Appendix K
Technology and System Management Tool Definitions Technical Memorandum

Technology and System Management Tool Definitions

I-25 PEL: Colorado Springs Denver South Connection

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Tables

1 Existing Technology

Existing roadway technology in the Study Area was inventoried and is documented in Table 1-1, which quantifies existing technologies in the corridor (see the Initial Corridor Assessment in Appendix B of the PEL report).

Table 4-3. Existing Roadway Technologies in the Study Area

Technologies[a]	Quantity[a]
Automatic Traffic Recorder	3
Ramp Metering	2
Still Camera	32
Off Ramp Detector	1
Remote Traffic Microwave Sensor	19
Automatic Vehicle identification	33
Doppler Speed Sensors	23
Closed Circuit Television	7
Friction Sensor	2
Video Message Sign	16
Variable Toll Message Sign	4
Weather Station	9
Toll Tag Reader (Automatic Vehicle Identification)	6
Automatic Number-Plate Recognition	12
Fiber Optic Lines	Entire Length of Corridor
Weigh-in-Motion	1
Switches	27
Uninterruptible power supply	8

Note:

Combines data collected from CDOT spring 2017 and elements from the I-25 South Gap Project (currently under construction).

2 Applicable Technology and System Management Tools

The following technology and system management tools could help address the needs of the corridor and support the Colorado Department of Transportation (CDOT) mainline recommendation. Although several of the tools listed already exist in the corridor, they should continue to be considered for upgrades and applied to future projects.

2.1 Variable Speed Limits

Variable speed limits are a system management tool to dynamically adjust speed limits to maintain safe travel speeds based on traffic, weather, or other roadway conditions such as incidents. Variable speeds can be regulated and enforced or presented as speed advisories. The I-25 corridor could benefit from speed harmonization due to the adverse weather conditions and existing congestion observed within the corridor. Variable speed limits address the need to enhance safety in the I-25 corridor.

2.2 Dynamic Lanes

Dynamic lanes are managed lanes that serve multiple uses or accommodations based on time of day, congestion levels, or unfavorable roadway conditions. Dynamic lanes allow for Active Transportation Demand Management (ATDM), enabling Traffic Management Centers to close, restrict, or open lanes to designated or all vehicles. Examples of dynamic lane uses include transit-only lane, high-occupancy vehicle (HOV) lane, peak period lane or shoulder, tolling lane, emergency vehicle lane, autonomous or connected vehicle lane, and climbing lanes.

Dynamic lanes are best suited for regional corridors that are congested and serve a high percentage of through-trips. With CDOT's recommendation to extend the Express Lanes (ELs) further north to C/E-470, dynamic lanes as a system management or operational component should be considered. Mobility and reliability could be increased in the corridor by allowing priority to designated vehicles during periods of congestion, incidents, or unfavorable roadway conditions.

2.3 Variable Message Signs and Variable Toll Message Signs

Variable message signs (VMS) electronically notify motorists of approaching roadway conditions such as incidents, weather, and notable traffic conditions. Variable toll message signs (VTMS) alert EL motorists of closures, prices, or vehicle designations (e.g., HOV lane only). Traveler information signs are placed in locations with high visibility that will not distract drivers and will provide useful information about the conditions ahead.

VMS and VTMS are especially beneficial to corridors like I-25 that have high-volume, high-speed, and frequent through-trips where travel information is key for decision making.

2.4 Enhanced Lane Markings

Enhanced lane markings consist of pavement markings, reflectors, or lights to enhance driver recognition of the roadway (e.g., curves and lanes). Enhanced lane markings are applicable in areas where speeds are higher, and visibility can be low. Areas along the rural segments of I-25 where lighting may dim should be considered for enhanced lane markings. Enhanced lane

markings address the need for safety in the corridor and will better prepare I-25 for autonomous vehicles.

2.5 Roadway Weather Information Systems

Roadway weather information systems (RWIS) improve monitoring and prediction, information distribution, and decision support during adverse weather conditions. RWIS would allow CDOT to better inform and prepare drivers of adverse roadway conditions due to extreme weather.

2.6 Ramp Metering

Ramp metering uses onramp traffic lights with vehicle detection systems to prevent excessive vehicle numbers from entering the highway at once. Too many vehicles merging onto the highway causes conflict areas and slow-down areas during peak periods. Ramp metering allows for active transportation and demand management, fluctuating when ramp meters are active or idle. Ramp metering is often triggered when congestion reaches certain thresholds, for example during peak periods.

Ramp metering should be considered along with CDOT's I-25 mainline recommendation, especially as congestion increases on onramps.

