2013

Traffic Signal Coordination and Synchronization Project

Alessandro Boulevard/Central Avenue – Magnolia Avenue to Frederick Street

Prepared for the Mobile Source Air Pollution Review Committee (MSRC) under the AB 2766 Discretionary Fund Work Program.

City of Riverside – Department of Public Works
3900 Main Street, Riverside CA 92522
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Acknowledgements

The Alessandro Boulevard/Central Avenue Traffic Signal Coordination and Synchronization Project, "Project", was a collective collaboration and partnership between the following agencies and respective project team members:

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Project Sponsorship

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Disclaimer

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Purpose

Southern California continues to rank first in travel time, excess gasoline use and not surprisingly, commuter stress according to a 2011 Texas A&M University report that provided a snapshot of mobility problems in 439 large and medium-sized urban areas across the nation. In addition, the Inland Empire located within the Southern California Region has recently experienced massive migration of families in search of affordable housing, increased truck and train traffic from local ports, and continued development which has landed the Inland Empire in the nation's top five of most traffic-choked urban areas. Recent figures show that motorists in the Inland Empire who travel during the peak rush hours

have experienced a 500% increase in time spent trapped in traffic: from nine hours in 1982 to 57 hours per year on average in 2002, according to a 2008 study conducted by the Texas Transportation Institute.

Traffic congestion in the Inland Empire is at the forefront of residents' concerns, it is an indicator of quality of life and an issue that municipalities constantly study to identify factors, circulation patterns, and/or traffic operations to improve progression and minimize delay. One of the tools deployed by municipalities and consultants to mitigate congestion is signal timing. In short, signal timing is a cost effective tool to generate quantifiable traveler benefits as measured by decreased vehicle delay, increased safety, lower emissions and reduced fuel consumption. Signal timing is a process that optimizes the operations of signalized intersections through a variety of low-cost improvements, including development and implementation of new signal timing plans, optimizing phasing sequences, improved control strategies and occasionally implementation of minor roadway improvements. Qualitative benefits, such as decreased cut-through traffic on alternate routes, reduced traveler frustration, and reduced conflicts between motorists, pedestrians, and bicyclists can also be achieved.

A focused signal retiming program can provide municipalities with additional opportunities to examine intersection operations and corridor progression. This Project was a catalyst for the City of Riverside to partner with the City of Moreno Valley to study the Alessandro Boulevard/Central Avenue corridor between Magnolia Avenue (City of Riverside) and Frederick Street (City of Moreno Valley), a major thoroughfare that traverses local jurisdictional boundaries carrying close to 45,000 motorists per day as indicated in a 2012 average daily traffic (ADT) count. The goal of the Project is to optimize traffic flows on Alessandro Boulevard/Central Avenue within the project limits, thereby improving driving time, minimizing commuter stress, and reducing delay and emissions. The new signal timing plans will allow for response to peak traffic volumes, special planned events, unexpected incidents such as detours due to accidents, and major "spikes" in traffic volume.

Background

The City of Riverside partnered with the City of Moreno Valley and Riverside County Transportation Commission for the synchronization of 35 traffic signals along a 9.3-mile segment of Alessandro Boulevard/Central Avenue (street name changes at intersection with Fairview Avenue) beginning with the intersection of Alessandro Boulevard at Frederick Street in Moreno Valley, and proceeding westerly to the intersection of Central Avenue at Magnolia Avenue in the City of Riverside as shown on Figure 1. Alessandro Boulevard Location Map. The project also includes the installation of real-time roadway monitoring equipment, development of coordination timing plans, installation of count stations and establishment of communication links between Riverside, Moreno Valley's, and Caltrans Traffic Management Centers (TMC).

The real-time roadway monitoring equipment broadcasts close-circuit video feeds that are transmitted to the City of Riverside's TMC but can be accessed by the Caltrans and City of Moreno Valley. The video transmissions allow jurisdictions and municipalities to:

- Monitor traffic conditions and adjust signal timing

- Detect incidents and adjust signal timing on the impacted corridor or parallel corridor (s) to handle the diverted traffic.
- Monitor traffic conditions resulting from special events
- Video record nighttime, weekend, school hours or special times of the day to study particular traffic concerns
- Conduct traffic studies such as turning movement counts, pedestrian and bicycle counts, pedestrian walking times and more

The new coordination timing plans accommodate current traffic volumes, traffic patterns and account for recent and ongoing roadway improvements on Alessandro Boulevard/Central Avenue which is undergoing construction, primarily in the Central Avenue are due to construction of the 91 FWY widening. In addition, the Project installed traffic counts at three locations along Alessandro Boulevard & Central Avenue to continuously sample traffic volumes to help adjust the signal timing when significant increase in traffic volumes are noted. Furthermore, the Project deployed wireless communication equipment throughout the Alessandro Boulevard/Central Avenue corridor to establish wireless signal interconnect systems and provide communications to the City of Riverside's TMC. The integration of real time monitoring equipment, count stations, and wireless communications allows for real-time monitoring of the corridors and deployment of signal timing adjustments to account for planned and unplanned incidents to ensure motorists are minimally impacted.

