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COMBINING SIGNAL TIMING, DETECTION TECHNOLOGY, AND ALTERNATIVE INTERSECTION DESIGN TO IMPROVE TRAFFIC OPERATIONS AND SAFETY ON A POPULAR MOUNTAIN HIGHWAY IN COLORADO

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ABSTRACT

As the premiere and busiest east-west highway in south and southwest Colorado, US 160 assumes a vital role for the region's commerce and tourism. However, it has been facing some unique challenges that threaten to congest portions of the corridor throughout different seasons. In the summer, numerous tourists drive on this highway, mingling with local commuters, often causing over-capacity issues on the mostly two-lane corridor. In the winter, skiers from all over the country use this highway to access major ski resorts in southwest Colorado, and they have to deal with reduced capacity and unfriendly road conditions due to inclement weather.

In this CDOT Region 5 project, a comprehensive toolbox of "low-hanging fruit" solutions and capital projects has been developed to address these unique challenges for the 195-mile US 160 corridor and other "hot spot" locations in southwest Colorado. New summer and winter timing plans were developed for 44 traffic signals throughout the area to improve throughput and reduce travel time while balancing the needs of both local commuters and tourists. Detection technology appropriate for weather and road conditions of the region was identified to help improve accuracy and signal operations. Alternative intersection solutions were evaluated for various locations along the corridor. This project also includes the development of traffic signal timing guidelines that not only reflect state-of-the-art practices, consistent with national standards, but also address the unique traffic and geographic environment of the mountain region.

