SMART WORK ZONE (SWZ) Project
Lessons Learned

BACKGROUND

In December of 2012, the Colorado Department of Transportation (CDOT) announced the start of the long-awaited bore widening of the eastbound Twin Tunnels project on I-70 west of Denver.

This project was the first of several highway improvements proposed along this corridor to address the heavy traffic congestion that occurs every weekend and holiday. Construction improvements are focused on providing significant traffic benefit for the eastbound direction coming home from their recreational trips in the mountains. The project objective is to unclog the tunnel known as the eastbound "choke-point" of this corridor. (Note: The westbound tunnel bore is planned to be addressed later depending on availability of funds).

The Smart Work Zone Concept was first introduced in Colorado on July of 2012 when the Western Association of State Highway and Transportation Officials (WASHTO) held their annual conference in Colorado Springs, Colorado. Several DOTs presented the Smart Work Zone concept: Utah, Nevada, and Texas. Richard Skopik, Waco District Engineer with Texas Department of Transportation (TxDOT) demonstrated how the current wireless technology can transmit information such as video images, speed data, and traffic volumes via temporarily installed closed-circuit televisions (CCTVs) and Bluetooth speed sensors. Data collected are processed on a computer server that instantaneously relays it to portable variable message signs placed at chosen strategic sites along the affected segment of the highway. On TxDOT's I-35 construction (90 miles), they were able to successfully accomplish the following:

- Real-time queue warning
- Lane and road closure information
- Current travel time
- Expected construction delay
- Daily volumes
- Spot speeds
- Traffic video streaming

All of the above were gathered, collected, and made available to the traveling public to give them the ability for timely reactions and allow them to plan their trips based on the traffic conditions provided by the Smart Work Zone system.

This is another tool in the Intelligent Transportation System (ITS) toolbox. As explained in the 2008 *Intelligent Transportation System Technical Report*[1] in Colorado's *2035 Statewide Transportation Plan:*

> "Potential benefits attributed to ITS show: speeds increased by 16 percent, travel times on congested corridors were reduced by 22 percent, primary accidents decreased by 15 percent, secondary accidents decreased by 30 percent and average incident duration decreased by 50 percent, depending on the specific circumstances."

Smart Work Zones were also the subject of a study performed by researchers at the University of Saskatchewan, along with personnel from the Federal Highway Administration and International Road Dynamics. The article (at http://www.irdinc.com/library/pdf/ProbabilisticSmartWZ.pdf) described a case study that used a traffic model analysis based on comparison between a site without a Smart Work Zone and a site with a Smart Work Zone. The study concluded that Smart Work Zones can provide significant benefits to motorists, and that in fact it can cost less to use a Smart Work Zone than not to.

PROJECT GOALS AND OBJECTIVES

CDOT saw the potential traffic benefits of the Smart Work Zone for many of their major highway projects. Specifically, they became very interested in the significant traffic benefits TxDOT realized after implementing the concept along the 90-mile segment of I-35. CDOT Region 1 tasked Stantec Consulting to design a pilot Smart Work Zone project to be implemented by the start of the Twin Tunnels project in early 2013.

The primary goal was to increase work zone safety while reducing traffic delays, inconvenience, and complaints from motorists due to construction. The objective was to provide real-time notification of traffic delays, travel times, and queuing conditions to the affected motoring public. This real time notification was delivered to the public via traffic data gathering, processing and dissemination utilizing **portable message sign panels (PMSPs**). E-mail and texting notification and a temporary project website (www.twintunneltraffic.com) were added components of the system that would enhance accomplishing the goals and objectives.

THE PROJECT

Stantec was tasked by CDOT Region 1 Traffic to design the ***Smart Work Zone (SWZ)*** system for the Twin Tunnels project and write the specifications for a project advertisement in December 2012. The project was designed and advertised as scheduled (See the **Appendix Section** for a link to the project plans and specifications).

[1] http://www.coloradodot.info/programs/statewide-planning/documents/2035-plan-technical-reports/ITS%20Technical%20Report.pdf

The project was advertised on December 27, 2012 and was awarded to TK Construction on January 17, 2013. As part of the contract, the Contractor provided the SWZ system sensors and delivered condition-responsive messages related to the work zone. Per the specifications, CDOT reserved the option to deploy or remove individual devices or the entire SWZ system.

The SWZ system consisted of several devices linked together in a wireless network to perform as one unit. The components included portable non-intrusive traffic sensors, portable pan-tilt-zoom cameras, PMSPs, and software with user-defined parameters to collect and analyze data and trigger new messages on the system and/or send warnings to appropriate personnel. It also included a central control system for various data processing and communication functions, and a website for user interface and data display. The quantities of each device were as shown on the plans.

The work consisted of all labor and materials to furnish, install, relocate, operate, service, maintain and remove various components of an automated, portable, real-time SWZ system meeting all the contract requirements. Payment for the devices included the maintenance of the complete system during the duration of the project or as directed by the project engineer.

The main purpose of the SWZ system was to collect real time vehicle data at various locations, in advance of and within the work zone. The data would be used to inform the affected motorists a well as the Colorado Transportation Management Center (CTMC) personnel, the SWZ Project Engineer, and the Region 1 Traffic Engineer of operational conditions and historical data related to traffic delays, stopped conditions, queuing, and other pertinent traffic information. The ultimate goal was to assist the affected drivers in reacting accordingly and/or planning their travel through the work zone. Traffic thresholds (such as slow speeds, delay, and queuing) were relayed by the system during the work. The real time traffic data were input into control software that communicated with the PMSPs displaying these messages. These messages were real time and dynamic based on collected data at the SWZ system monitoring points. In addition, the SWZ system had the ability to inform the CDOT Region 1 Traffic office of traffic delays via the project website and e-mail notification.

DURING THE PROJECT

On February 5, 2013, the Contract was executed between the lowest-bid Contractor (TK Construction) and CDOT.

