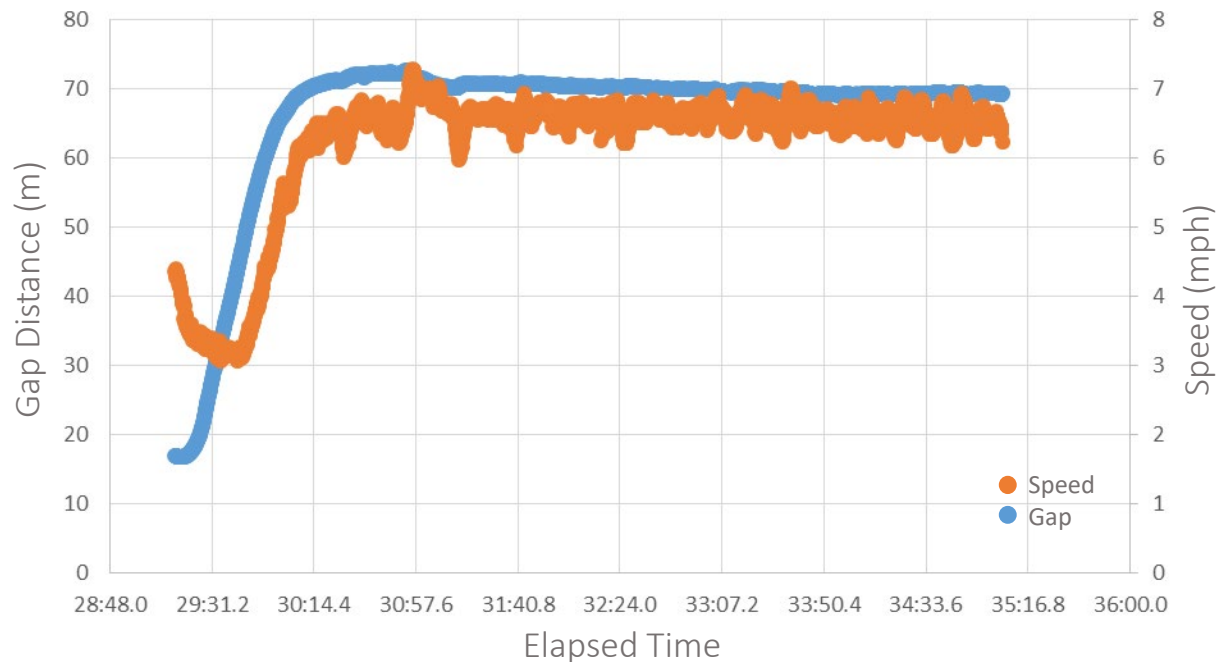


Gap Control

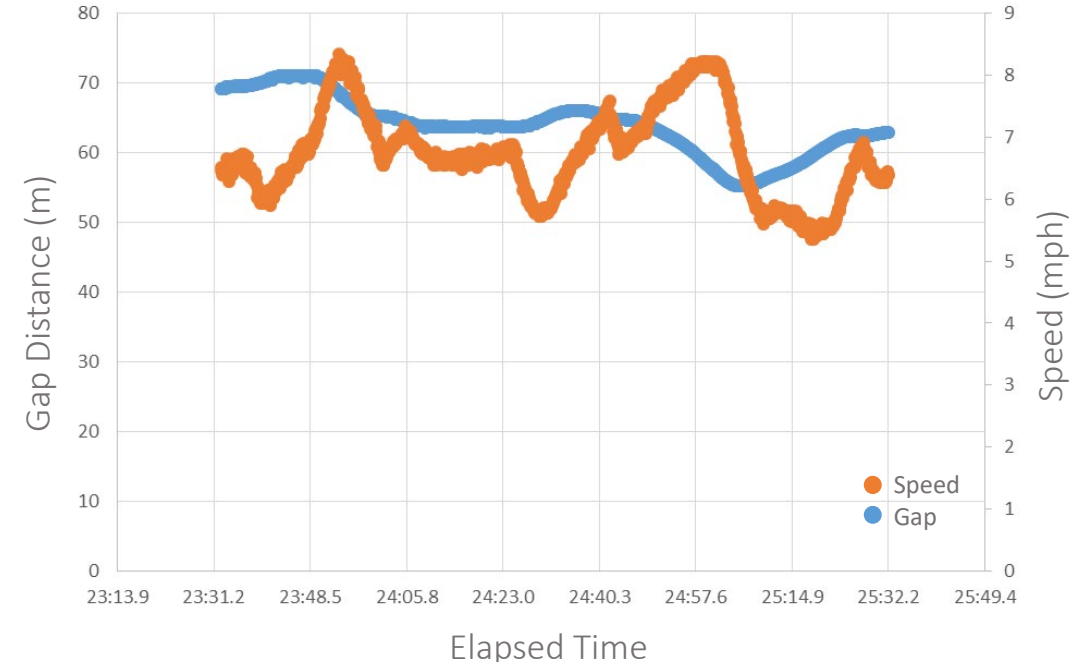


- Straight line following for 4000' with desired speed 7 mph (striping operation speed) and desired gap 60m
- Recorded gap is measured antenna to antenna: 60m bumper to bumper is 68.89m antenna to antenna

Actual Gap Distance and Speed (Automated System)



Actual Gap Distance and Speed (Human Driver)



Driverless Run



Results



- Lane accuracy within +/- 4 in
- Gap distance much more consistent than human driver
- Accurate following in cornering and slalom setups
- Performed turns as tight as 45 ft radius
- Identified software and hardware changes to be made
 - CDOT's production model will address issues found in evaluation of prototype
 - Further suggested modifications will be implemented in future