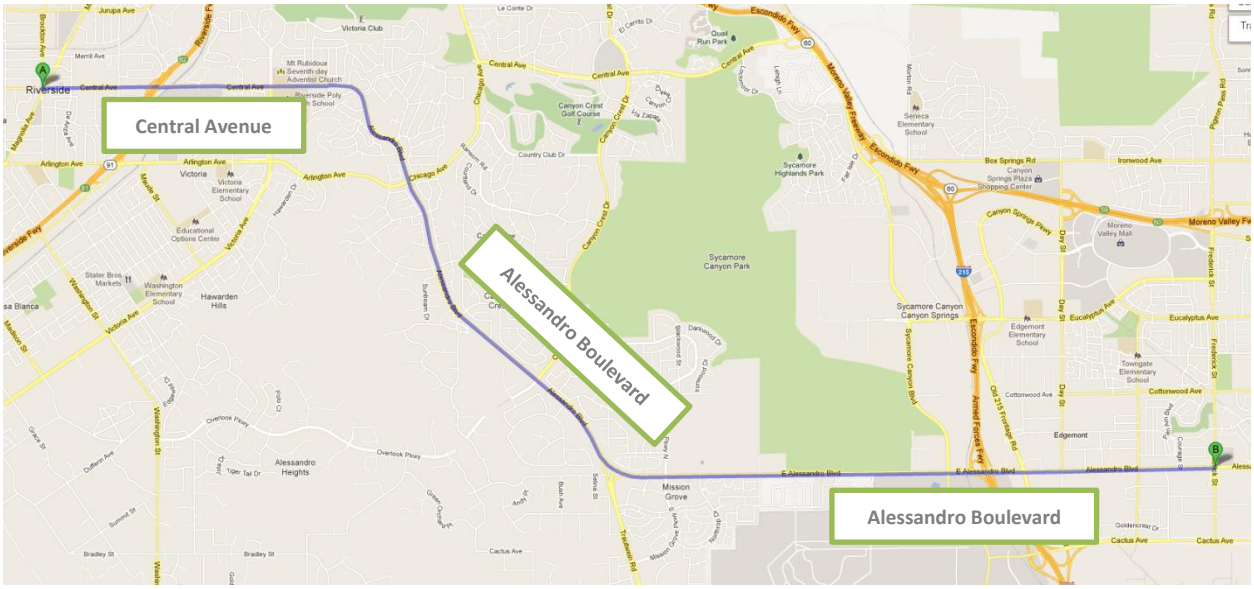

Figure 1. Alessandro Boulevard Location Map

Scope

The scope of work for Alessandro Boulevard/Central Avenue focused on optimizing traffic progression during the morning, afternoon and evening peak hours through the use of roadway monitoring equipment and traffic signal optimization. The methods to accomplishing these goals were as follows:

- Data Collection – Inventoried existing traffic equipment at the City of Riverside Traffic Management Center and at signalized intersections along the Alessandro/Central corridor.
- Asset Requirement Identification – After the existing infrastructure and data were determined, the additional required infrastructure was identified.
- Signal timing Optimization – Peak Hour (AM, midday, PM) traffic counts were obtained to generate optimized signal timing plans into the modeling software.
- Traffic Monitoring Equipment Installation and Integration – The previously identified required infrastructure was purchased, installed, and integrated in the City of Riverside's traffic management network.
- Signal Timing Implementation and Analysis – The newly created timing plans were implemented and fine-tuned on the roadway and analyzed for their effectiveness and improvements.