On March 18, 2013, the pre-construction meeting was held. On March 28, the pre-deployment final testing and inspection of devices were performed for the Twin Tunnels SWZ project. PDP Associates, the sub-contractor for these electronic devices, provided a hands-on training on how to access and monitor the website dedicated to this project. The SWZ team then met to finalize the system logic and PMSP messaging in preparation for the Twin Tunnels project's April 1, 2013 schedule of rerouting eastbound I-70 mainline onto the newly constructed detour.

Construction Delay Messages

Goal: The goal, as originally intended, was to provide travelers real time information on construction delay at the Twin Tunnels construction project.

Objective: The objective was for the system to relay the construction delay information via the PMSPs and the website. For example, at the eastbound PMSP located at MP203 (Frisco) or 37 miles away, the PMSPs would display the following messages on two alternating panels:

The other four (4) eastbound PMSPs located at Silverthorne, Herman's Gulch, Empire, and US 40 and the three(3) westbound PMSPs located at Chief Hosa, US 6 (Golden), and C-470 would display their respective distances to the work zone and the current construction delay at the work zone at the time.

The SWZ system as designed was measuring the travel time between sensors, not the travel time from the individual PMSP all the way through past the work zone.

Major Observation 1: The public apparently misunderstood the delay message, which was exclusively for the 7.60 miles, not for the entire 37 miles of travel. As the motorists read the message on a PMSP, the delay message was being misconstrued as the total travel time from that point of travel all the way through the Twin Tunnels work zone.

- For example, the eastbound PMSP, EB-2 at Silverthorne, MP 206 (37 miles away), would display the eastbound travel time between Sensor EB-S1 at MP 237.4 and Sensor WB-S3 at MP 245, or only 7.60 miles apart. The travel delay measured between these two sensors would then be shown at the PMSP at Silverthorne (MP 206). The confusion arose when motorists understood the travel time being shown as the travel time from the moment the message was read (at Silverthorne) all the way to the end of the work zone. In reality, it was showing the travel time at the work zone, measured between the sensors.

Major Observation 2: The most challenging occurrence during the SWZ project was when the rockfall mitigation project started in the spring.

- For example, one eastbound rockfall mitigation site was at Georgetown (MP 228). As per the rockfall mitigation project protocols, all vehicles must be stopped (approximately 20 minutes) during the rockfall procedure. This stoppage created a significant traffic delay from Georgetown and backed up to the west for a few miles. Ironically, the eastbound traffic delay being monitored by the SWZ System between MP 237.4 and MP 245 did not show any delay. So, due to the fact that the system found no delay in the 7.6-mile Twin Tunnels Work Zone, the eastbound PMSP at Silverthorne (37 miles away) relayed minimal travel time (minutes). This situation aggravated the misperception of many motorists who, after seeing minimal minutes through the Twin Tunnels Work Zone at the Silverthorne PMSP (MP 206), then found themselves in standstill traffic at the rockfall mitigation project (MP 228). Somehow, it apparently was not well understood that the message as displayed was solely for the 7.6-mile work zone that was 37 miles ahead (MP 235), the start of the Twin Tunnels project.

Major Observation 3: The project staff of the Twin Tunnels expressed concern regarding the word "delay," saying that it apparently created a "negative" perception of the Twin Tunnels project.

System Adjustments: Based on feedback received from CDOT Public Relations, Region 1 Traffic and Twin Tunnels Project staff, SWZ system adjustments were made as shown below in *Message and Logic History.*

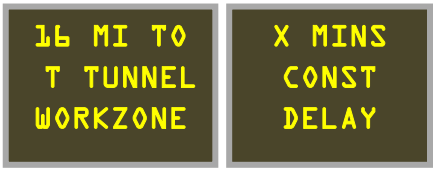
Message and Logic History

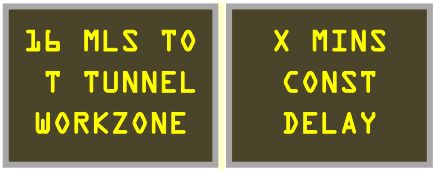
The following is a history of the order of events related to the various PMSP message changes we made including their respective logic changes.

Date	Event	Description
Feb 27	Meeting	Stantec and CDOT met with PDP to discuss programming logic
Mar 20	Meeting	Stantec and CDOT met with PDP to further discuss the messaging strategy
April 1	Message Initial	SWZS went live with the initial message design. The challenge that was experienced during the initial stage of the project was related to available cellular signal in the mountains. It was learned that the best network provider (Verizon) had only 2 towers in the corridor that were receivable by the devices. Contractor had to install supplemental antennas and special programming to correct for frequent low band width conditions.
April 4	System Check	System check: messages were functioning well
April 6	Message Change	Stantec meeting - Messages and website display were changed to keep all speeds shown below posted speed limits. Running average was adjusted to 5 minutes. System was reportedly working well.
April 10	Message Change	Logic revised to prevent inadvertent triggering of delay messages due to rockfall mitigation project, and mistaken reports of no delay on closed portions of road with no traffic and outside of the monitored area.
April 13 and 14	System Check	Stantec reported the system working well despite heavy storm and traffic. Due to cloudy conditions and snow cover, the batteries were getting drained early and frequent battery charging using generators became necessary. We learned that in the Idaho Springs area, the local weather