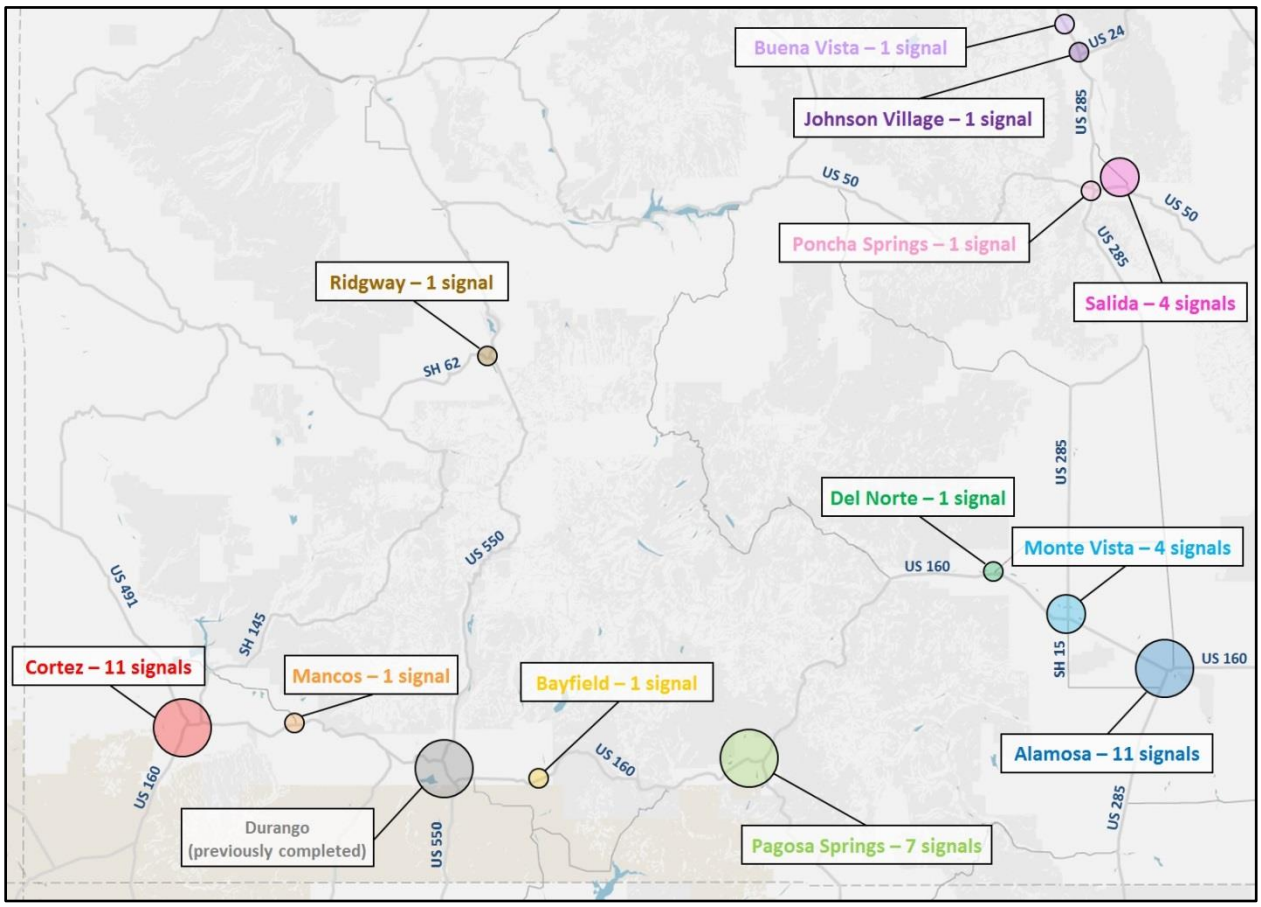
INTRODUCTION

In 2012, CDOT Region 5 undertook a project to improve traffic operations along the US 160/ US 550 corridor in the City of Durango through signal coordination and minor physical improvements. Upon completion of that venture, a significant net reduction in traffic delays was observed – up to 20% in some locations. Inspired by the success of that project at improving the driving experience in Durango for local traffic and tourists alike, CDOT elected to consider similar adjustments for other signals throughout the rest of Region 5.

The main corridor featured in this project is a nearly 200-mile stretch of US 160 in south and southwest Colorado. 36 traffic signals located along US 160 in seven different cities are included in the scope, from Cortez on the west end, just past the Four Corners area, to Alamosa on the east end. In addition to these signals on US 160, another eight “hot spot” signals located

on other federal and state highways throughout the region were also analyzed for improvements.

Figure 1 – Traffic Signals for Improvement



The project area is mostly composed of mountainous terrain, with fairly steep grades in many spots along US 160. Colorado's mountains are famous for their sunny summers and snowy winters, and this region is no exception. Snow can cause major delays on many of these narrow, winding roads. US 160, primarily a two-lane highway throughout this region, is one of the major routes used by both local residents and tourists visiting the area for activities such as hiking in the summer and skiing in the winter. The mix between local drivers and tourists can prove disadvantageous, particularly in inclement weather, if there are many people on the road who are unfamiliar with the normal driving conditions.

Through retiming traffic signals, renovation of the vehicle detection system, and physical improvements, this project aims to improve traffic operations by at least 20%.

REVISED SIGNAL TIMING

The primary means by which this project sought to improve intersection operations along US 160 was through the development of new signal timing plans for all 44 signals included in the scope. Because US 160 is heavily used by local commuters and tourists in both summer and

winter conditions, timing plans were created separately for each season and for both weekday and weekend periods.

Certain aspects of the signal timing were standardized as the timing was revised to create a more uniform experience for drivers along US 160. New clearance intervals for both vehicles and pedestrians were calculated for all intersections. The formulas used are described in the FHWA Traffic Signal Timing Manual and the ITE Manual of Traffic Signal Design. The newly-established criteria include a minimum yellow interval of 3.0 seconds, a maximum yellow interval of 4.0 seconds, and a minimum all-red interval of 2.0 seconds.

Additionally, revised national standards were taken into account in the design of these new timing plans. This included setting the minimum WALK interval to 7.0 seconds and reducing the pedestrian walking speed as recommended in the 2009 MUTCD. Increasing the WALK time and lowering the walking speed from 4.0 feet per second to 3.5 feet per second increased the split required to accommodate pedestrians crossing the main street. Consequently, in cases where the side street vehicle phase was not long enough to accommodate pedestrians and had to be lengthened, the time allotted to the main street through phase – and the time available for progression along the main street – needed to be reduced.

One of the priorities of this project was to improve throughput along US 160, particularly within the larger cities such as Cortez, Pagosa Springs, and Alamosa, where there are many signals in close proximity. Coordinating these signals was essential to prevent unnecessary stopping and improve safety, but certain limits of coordination had to be observed. In general, signals were only coordinated if they were less than half a mile apart. Isolated signals, such as those in Mancos, Bayfield, and Ridgway were automatically left uncoordinated. Multiple signals within the same city or town could be coordinated, but the distance between each cluster of signals on US 160 is too great to effectively be coordinated between cities.

Even in locations with multiple signals, not all of the signals were necessarily coordinated together. In some cases, like in Salida or Cortez, a single signal was located far enough away from the others that trying to coordinate it with the majority resulted in a decreased level of service for the entire city overall. If the isolated signal was left uncoordinated with the others, operations improved at all the intersections. In other places, like Alamosa or Pagosa Springs, the signals had to be divided into multiple coordination zones in order to improve progression through the city as a whole. Interaction between the different zones within one city was minimal.