Work Performed

Data Collection

The project entailed collection the following data:

- Turning Movement Counts - morning (7:00 am – 9:00 am), midday (11:00 am – 1:00 pm), and evening (4:00 pm – 6:00 pm) turning movement counts were collected at key or large intersections to help determine the signal timing cycle length, intersection splits, offsets, force-offs, and phase sequencing.
- Asset Inventory - Signal controller type, cabinet type, video monitoring and vehicle count capabilities were noted at each traffic signal location. Existing communication infrastructure at the City of Riverside TMC and at each project intersection were also recorded

Asset Requirement Identification

Traffic signal controllers, software, as well as necessary signal interconnect devices to interface with fiber, copper, and/or wireless transmissions mechanisms were identified. Required hardware such as wireless communication radios and software were necessary to establish a robust signal management network. At the completion of the project, along the Alessandro/Central corridor received two closed-caption television (CCTV) cameras, three traffic count/speed detection systems, nineteen signal controllers and interconnect communication systems for ten signalized intersections.

Roadway Monitoring Equipment

Roadway monitoring equipment is a critical component in a traffic management network. It allows for real-time observation of critical intersections, roadway segments, vehicular traffic and disruptive incidents that may impact traffic progression and cause unnecessary traffic delays. When incidents are identified, TMC staff can implement signal timing changes to relieve congestion and keep traffic moving. CCTV cameras were present at the intersections of Alessandro at Sycamore Canyon, Alessandro at Mission Grove, Alessandro at Arlington/Chicago, Central at Victoria and Central at Magnolia. Two additional intersections were identified as candidates for a CCTV camera:

- Alessandro & Canyon Crest
- Alessandro & Trautwein

Traffic Count/Speed Detection Systems

Traffic count and speed detection systems are useful in detecting changes in traffic patterns. Once a baseline volume and/or speed is established, variations from that baseline can be an indicator of an incident in that area and timing changes can be made to improve flow. The City did not have any volume or speed detections systems installed prior to this project. The following locations were identified as candidates for a traffic count/speed detection system:

- Alessandro & San Gorgonio
- Alessandro & Commercial Center
- Central & Falkirk

Traffic Signal Controllers

Every signalized intersection requires a traffic signal controller to control and monitor the traffic signal operations. The controller can operate in a demand-based operation called Free Operation where every controller is independent of adjacent signalized intersections, or a semi-pretimed operation called Coordinated Operation where adjacent signalized intersections along a corridor operate together to allow for vehicle progression. When a corridor has controllers that are operated in coordination, it has been shown that travel time, delay and number of stops can be reduced and average speed increased.

A total of 35 traffic signal controllers operate on the Alessandro/Central corridor. The existing controller is McCain Inc.'s 170 controller and can run the 200 and 750ATC software, with the 750ATC model being newer and more advanced. Nineteen intersections were identified on the corridor as having the older 200 version software and required an upgrade to the 750ATC software. Those intersections include:

- Alessandro & Old 215
- Alessandro & ARCO Gas Station
- Alessandro & San Gorgonio
- Alessandro & Commercial Center
- Alessandro & Barton
- Alessandro & Northrop
- Alessandro & Mission Village (LA Fitness Center)
- Alessandro & Mission Grove
- Alessandro & Mission Plaza (Ralphs Center)
- Alessandro & Trautwein
- Alessandro & Communication Center
- Alessandro & Cannon
- Alessandro & Overlook
- Alessandro & Via Vista
- Alessandro & Century
- Alessandro & Glenhaven
- Central & Riverside
- Central & San Diego
- Central & De Anza

Intersection Communications

The City of Riverside utilizes several methods of intersection network communications to allow for real-time manipulation of field devices such as controllers and CCTV cameras. A few of these methods

include copper interconnect pairs, fiber optic cables and wireless radios. Having the ability to use multiple methods to achieve communications allows for "best fit" solutions for each intersection.

Where copper interconnect or fiber optic cable is not already installed, wireless radios are a low-cost solution that can be used to establish communications at intersections. The City of Riverside determined that a wireless radio network would be the optimal choice for incorporating field devices into the traffic management network. The following intersections (in no particular order) were identified as requiring wireless network communications:

- Alessandro & Sycamore Canyon
- Alessandro & Chicago/Arlington
- Alessandro & Trautwein
- Alessandro & ARCO Gas Station
- Alessandro & San Gorgonio
- Alessandro & Via Vista
- Alessandro & Cannon
- Alessandro & Commercial Center
- Alessandro & Old 215
- Alessandro & Canyon Crest

Corridor Coordination Design

Previous studies have shown that traffic signal synchronization is an effective and economical way to reduce delay to the major movement along a corridor. Optimized phase sequencing, intersection offsets, network cycle lengths, pedestrian walking times and maximum and minimum green times were defined as parameters that needed to be accounted for or incorporated into coordination plans in order to minimize delay and optimize progression along a corridor.