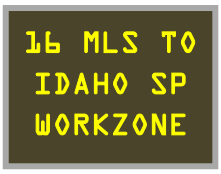
Date	Event	Description
		phenomenon (year round) includes mostly cloudy conditions and mountain shading, resulting in added maintenance of the devices (such as battery charging).
April 15	Message Change	Striping caused major delays; project personnel (Brian Gilbert, Russel Cox) did not like delay messages reflecting badly on their project, which was apparently "not the source of the delays." Messages were changed from delay and travel time to speed information only. Overheads were used for Travel Time and major delay information. Stantec was informed of planned road closures in advance and coordinated overhead messaging. Project people were informed to call Stantec with questions. PDP produced graphs of speeds and printouts of all messages to explain what happened.
April 17	Meeting	PR meeting to discuss re-launch of the websites and publicity campaign. Twintunneltraffic.com website was linked to COTrip.org. Project people attended the meeting and asked for some additional wording changes on some messages, which were approved and made.
Apr 19	System Change	EB message changed from  to  This change was made due to the apparent confusion that "tunnel" might cause to some motorists, who might misconstrue it as referring to the Eisenhower-Johnson Memorial Tunnels. It was felt that "Idaho Springs" would be clearer to the public.
Apr 20	System Change	Stantec blanked message boards for rockfall mitigation, because traffic was stopped outside of the SWZ monitored area. As discussed previously, the rockfall mitigation project was located approximately 9 miles from the detection zone. Therefore, any traffic condition on this rockfall project could not be relayed by the SWZ system. Thus, it was best to blank out the signs each time the rockfall mitigation project impacted the traffic flow at the Twin Tunnels.
Apr 29	System Change (website)	At CDOT PR's request, PDP added verbiage to the Twintunneltraffic.com website to describe the project. It is important to note that over the weekend, a major snow storm hit the project area. There were significant damages to the devices caused by snow plowing operations. Specifically, some of solar panels were shattered by snow plow discharge and brand new cameras experienced rusting possibly due to magnesium chloride deposits.
Apr 30	System Change (website)	Bluetooth data and messaging were added to Twintunneltraffic.com website. It was decided to add two Bluetooth sensors on the project in order to have a more accurate measurement of travel time within the work zone. The speed sensors can also capture travel time. However, it is reported using only average speeds. Measurement of the typical "stoppage" of traffic does not work as well with speed sensors as with Bluetooth sensors. It was reported at one of the meetings that the project staff and the

Date	Event	Description
		public had been using the travel time reports posted on the website.
May 21	System Change (website)	CDOT Project Engineer (Solomon Haile) added an icon to the website to indicate the tunnel location on the map.
Jun 4	Meeting	Meeting at CDOT was held to discuss messaging changes and to begin the process of integrating COTrip sensor data into the SWZ System. The immediate "phase 1" changes were complete (restricting posted speeds on the website to the respective posted speed limits on the work zone). Maximum (reported) speeds EB through the WZ were restricted to 35MPH (the speed limit) or below. Maximum (reported) Speeds WB through the WZ were restricted to 45MPH (the speed limit) or below. "Phase 2" (posting en route speeds) to be implemented once CTMC sensor data able to be imported with "en route speeds" per the CDOT Program Engineer (Clark Roberts).
Jun 5	System Change	Reset suggested and approved for sensor S2-WB to move it closer to the tunnel.
Jun 9	System Check	Summary of conditions: EB and WB calculations are separate. The computer checks for the conditions in order (1 through 4). If a condition is met, then the logic stops at that step and the appropriate message is displayed.
		Condition 1 (most restrictive): Happens when: Traffic is stopped--which we have defined as the 3 minute average speed less than 20MPH at the sensor closest to the tunnel. Message (alternating panels):  **Condition 2:** Happens when: the sensor closest to the tunnel measures greater than 20 MPH and the 3-minute average speed of any other sensor is less than 20 MPH. Message (alternating panels):  **Condition 3:** Happens when: Traffic is moving better than 20MPH everywhere, but there is a delay more than 4 minutes above average transit speed for that direction. We have eliminated "no delay" messages, but we still have this delay message programmed. For example, if the travel time from top of

Date	Event	Description
		Floyd Hill to the mouth of the Twin Tunnels exceeds the free flow travel time of 5 minutes by the delay threshold which is 4 minutes, then the "delay" will be displayed. The minimum delay that will be displayed shall be 5 minutes. In this case, the total travel time from the top of Floyd Hill to the mouth of the Twin Tunnels is 5 minutes plus 5 minutes or 10 minutes. Message (alternating panels):  **Condition 4:** Happens when: None of the other conditions above are true. We now display the lowest 3 minute average sensor speed, limited to the applicable posted work zone speed limit. This will change once we have CDOT data--and we will then display lowest average sensor speed including all sensors en route--and the message will change to indicate "en route" instead of "workzone." Message (alternating panels): 
Jun 11	Meeting/ change	CDOT meeting, changes: 1. All delay messages will be dropped and only speeds reported. 2. Clark Roberts promised Jim Bemelen (CDOT Twin Tunnels Program Engineer) that PDP would be able to implement en route speeds with CTMS data integration 3. Bob Wilson (CDOT PR) wants to make a statewide press release as soon as we are ready with the new system integration and messaging.
Jun 27	System Change	Bernie Guevara (Stantec) made a change per consultation with Clark Roberts and later phone conversation with Frank Zucco (PDP) to lower the algorithm threshold down to 10 MPH (from 20 MPH). In addition, also agreed to modify the message to say "Stop & Go" (from "Stopped"). SWZ system adjusted as follows for Condition 1: **Condition 1 (most restrictive):** Happens when: Traffic is stopped – which we have defined as 3-minute average speed less than 10 MPH at the sensor closest to the tunnel. 