ENHANCED VEHICLE DETECTION

CDOT Region 5 made the switch from inductive loops to video detection several years ago. However, the video detection system has encountered problems largely brought on by winter conditions in this mountainous area. Below-freezing temperatures and blowing snow often result in low-quality images and therefore increased delays. Part of the scope of this project involves identifying detection technologies other than loops and video that could potentially function better in the variety of weather conditions this region sees throughout the year. This

section of the project is still a work in progress, and some of the preliminary research results are presented below. No recommendations have yet been made regarding what kind of detection system is appropriate for the project area.

Detectors such as radar or infrared sensors are commonly accepted replacements for vehicle actuation in areas where loops have not proved successful. They rely on signals transmitted between the overhead sensor and the roadway, and the particular ways the presence of a vehicle disturbs those transmissions. These detector technologies can be impacted by atmospheric conditions; the presence of particles such as dust, smoke, or water in the air can scatter, absorb, and reflect radio wave and infrared energy signals away from the sensor. These systems, like video detection, are non-intrusive and fairly easy to install over the road, but would still require periodic maintenance in inclement weather to avoid blocking the signals.

CDOT is also considering new technologies in the form of Bluetooth and Wi-Fi detection. These techniques are possible because of how many devices, from phones to laptops to cars themselves, now carry Bluetooth transmitters or are Wi-Fi enabled. Bluetooth and Wi-Fi sensors are only minimally affected by weather and tend to require very little maintenance. This type of system is most commonly used for travel-time measurement or origin/ destination studies because the sensors installed on the side of the road can track a single device anonymously through an entire network of roads. CDOT, in conjunction with the City and County of Denver, has already begun using Bluetooth detection to measure travel times along other major corridors in Colorado, including Federal Blvd. However, Bluetooth and Wi-Fi detection are rarely used for traffic signal actuation. There is a chance, particularly in a rural area such as the US 160 corridor, that a vehicle containing no Bluetooth or Wi-Fi technology could approach a signal and not be detected by such a system.

PHYSICAL IMPROVEMENTS

In addition to modifying signal timing and updating the region's detection system, some minor physical improvements were considered to further enhance operations in certain areas. Most of these potential improvements were focused on low-cost, easy-to-implement elements such as striping, routing, and intersection reconfiguration, rather than extensive reconstruction projects. Lane widening was a common suggestion at many of the intersections within the scope. Other striping changes included lengthening left-turn or right-turn pockets to alleviate queues or adding a two-way left-turn lane in the median of US 160 in downtown Pagosa Springs. This center left-turn lane removes vehicles waiting to turn left from the through lane, thereby reducing the delays experienced by drivers traveling through the downtown area.

CDOT specifically requested an investigation into the feasibility of implementing flashing yellow arrow (FYA) signals throughout the region. While some areas see too many left-turning vehicles for FYA to operate efficiently without worsening queues, other areas show promise for successful implementation of this increasingly popular method of traffic control. Further analysis still needs to be completed before any final decisions are made.

CASE STUDY – RIDGWAY:
VISIBLE EVIDENCE OF THE IMPACT OF SKI TRAFFIC

The traffic signal at the intersection of US 550 and SH 62 is the only signal located in Ridgway and in the entirety of Ouray County. There is little to make this intersection stand out from some of the others included in the scope of this project.

However, this signal is located approximately 28 miles directly south of Montrose Regional Airport along US 550. In the winter, out-of-state skiers must drive through Ridgway on their way from the airport to the surrounding ski resorts. Multiple flights arrive at and depart from Montrose Regional Airport throughout the day, and some of the flights can carry upwards of 150 passengers, meaning that ski traffic could potentially have a large impact on the vehicle volumes counted at this intersection.

The traffic counts used for the development of the winter signal timing plans for the other 43 signals in the scope were collected in late October, at the beginning of the winter season. However, these counts were gathered prior to the start of Montrose Regional Airport's ski season flight schedule. Analyzing the ski season flight schedule revealed that the number of passengers potentially arriving at and departing from the airport each day peaks in January and March. So-called "deep winter" traffic counts were collected in January at this intersection specifically to capture the artificial increase in volumes on US 550 during ski season in order to adjust the signal timing in winter accordingly.