The development of new timing plans began with an evaluation of the existing traffic conditions within the project limits. The existing Alessandro Boulevard/Central Avenue *Synchro* models were updated with current traffic volumes, timing parameters and lane configurations. The cycle lengths for the signalized intersections were optimized to 135 seconds and adjustments to the splits and offsets were made accordingly. The signal timing plans were analyzed using *Synchro's Simtraffic* tool which models traffic flow and allows the user to determine if corridors have backup or congestion in particular directions or at a specific intersection. The traffic model allowed the user to make timing adjustments to improve efficiency at those key intersections or directions while maintaining acceptable progression. Once the City was confident that the *Synchro* timing provided the desired progression, the signal timing plans were implemented.

Device Installation and Integration

Roadway Monitoring Equipment

Roadway monitoring equipment is necessary to provide real-time adjustments to signal timing when incidents occur. Additionally, they save time and energy costs by allowing engineers to make signal timing adjustments from the office rather than having to travel to the location to observe the signal and corridor operations. Five cameras were installed prior to the project at the intersections of Alessandro at Sycamore Canyon, Alessandro at Mission Grove, Alessandro at Arlington/Chicago, Central at Victoria and Central at Magnolia. Two additional cameras were installed at:

- Alessandro & Canyon Crest

- Alessandro & Trautwein

The CCTV cameras are displayed in the City of Riverside TMC and a full-time staff member is assigned to the TMC and constantly scans the video transmissions to identify incidents or changing traffic patterns which may require immediate timing changes. In addition, staff also monitors any SR-91 and I-215 incidents within the City of Riverside and surrounding areas to identify accidents or events that may require motorists to use City streets to bypass freeway congestion.

In addition to the real-time monitoring of road conditions, the CCTV's allow staff to record video feeds during nights, weekends or non-peak hours to facilitate traffic studies. These studies can be reviewed by staff during work hours and allows the City to be responsive to residents' concerns and implement roadway improvements or signal timing changes based on those studies.

Traffic Count/Speed Detection Systems

Two types of traffic count/speed detection were installed. The first method utilizes radar to detect each vehicle and determine its speed and size. The second method uses features in the traffic signal controller and induction loops to count vehicles and estimate speed. Both methods are able to provide reports for user-defined time periods. Three traffic count/speed detection systems were installed along Alessandro/Central:

- Alessandro & San Gorgonio – Wavetronix SmartSensor HD (Radar)
- Alessandro & Commercial Center – McCain 170 Controller with 750 ATC software (inductive loops)
- Central & Falkirk - McCain 170 Controller with 750 ATC software (inductive loops)

Traffic Signal Controllers

Most of the traffic signal controllers along the Alessandro/Central corridor had been previously upgraded to the newer McCain 750ATC controller software. Nineteen additional McCain 750ATC controllers were installed along Alessandro/Central:

- Alessandro & Old 215
- Alessandro & ARCO Gas Station
- Alessandro & San Gorgonio
- Alessandro & Commercial Center
- Alessandro & Barton
- Alessandro & Northrop
- Alessandro & Mission Village (LA Fitness Center)
- Alessandro & Mission Grove
- Alessandro & Mission Plaza (Ralphs Center)
- Alessandro & Trautwein
- Alessandro & Communication Center
- Alessandro & Cannon
- Alessandro & Overlook
- Alessandro & Via Vista
- Alessandro & Century
- Alessandro & Glenhaven
- Central & Riverside
- Central & San Diego
- Central & De Anza

Intersection Communications

A wireless radio network was installed in the City as a low-cost solution to establish communications at intersections that did not already have copper interconnect or fiber optic cable installed. The wireless radio network for the Alessandro/Central corridor consists of radio transmitters on nearby Box Springs and Tilden Peaks sending a wireless signal to the City's TMC. "Access point" radios (AP) at each peak receive the signal from "subscriber module" radios (SM) installed at individual intersections using the point-to-multipoint methodology. Where AP's could not be reached due to distance or obstructions, point-to-point radios were used to establish communications. The following intersections were identified as requiring wireless network communications:

- Alessandro & Sycamore Canyon – SM Radio
- Alessandro & Chicago/Arlington – SM Radio
- Alessandro & Trautwein – SM Radio
- Alessandro & ARCO Gas Station – SM Radio
- Alessandro & San Gorgonio – SM Radio
- Alessandro & Via Vista - SM Radio
- Alessandro & Cannon - SM and PTP Radios
- Alessandro & Commercial Center - SM Radio
- Alessandro & Old 215 – SM Radio
- Alessandro & Canyon Crest – PTP Radio

The City of Riverside also implemented a fiber-optic backbone communication link between the City's TMC located at City Hall (3900 Main Street, 4th floor) and Caltrans fiber-optic hub located at Lime Street at Tenth Street to establish shared CCTV and signal timing transmissions between City of Riverside and Caltrans. The City of Riverside coordinated with its IT Department to share the respective CCTV and sign timing feeds with the City of Moreno Valley's Traffic Engineering Department.