Date	Event	Description
Jul 1	Meeting	CDOT meeting, action items: ❖ Will, Frank, ASAP -- Email CDOT: Solomon (copy Clark)--as soon as en route messaging is done so they can contact Mindy and do a press release process. ❖ Will, ASAP -- PMSP: Change "9 MI TO" to "9 MLS TO" or whatever fits. Public is reading MI sometimes as minutes and getting confused. ❖ Will/Frank, ASAP -- Solomon needs to know how many website hits (unique visits) there have been to the twintunneltraffic.com website. Messaging change was made the same day.
Jul 3	System Change	Summary of current conditions: EB and WB calculations are separate. The computer checks for the conditions in order (1 through 4). If a condition is met, then the logic stops at that step and the appropriate message is displayed. Changes underway to the system are shown in **blue**. **Condition 1 (most restrictive):** Happens when: Traffic is stopped--which we have defined as a 3-minute average speed of less than 10 MPH at the sensor closest to the tunnel. Message:  **Condition 2:** Happens when: Speed closest to the tunnel is greater than 10 MPH and the 3 minute speed measurement of any other sensor is less than 10 MPH. Message:  **Condition 3:** **(Note: this entire condition will be eliminated, and en route messaging activated ASAP – then we will only be reporting stop & go, or speeds)** Happens when: Traffic is moving better than 10 MPH everywhere, but there is a delay of more than 4 minutes above average transit speed for that direction. Message (alternating panels): 

Date	Event	Description
		Condition 4: Happens when: None of the other conditions above are true. In this case, (where we used to display "no delay") we now display the lowest 3 minute average sensor speed, limited to the applicable speed limit. **This will change once we have CDOT data – and we will then display lowest average sensor speed including all sensors en route – and the message will change to indicate "en route" instead of "workzone." Estimated that the programming required to do this may be done as soon as mid-July.** Message (alternating panels): 
Jul 20	System Change	En route speeds change – COTrip data integrated: We have integrated the CDOT speed data from the TMC xml feed into the Twin Tunnels Smart Work Zone System. We also changed the messaging on all message boards (except 3 WB) to reflect the following: During non-stop and go times, the message will now read:  The old message read: 
Sep 11	Meeting	In CDOT meeting about messaging, Ryan Rice recommended changes to the portable VMS or PMSPs: ❖ Change all signs to say "Idaho SP Work Zone" instead of half saying "T Tunnels work zone":  changed to  ❖ Change "speed en route..." to say "current traffic stop & go" as some did when conditions were such in the work zone. En route average

Date	Event	Description
		speed of 20 MPH and below was used as the "Stop & Go" threshold.  changed to  ❖ When conditions are flowing normally in the work zone the signs should say "current traffic normal." ❖ En route average speed of over 20 MPH was used as the "Normal Traffic" threshold. ❖ If that is promising too much to travelers, then recommend dropping the second panel when conditions are normal in the work zone. Apparently, "en route" means nothing to the public; it would be better to have nothing than that.  Any other messaging that needs to be done about the work zone conditions should be done on permanent VMS by the CTMC.
Sep 13	Message Change	All messages blanked for a while due to rock slides from big storm. This was the record rainstorm (500 year flood) that wiped out many roadways especially in northern Colorado (Boulder, Greeley, Fort Collins). The storm caused significant rock fall that required the closure of the existing westbound lanes. The SWZ cameras became very useful as they provided the means to remotely view the road damage and reroute westbound traffic to the construction lane.
Sep 16	Meeting/ change	Stantec and PDP meeting about message changes. Proposed messages: Agreed changes: **Condition 1:** Less than or equal to 20 MPH 3-minute average at closest sensor to tunnel (EB and WB) Stop and Go Message:   **Condition 2:** Greater than 20 MPH, less than or equal to 40 MPH average speed from PMSP to Tunnel (3-minute averages of all sensors including COTrip).

Date	Event	Description
		Slow Speed Message:  **Condition 3:** Greater than 40 MPH average speed of all sensors from PMSP to tunnel. Normal Conditions Message: 
Sep 17	Message Change	Changes from previous day complete.
Sep 23	System Change	Changes suggested by Ken Wissel approved by Solomon Haile, changes made on Sept 24. Because of a varied speed limit between EB and WB directions, conditions adjusted accordingly. EB speed limit is 35 mph and WB speed limit is 45 mph through work zone. The condition set during prior week should **only apply for westbound traffic**. Following parameters changed and implemented: **Eastbound Condition 1:** Remains the same speeds, less than or equal to 20 MPH 3-minute average at closest sensor to tunnel. Message shall be:  **Condition 2 (new)** Speed greater than 20 MPH, less than 30 MPH, average speed from PMSP to tunnel (3-minute averages of all sensors including COTrip). Message shall be: 

Date	Event	Description
		Condition 3 (new) Speed greater than 30 MPH, average speed of all sensors from PMSP to tunnel. Message shall be: 
Oct 31, 2013	Change	Twin Tunnels SWZ deactivated; project completed as per contract.

Lessons Learned

Because this was an innovative traffic strategy, one of the primary goals we set for the I-70 Twin Tunnels Smart Work Zone project was the opportunity to gain a good understanding of the system devices, their individual capabilities and the overall knowledge of this tool in mitigating for traffic congestion and safety. This plan is in line with the states of Iowa, Kansas, Missouri, and Nebraska, which created the Midwest States Smart Work Zone Deployment Initiative (MwSWZDI). Through this pooled-fund study, researchers investigate better ways of controlling traffic through work zones. Their goal is to improve the safety and efficiency of traffic operations and highway work.

The knowledge they acquired from this innovative study improved their work zone processes and activities, creating a safer work environment that is more efficient and of higher quality. The lessons we learn from this are valuable knowledge gained by experience.

The Smart Work Zone project team learned many significant strategies that will be important as we plan the next Smart Work Zone projects for Colorado. Among others, they are as follows:

- "Tunnel" on I-70 could possibly refer to two different tunnels: either the Eisenhower-Johnson Memorial Tunnels or the Twin Tunnels. For this project, "Idaho Springs" was used in lieu of "T. Tunnel."
- Standard maximum number of character display per line on a typical PMSP is limited to eight (8) characters. This is important when figuring out the proper PMSP messages.
- Traffic psychology – Motorists do not necessarily process the message as shown on the PMSP. For example, a PMSP showing speeds at the work zone (7.60 miles) may still be understood to mean the speed from the time they read the message up to the work zone.
- "Delay" messages could have a negative public relations effect; project staff are sensitive to messages that could affect the public perception of their projects.
- Speed displays should not be the actual speeds exceeding speed limits. Speed sensors will always capture actual speeds within the detection zone. We should be careful to follow CDOT's policy of not displaying speeds above the posted limits.
- We need to be cognizant of any activities that may affect the traffic conditions within the detected zone (work zone). For example, the rockfall project was slowing traffic but those impacts were not within the detected zones, creating confusion as mentioned previously. Be prepared to blank out signs in case of activities that could occur outside the detection zone. It is best not to display messages pertaining to the work zone if there are other activities outside the detection zone that could affect the effectiveness of the traffic messages.