2.7 Wildlife Detection and Alert Systems

Wildlife detection and alert systems are comprised of wildlife sensors, roadway markings, and signage with activated flashing warning beacons installed along the roadway at known wildlife movement locations. These systems are most effective when animals are naturally directed to crossings, whether through fencing, foliage, or topography and are applicable to corridors where the frequency of wildlife-vehicle collisions meet CDOT thresholds of 25 crashes per mile over a 5-year period. Some of the locations within the I-25 Study Area where detection systems are justified have already been addressed by wildlife underpasses and fencing constructed with the I-25 South Gap Project. For other locations within the Study Area, or if wildlife-vehicle collisions continue in the Gap portion of the corridor, then these systems should be considered.

2.8 Autonomous Vehicle Lanes

Autonomous vehicle lanes are dedicated lanes for autonomous vehicles, which allow safe operational movements for vehicles that can sense the environment around them and navigate without human input. A dedicated lane for such vehicles could potentially be narrower than a general-purpose lane and provide greater capacity with reduced vehicle headways. Although there are still unknowns associated with autonomous vehicles, this option assumes vehicle technology will continue to evolve that would allow vehicles to travel in a specified lane to maximize the technological benefits of autonomous vehicles. Autonomous vehicle lanes are applicable to all areas of the I-25 corridor. To allow flexibility in the timing and implementation, a future autonomous vehicle lane could initially be used as a general-purpose or managed lane, then repurposed as the percentage of autonomous vehicles in the overall vehicle mix reaches an appropriate level.

2.9 Transit Signal Priority and Que Jump

The transit signal priority (TSP) and queue jump would improve transit mobility and transit user experience for Bustang. Buses equipped with technology communicate with close-range traffic

signals to modify the signal timing and reduce delay for the transit vehicle. The modification usually changes the length of the green or red phase based on the signal distance. To take it a step further, TSP can be supplemented with queue jumping, which incorporates an additional lane at intersections for transit vehicles to proceed forward before other queued vehicles traveling the same direction; this further reduces signal delay for transit vehicles. The most direct benefits of TSP are the reduction in transit vehicle delay at intersections and the increased reliability of transit service. This can make transit a more attractive mode choice. Because the signals react to the buses, TSP may affect queuing on cross streets as well as affect the network of signals if the signals are connected and communicate with one another. Signal controller cabinets and bus technology may need to be updated. This technology is most effective at intersections that have far-side or no bus stops because it is much easier to anticipate transit running time than dwell time. The I-25 mainline does not have traffic signals to make this technology applicable; however, TSP would be applicable at interchanges where there are existing and planned Bustang Stops adjacent to the mainline.

2.10 Fiber Optic Lines

Fiber optic lines quickly transmit data to advanced/adaptive Intelligent Transportation System (ITS) devices, vehicles, traffic control centers, and mobile devices. Fiber optic communication infrastructure supports data transmission from vehicle detection systems, closed-circuit television cameras, vehicle-to-roadway technology, and other connected roadway technologies. This communication is necessary to activate measures needed in the event of accident, unsafe weather conditions, congestion, and other variable roadway conditions.

In a fully connected roadway environment, communication and data can be collected and monitored to pinpoint issues and identify measures to improve overall system performance. Vehicles can be informed to enact countermeasures, such as alternate route selection or cautionary speeds, to avoid various roadway hazards.

Updating existing fiber optic throughout the corridor and increasing fiber count should be considered with CDOT's mainline recommendation. As connected vehicles become more abundant, having effective communication systems already in place will maximize the utility of these vehicles types within the corridor.

2.11 Closed Circuit Televisions

Closed circuit televisions (CCTV) are cameras that provide real-time still or streaming video to help identify incidents and road conditions. Although CCTVs are currently located throughout the I-25 corridor, additional cameras would better monitor congestion, incidents, EL activity, and other roadway conditions in real time.

2.12 Dedicated Short Range Communications

Dedicated short-range communications (DSRC) is a wireless communication method used to send information between roadway infrastructure and connected vehicles. Connected vehicles can receive information from the traffic message channel (TMC) regarding traffic conditions, alternate routes, and detours. As connected vehicles become more abundant on I-25, having effective communication systems in place will maximize the effectiveness of these vehicles types.

2.13 Vehicle Detection Methods

There are several vehicle detection methods used to recognize the presence of a vehicle and/or identify a vehicle:

- **Automatic Vehicle Identification (AVI)** is a technology that uses sensors to determine a vehicle's classification, such as a truck versus a passenger car, or a single occupancy vehicle versus an HOV. Sensors determine if vehicles using ELs are carrying a transponder or not, and that information is used to implement toll transactions based on transponder use and vehicle classification.
- **Travel Time Indicators (TTI)** are roadside antennas that pick up toll transponder signals to calculate travel time between indicator stations.
- **Remote Traffic Microwave Sensors (RTMS)** report traffic volume, speed, and occupancy at a fixed point using radar detection.
- **Automatic Plate Number Recognition (APNR)** can capture license plate numbers with location, date, and time of capture using optical character recognition. They can also capture photographs of the vehicle and sometimes its driver and passengers.