Signal Timing Implementation

The Alessandro Boulevard/Central Avenue corridor was coordinated in three distinct segments. The first segment on Alessandro was from Frederick Street to Arlington Avenue. This segment of the corridor defines Alessandro at its maximum volume in both the AM and PM progression and is a crucial to signal timing progression. The City also coordinated with the City of Moreno Valley to optimize the travel time through City of Moreno Valley. The second segment was from Arlington Avenue to Victoria Avenue. This segment has several areas where signalized intersections are very closely spaced making well-refined signal timing very important for progression. The third segment on Central Avenue from Victoria to Magnolia focused on the progression to and from the SR-91 freeway ramps.

For each segment, at least three timing plans were developed to address the morning, midday or afternoon peak hour traffic. These timing plans were implemented into every traffic signal controller along the corridors and were observed from the TMC to ensure proper traffic signal operation.

Field observations were conducted to ensure the plans were operating as expected. Additionally, the timing plans required fine-tuning by engineers to best accommodate field conditions that could not be account for in *Synchro* such as increased or decreased speed caused by horizontal and vertical curves, roadway pavement conditions, land widths and other factors.

Signal Timing Analysis

Signal Timing Change Effectiveness

Two methods were used to determine if the timing change effectiveness:

1. Tru-Traffic Analysis – The "before" and "after" travel time runs were conducted to obtain more accurate travel time and delay values for both the existing and newly implemented signal timing plans. The *Tru-Traffic* software then utilized the GPS data to compare the average speed and number of stops from the "before" and "after" runs which allowed engineers to determine if the new signal timing had improved the driving experience for daily commuters on the two corridors.
2. Emissions Reduction – *Synchro* Analysis utilizes travel distance, delay and stop times to determine emissions reductions based on current traffic volumes. In turn, the emissions reports allowed us to determine how effective the new signal timing plans affects motorist cost savings.

Travel Time & Delay

In order to analyze the improvements, a travel time and delay "after" study was conducted along Alessandro Boulevard during the weekday AM (7:00 am to 8:00am), midday (11:00 am to 1:00pm), and PM (4:00 pm to 6:00pm) peak periods, which were compared to the results of the "before" studies conducted. The City of Riverside conducted a GPS-based floating car method to determine the travel time and delay "before" studies in December 2012 and an "after" study in February 2013. *Tru-Traffic* software was used to collect and process the survey data. A total of five runs were conducted for each direction of the corridor for each peak time period. The corridor-based measures of effectiveness (MOE's) performance consisted of average (combined directions) travel time, average speed, number of stops per vehicle, and total delay time per vehicle. The corridor-based MOE's performances are summarized as follows:

- Average Travel Time (seconds) – the total elapsed time spent driving along the study corridor from the first intersection to the last intersection. This study reports the average travel time of five runs.
- Average Speed (miles per hour) – the total distance a vehicle travels divided by the total time elapsed
- Number of Stops – the average number of stops during five survey runs.
- Total Delay (seconds) – the time difference between actual travel time and desired travel time based on the posted speed limit and traffic flow model output.

The detailed travel time and delay (per vehicle) "before" and "after" studies for Alessandro/Central are shown in Table 1. During the AM peak period, the optimized timing plans decreased average travel time along Alessandro/Central by 6%, therefore decreasing the total delay of each run by 19%. During the

midday period, the comparison shows a 3% reduction in average travel time of 10 runs (5 runs per direction), with a total delay decreasing by 11%. The average speed increased by 3%. During the PM peak period, the comparison reports a 2% reduction in the travel time, with an 8% reduction in total delay.