- Continuously monitor the effectiveness of the messages by holding regular project staff meetings. As in the case of this pilot project, the evolution of traffic messaging was significant in order to align its use to the changing conditions of the construction project.
- Communication between the field personnel and systems technicians is very important. The field personnel are tasked with inspection of the devices and timely relay of adjustments and/or repairs as needed.
- Place the PMSPs at locations safe from errant vehicles. We had a PMSP that was hit and destroyed by a semi-truck trailer that overturned at one of the PMSP sites.

CDOT HQ Recommendations

Based on study of the results of the 7-month I-70 Smart Work Zone project, CDOT Headquarters ultimately recommended that CDOT continue to deploy Smart Work Zones in future construction projects, with the following suggestions:

- Empower the Region Traffic Unit/Operations Engineer to evaluate which locations are best suited for Smart WZ deployment based upon:
  - Project duration
  - Space for devices
  - Lane configuration
  - Available decision points (for dynamic routing)
- Involve the CDOT Office of Public Information as early as possible to help explain the project to the general public
- Where possible, integrate the Smart Work Zone with permanent ITS devices
- Incorporate back of queue notification (especially where dynamic routing is unavailable)
- Don't message travel time or delay on a corridor that already has it
- Select two to three Smart Work Zone vendors via non-project specific contract (or other contracting method) with a price agreement vs. a design-build RFP

HQ also made recommendations on **specifications** for future Smart Work Zone projects:

- Revise the specs to require that Bluetooth technology be used for the data collection
- Use the following lump sum items to eliminate daily documentation requirements associated with items paid for by the day:
  - Smart WZ (sensors, cameras and software)
  - Reset Smart WZ Devices (VMS boards, cameras, and sensors)
- Pay for VMSs as EACH vs DAY to realize a cost savings
- Add two 3rd-party weekend/holiday/event managers (one at project site and one at CTMC)

HQ noted the following **residual benefits:**

- Smart Work Zones allowed Idaho Springs residents to use the cameras to determine the best trip times into Denver.
- Construction personnel used cameras to spot queues and delays real-time.

Appendix: Supporting Information

Project Plans and Specifications, Supporting Studies

The project plans and specifications can be viewed at the following FTP site until November 21, 2014:

FTP site link: ftp://CDOTSMZ1402-r:1625716@projftp.stantec.com
Login name: CDOTSMZ1402-r
Password: 1625716

There is also a folder on that FTP site that contains supporting studies that discuss Smart Work Zones.

Device Tracking Data

Sensors were placed at 19 locations along the eastbound and westbound corridor during the Smart Work Zones project to quantify three traffic measures in the affected area of the corridor: **speed, volume,** and **occupancy.**

To view the raw data collected by the sensors along the corridor, please see the spreadsheets stored at the following FTP site until November 21, 2014:

FTP site link: ftp://CDOTSMZ1402-r:1625716@projftp.stantec.com
Login name: CDOTSMZ1402-r
Password: 1625716

The charts on the following pages give a snapshot of the data collected by these sensors for the Smart Work Zones project. The sensors collected data for each minute of the days they were operational. For this snapshot, the charts show the data for the minute at the top of each hour between 10 am and 10 pm on selected days.

Speed as measured by the sensors is the average speed in miles per hour (MPH) for all cars in both lanes for that minute.

Volume is the total number of cars passing that sensor in one minute.

Occupancy shows what percentage of time the lane has a vehicle in it during that minute. Along with speed and volume, occupancy gives a picture of how full the road is.

Figure 1: Sample Data – Westbound Saturday, May 18, 2013 – 10 am to 10 pm (Sensor S4 WB)