Future Modifications



- Full user interface with
 - Adjustable gap distance
 - Diagnostics monitoring
 - Video livestream with switchable camera views
 - Test mode to check radar system during pre-trip
- “Pause Mode” allowing ATMA to be stopped while leader continues
- “Tight turn mode” allowing vehicle to make tight U-turns
 - Making this a separate mode used only in turning around allows for the straight line driving to be much smoother

Operational – Fort Collins, CO Event



- Fort Collins – August 18th, 2017
- <https://www.youtube.com/watch?v=8GPcbtVaqnY>
- <https://www.youtube.com/watch?v=N-GkbFXq3Ts>



Operational – Fort Collins, CO Event



- First time in painting operation on public road
- Face book Live Event
 - Internet — 421 online stories
 - TV/Radio — 41 stories
 - In total, that's 945 hits for an estimated reach of 297,084,950 and publicity value of \$2,378,632.62



FHWA Peer Exchange – Greeley, CO



- FHWA Peer Exchange
September 19 & 20th 2017
 - 15 States
 - Live Operation on State Highway 34
- Discussions
 - Policy
 - Operations
 - Project Development
 - Future Steps – Pool Fund



An Act

SENATE BILL 17-213

BY SENATOR(S) Hill and Moreno, Baumgardner, Cooke, Crowder, Gardner, Holbert, Lambert, Lundberg, Marble, Smallwood, Tate, Todd, Williams A., Zenzinger, Grantham;
also REPRESENTATIVE(S) Winter and Bridges, Lundeen, Arndt, Becker K., Buckner, Covarrubias, Garnett, Ginal, Gray, Hansen, Kennedy, Kraft-Tharp, Lawrence, Liston, Melton, Nordberg, Saine, Singer, Valdez, Wist, Young, Coleman, Hooton, Jackson, Michaelson Jenet, Pabon, Sias, Duran.

CONCERNING AUTHORIZATION FOR AUTOMATED DRIVING SYSTEMS TO
CONTROL MOTOR VEHICLES THROUGHOUT COLORADO.

Policy and Operational Usage



- Task Force including CDOT & CSP & Revenue to Review
 - Risk, Public Relations, Operations & Policy
- Autonomous CSP & CDOT Process
 1. Operational Domain
 2. Certifications
 1. Safety Assessment
 2. Driver
 3. Vehicle
 4. Insurance
 5. Special Event
 3. Other



COLORADO
Department of Transportation



COLORADO
State Patrol
Department of Public Safety



COLORADO
Department of Revenue

AUTONOMOUS CERTIFICATION PROCESS

The state of Colorado believes in a shared vision of a safer highway system by advancing the deployment of autonomous vehicle technologies. The autonomous certification process outlines the expected safety, driver, vehicle and insurance certifications prior to deployment and following Senate Bill 213 should the vehicle not currently be able to meet all driving rules and regulations.

Policy and Operational Usage



Autonomous Truck Mounted Attenuator Operations Plan

Contents

CDOT Operating Plan	2
Scope	2
Non-Autonomous Operation	2
Autonomous Operation	2
Safety Observer	2
Authorized Use	2
Operating Procedure	3
Emergency Stop Conditions	3
Crash / Incident Involving ATMA	3
Authority and Adoption	4

Completed Goals and Future Steps



- Goal #3 (Complete) - Log Highway Miles
 - June 2018 – 7 Miles
 - July 2018 – 50 Miles
- Goal #4 – Interchangeability
 - Additional Leader Vehicle (Paint Truck) Planned





- [illegible]


Timeline Summary and Future Steps



- February 2017 - Initiated Project
- SCOM 2017 – Set Goals and Developed Plan
- April 2018 – CSP Final Inspection
- May 2018 – State of Colorado Approval
- June 2018 – Go Live

 **COLORADO**
Department of Transportation

 **COLORADO**
State Patrol
Department of Public Safety

 **COLORADO**
Department of Revenue

**AUTONOMOUS MOBILITY TASK FORCE
PROCESS COMPLETION CONFIRMATION**


This Process Completion Confirmation ("PCC") is issued by the Colorado Department of Transportation ("CDOT") and the Colorado State Patrol ("CSP") as recognition of completion of the Colorado Autonomous Vehicle Process provided by § 42-4-242, C.R.S. This PCC is issued for the request described below and is limited to approval of the conditions contained in that specific Request:

Original Submission Date	October 11, 2017
Company(ies)/Person(s)	Colorado Department of Transportation
Business Address	4201 E. Arkansas, Denver CO
Name and Title of Primary Contact Person	Tyler Sviak Connected and Autonomous Technology Program Manager Colorado Department of Transportation
Vehicle(s) Name	CDOT Attenuator Truck
Vehicle Description	Conventional and Autonomous capabilities

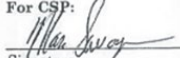
CONFIRMATION

By CDOT and CSP's signatures below, CDOT and CSP acknowledge Requestor has completed the process and, accordingly, may proceed with the requested testing on Colorado public roads.

For CDOT:


Signature
Herman Stacking
Name
Deputy Director
Title
5-14-18
Date

For CSP:


Signature
Mark Savage
Name
Deputy Chief
Title
5-8-18
Date

Pool Fund



- Pool Fund – TPF 5(380)
 - Autonomous Maintenance Technology (AMT)
 - Activities
 - Mission and Vision Document
 - Project Management
 - Bi-Weekly Calls
- Member States - Alabama, California, Colorado, Illinois, Kansas, Minnesota, Ohio, Texas and Washington
- \$650k Committed @ \$25k/yr



Questions?



Thank you



- CDOT - Presenter
- Kyle.Lester@state.co.us
- Kratos – Maynard Factor
- mfactor@gomicrosystems.com
- Royal Truck and Equipment
- fred.bergstresser@royaltruckequip.com