CASE STUDY – PAGOSA SPRINGS:
SIGNAL COORDINATION IN A MOUNTAIN TOURIST TOWN

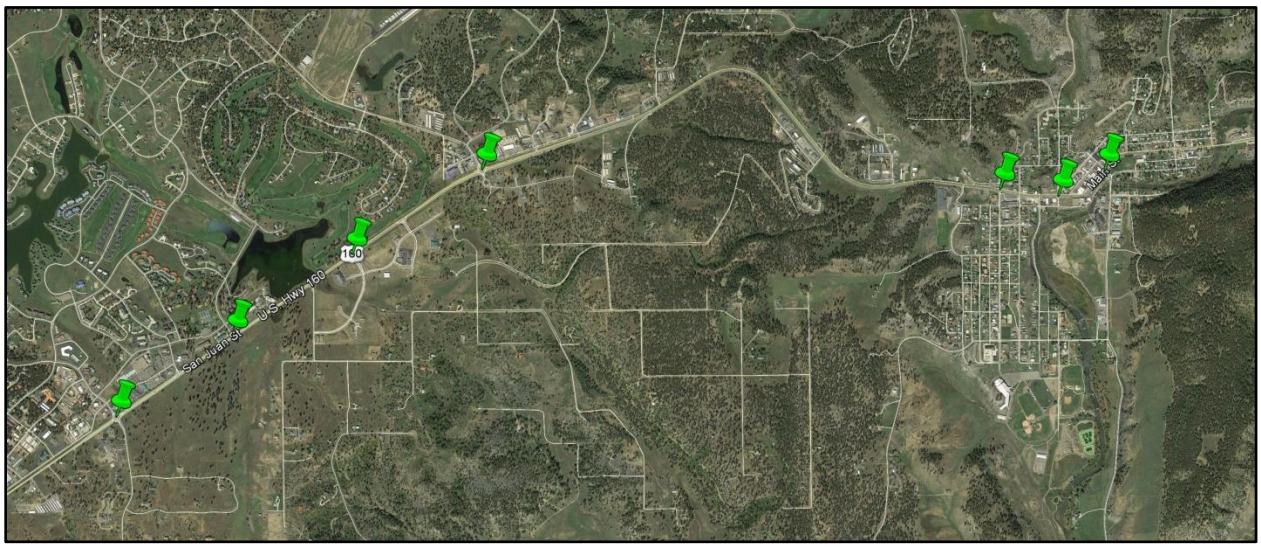
The stretch of US 160 that passes through Pagosa Springs embodies many of the more unique aspects of this project. The terrain is mountainous, with grades along US 160 as high as 6% in some places. The western end of Pagosa Springs is home to many full-time and part-time residents, and the eastern end is incredibly popular with tourists visiting the famous hot springs along the San Juan River. The downtown area surrounding the hot springs resort sees a lot of pedestrian traffic and features on-street parking on both sides of the four-lane highway.

There are seven traffic signals on US 160 within the limits of Pagosa Springs; three are located downtown, on the east end, and four are located uptown, on the west end. The three downtown signals are spaced closely together, all within a half mile. The four uptown signals are more spread out, with approximately half a mile between each of them. The distance between the two groups of signals is nearly two miles.

Determining how to coordinate these seven signals was the first step towards refining traffic operations in Pagosa Springs. The three signals located downtown were well within the half-mile limit for coordination. Challenges arose when determining whether or not the other four signals should be coordinated with the downtown signals, coordinated as their own zone separate from the downtown signals, or left uncoordinated altogether. These three options were modeled using Synchro and the level of service at all seven intersections was compared to determine which scenario would result in the greatest improvement over existing conditions.

Ultimately, it was decided that the four uptown signals should be coordinated into a zone distinct from the downtown signals to achieve satisfactory progression along US 160.

Figure 2 – Traffic Signals in Pagosa Springs



Although revising the timing for these seven signals improved driving conditions along US 160, left-turn queues were not completely alleviated in the downtown area during the peak hours. As mentioned previously, the absence of left-turn pockets through most of downtown means that vehicles waiting to turn continue to block through traffic behind them. The physical change proposed to resolve this issue is to add a two-way left-turn lane to the center of the highway. As this road cannot easily be widened, the simplest way to incorporate a center left-turn lane would be to remove the on-street parking from one side of the highway. There are several existing underutilized off-street parking lots on the south side of US 160 that could be developed to take the place of the on-street parking. Before moving ahead with this possibility, CDOT will need to reach out and involve the public and local businesses in the discussion of the potential impacts of not adding a center left-turn lane versus removing on-street parking in downtown.

LOOKING AHEAD – NEXT STEPS

While much has been completed for this project already, there is still more work to be done. The new summer signal timing plans are due to be implemented this summer, and the revised winter timing plans will be completed and updated later this year. Based on the recommendations presented by Stantec, CDOT will determine which physical improvements to pursue more in-depth, and how to move forward with revamping the vehicle detection system. Before and after studies of travel time along the corridor and vehicle collisions will be completed to assess how the changes implemented through this project have impacted traffic operations and safety throughout the region.