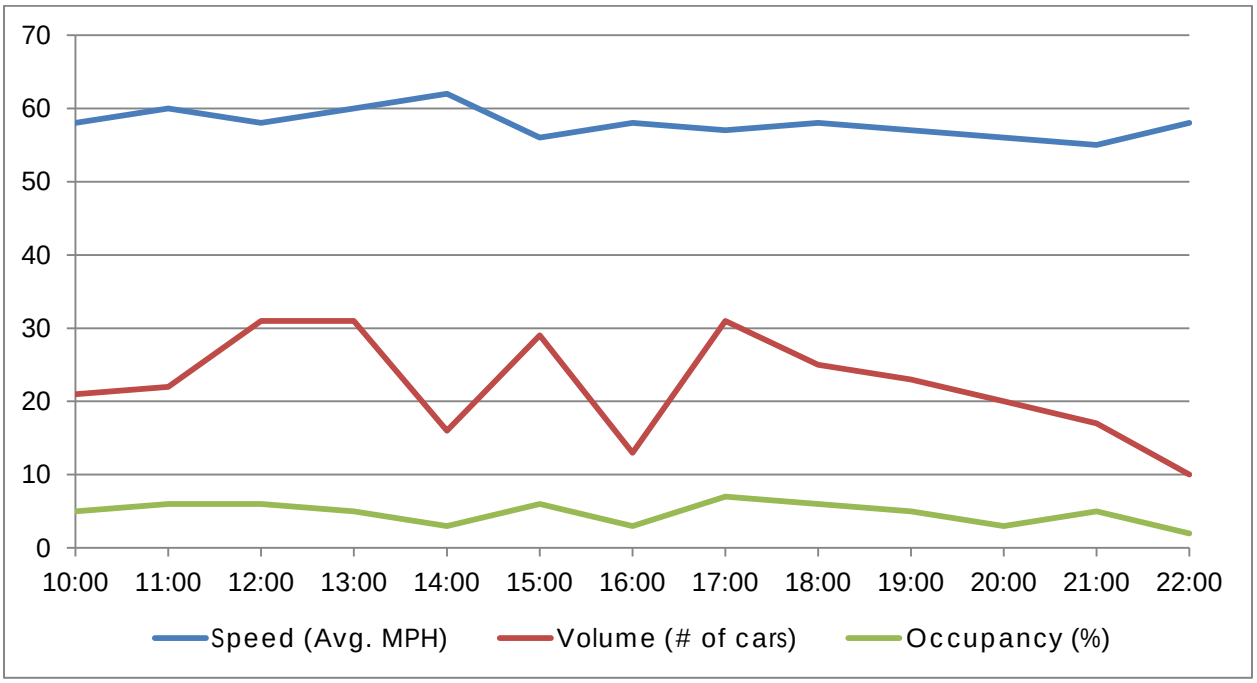


Figure 2: Sample Data – Westbound Saturday, June 22, 2013 – 10 am to 10 pm (Sensor S4 WB)

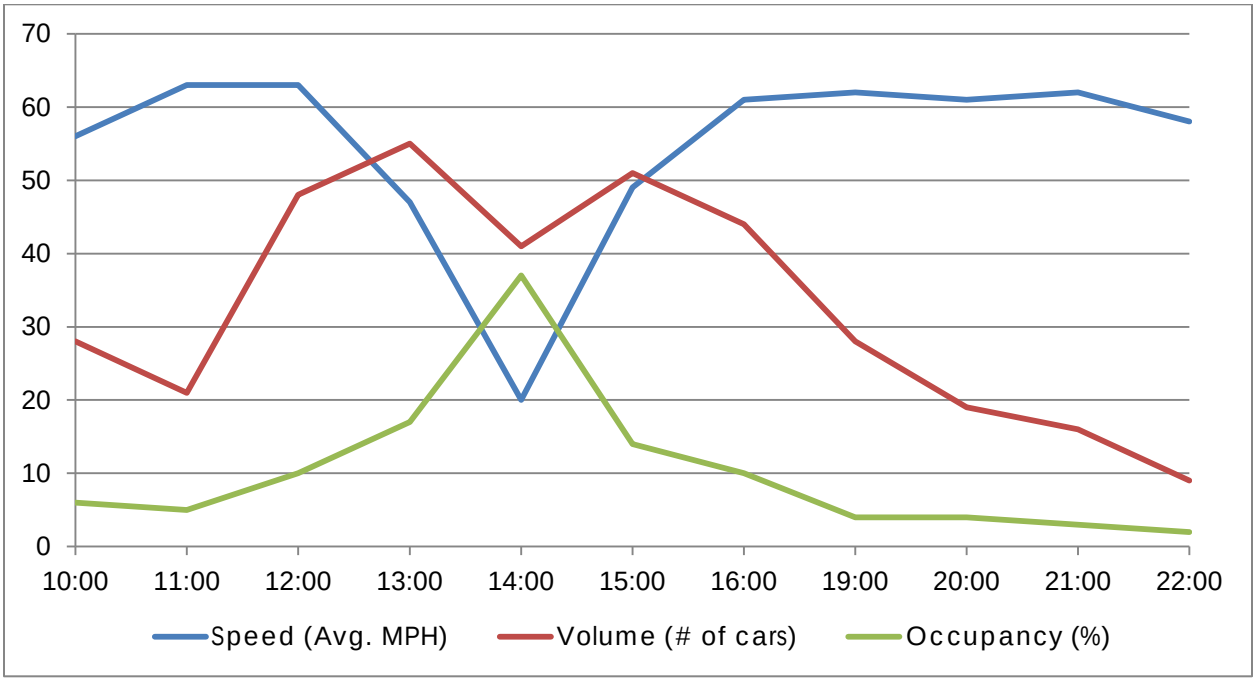


Figure 3: Sample Data - Westbound Saturday, July 13, 2013 - 10 am to 10 pm (Sensor S4 WB)

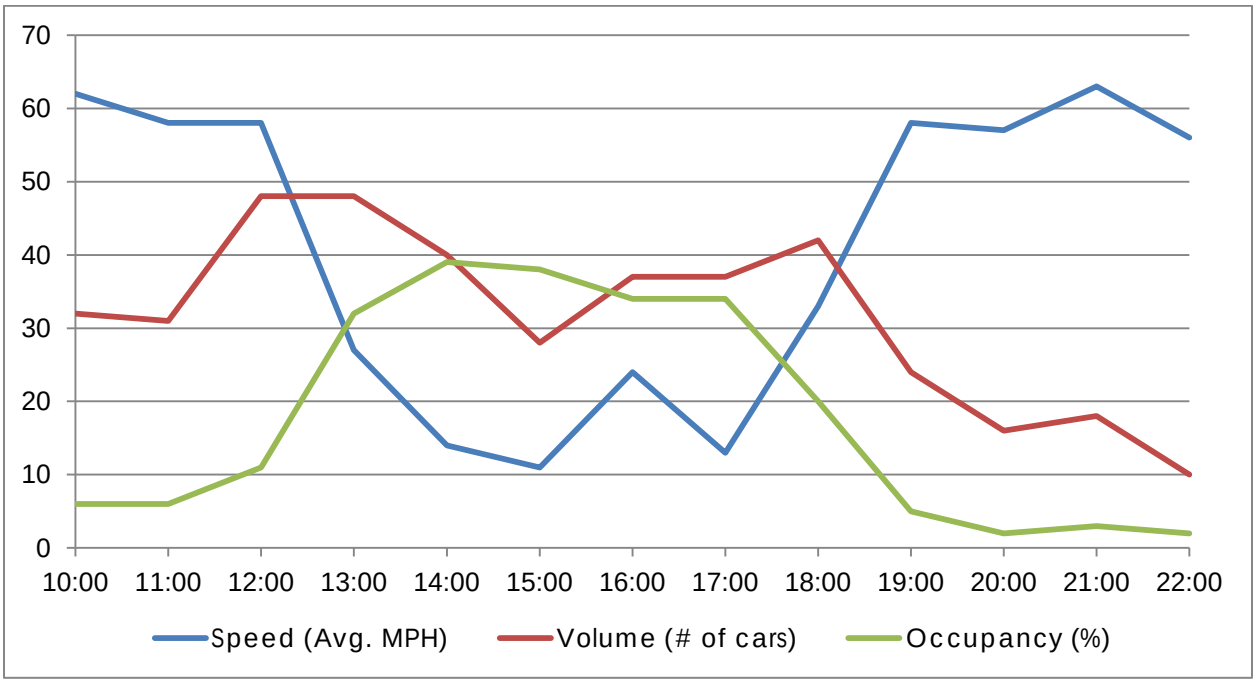


Figure 4: Sample Data – Eastbound Sunday, May 19, 2013 - 10 am to 10 pm (Sensor S2 EB)

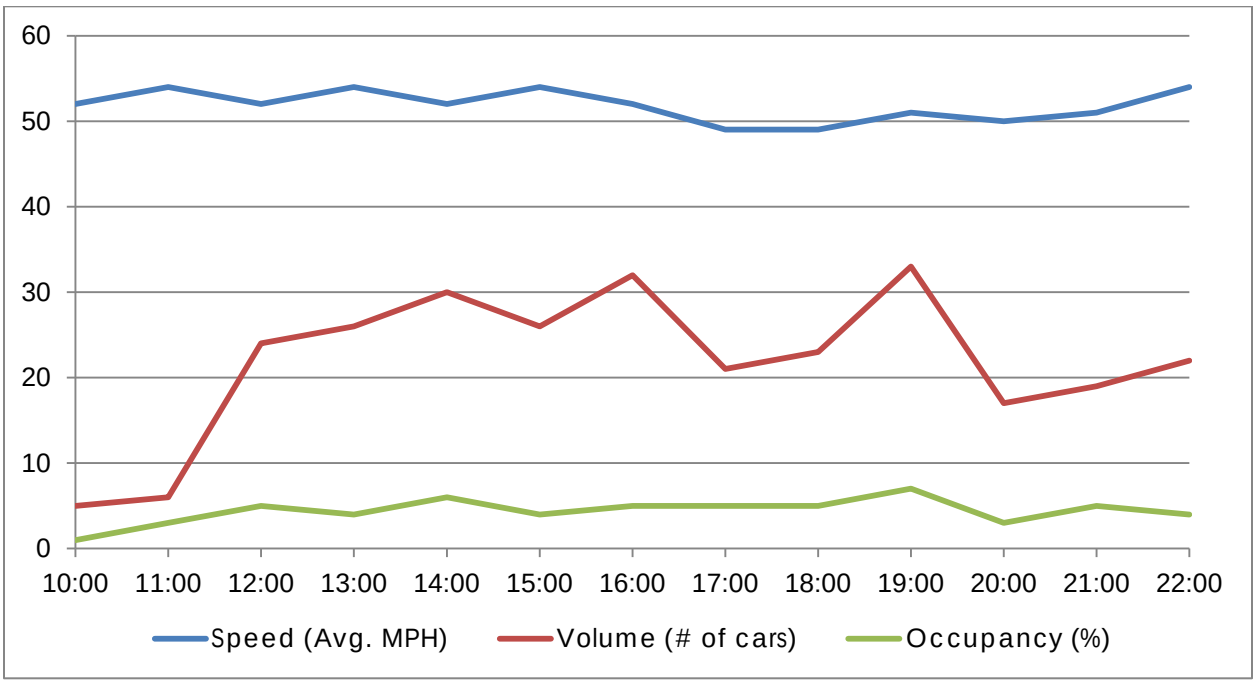


Figure 5: Sample Data – Eastbound Sunday, June 30, 2013 - 10 am to 10 pm (Sensor S2 EB)

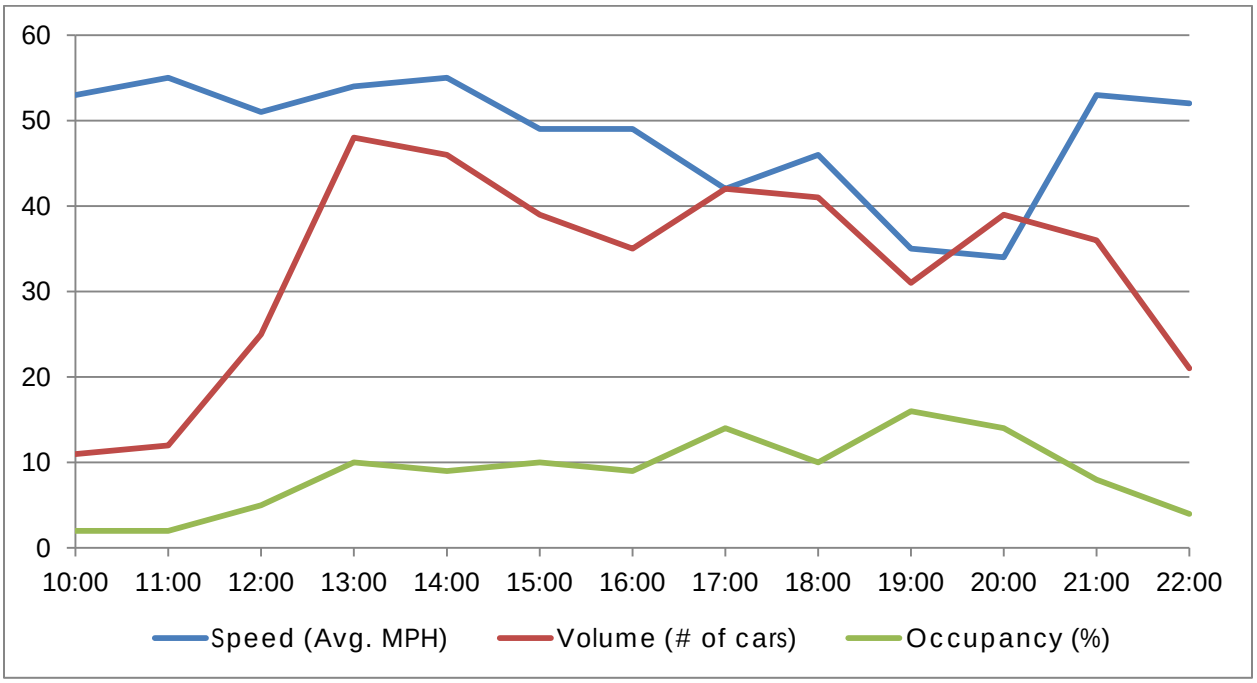
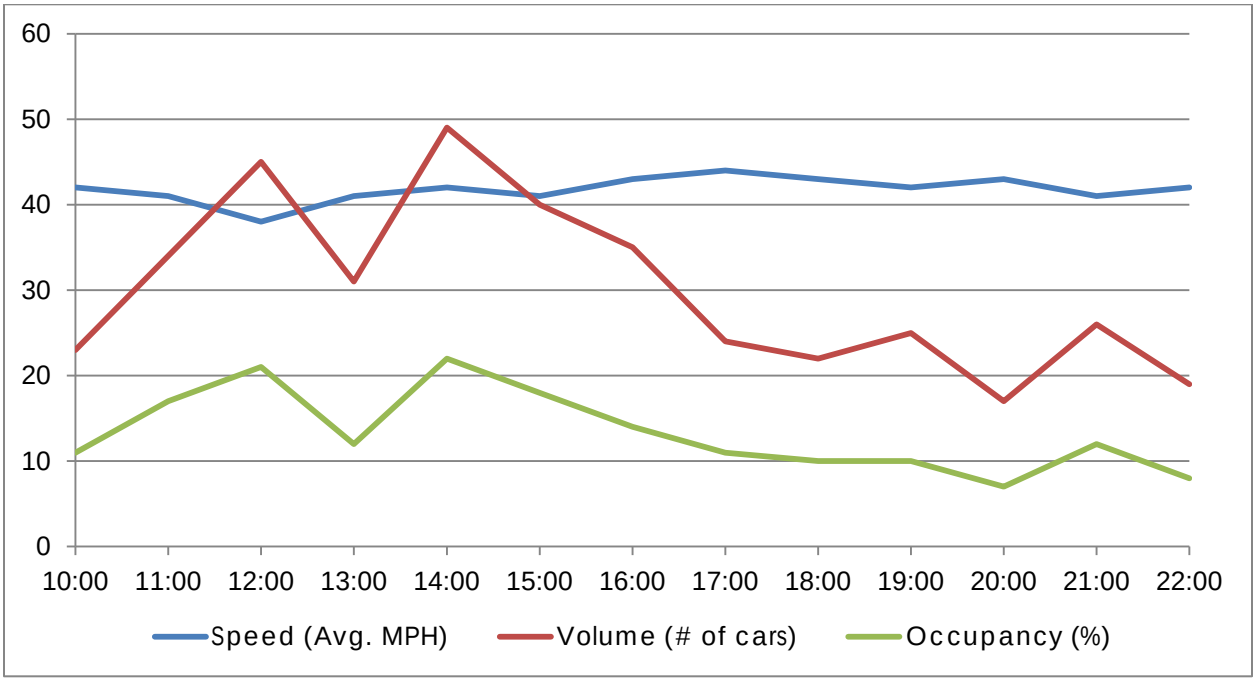


Figure 6: Sample Data – Eastbound Sunday, July 21, 2013 - 10 am to 10 pm (Sensor S2 EB)



Web Data: Google Analytics for the Colorado SWZ

The following graphic shows the analytics that were collected from the public SWZ website, showing significant public interaction with the website.

Google Analytics

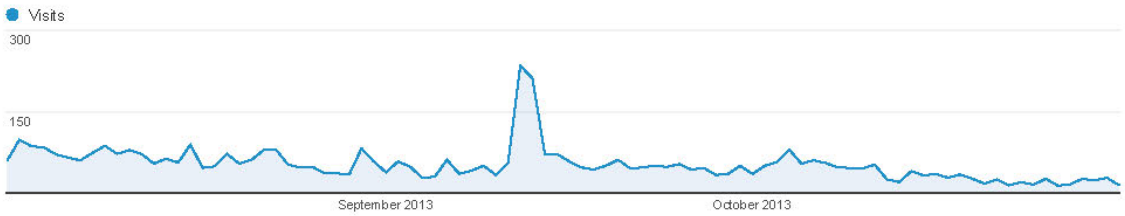
Go to this report

Colorado I-70 Twin Tunnels - http://108.253.96.164/public/mai...
All Web Site Data

Audience Overview Aug 1, 2013 - Oct 31, 2013

All Visits
100.00%

Overview



4,039 people visited this site

Visits	Unique Visitors	Pageviews
4,837	4,039	5,390

Pages / Visit	Avg. Visit Duration	Bounce Rate
1.11	00:00:35	91.94%

% New Visits
83.13%

	City	Visits	% Visits
1.	Denver	1,198	24.77%
2.	Breckenridge	153	3.16%
3.	Colorado Springs	145	3.00%
4.	Boulder	115	2.38%
5.	Evergreen	110	2.27%
6.	Chicago	106	2.19%
7.	Lakewood	93	1.92%
8.	West Jordan	89	1.84%
9.	Grand Junction	88	1.82%
10.	(not set)	87	1.80%