Table 1. Travel Time & Delay Results

Time Period	Travel Time (sec)			Delay (sec)		
	Before	After	Percent Change	Before	After	Percent Change
AM	1055	995	-6%	358	291	-19%
MD	1053	1017	-3%	358	319	-11%
PM	1159	1136	-2%	468	430	-8%

Alessandro/Central experienced a significant improvement in both average speed and total stops based on the reduction in travel time and total delay during all peak hours, primarily in the AM peak hours. Table 2 shows the total average speed and total stops per vehicle for the Alessandro/Central corridor for both directions. During the AM peak period there was a 6% increase in the average speed per vehicle and a 23% reduction in total number of stops per vehicle. During the MD period, the comparison shows a 5% increase in average speed and a 13% reduction in number of stops per vehicle. During the PM peak period, there is an increase in the average speed per vehicle along Alessandro/Central of 2%, and a decrease in number of stops per vehicle of 5%.

Table 2. Average Speed & Total Stops Results

Time Period	Average Speed (mph)			Total Stops (#)		
	Before	After	Percent Change	Before	After	Percent Change
AM	31.9	33.8	6%	8.1	6.2	-23%
MD	31.9	33.5	5%	7.5	6.5	-13%
PM	28.9	29.6	2%	7.5	8	-5%

Emissions Reduction

Minimized fuel consumption and related pollutant emissions were primary goals of the Project to measure improvements in the new signal timing plans were effective. Fuel consumption is closely related to traveling distance, delay and stop/idle time at each intersection. For a vehicle trip of a given length, the number of stops, acceleration and deceleration cycles, and speed changes can affect Carbon Monoxide (CO), Oxides of Nitrogen (NOx), and Volatile Organic Compounds (VOC) Emissions. Signal timing plans were optimized to reduce fuel consumption and pollutant emissions by minimizing system-wide delay and number of stops, and providing higher and steadier cruise speeds along the Alessandro/Central corridor.

The network-wide fuel consumption savings and emission decrease are reported by *Synchro* models. Table 3 provides a summary of the total delay and stops per vehicle for the Alessandro/Central corridor:

Table 3. Network-Wide Measures of Effectiveness Improvements						
Time Period	**Total Delay (hr)**			**Total Stops (#)**		
	Before	**After**	**Percent Change**	**Before**	**After**	**Percent Change**
AM	652	613	-6%	52701	46786	-11%
MD	479	421	-12%	36500	33413	-8%
PM	705	679	-4%	54308	49391	-9%

Table 4 shows the annual fuel consumption results based on these measurable improvements on Alessandro/Central:

Table 4. Peak Hour Fuel Consumption and Pollutant Emission Comparison				
Peak Hour	**Network MOE**	**Before**	**After**	**Percent Change**
AM	Fuel Consumed (gal)	2102	1984	-6%
	CO Emissions (lbs)	324	306	-6%
	Nox Emissions (lbs)	63	59	-6%
	VOC Emissions (lbs)	75	71	-6%
MD	Fuel Consumed (gal)	1509	1432	-5%
	CO Emissions (lbs)	232	221	-5%
	Nox Emissions (lbs)	45	43	-5%
	VOC Emissions (lbs)	54	51	-5%
PM	Fuel Consumed (gal)	2241	2142	-4%
	CO Emissions (lbs)	345	330	-4%
	Nox Emissions (lbs)	67	64	-4%
	VOC Emissions (lbs)	80	76	-4%

The annual reductions figures shown in Table 5 were generated by taking an average of 250 business days per year and multiplying the daily savings by those 250 days.

Table 5. Annual Fuel Consumption Reduction		
	Daily Reduction	**Annual Reduction**
Fuel Savings (gal)	588	147,000
CO Emissions Reductions (lbs)	90	22,520
Nox Emissions Reductions (lbs)	18	4,398
VOC Emissions Reductions (lbs)	21	5,214

In general, motorists will experience fewer stops, more efficient commutes and less stress on Alessandro Blvd/Central Ave. In addition, the corridors will produce approximately four to six percent less pollutants throughout the day which translates to more efficient commutes and fuel savings. Fewer stops will help reduce accidents, another byproduct of improved signal timing.

Conclusions

Cost Projections

The motorist annual cost savings associated with signal timing optimization Project were estimated using the following assumptions:

- Vehicle delay cost is $10.00 per vehicle hour – The hourly gasoline consumption rate for the corresponding peak hours (AM, MD, PM) was extracted from the *Synchro* model output.
- Vehicle stop saving is $0.014 per vehicle stop – Taking the vehicle delay cost value and the existing volume, the *Synchro* model is able to determine the cost per vehicle stop.
- Fuel cost is $4.00 per gallon – Based on current average fuel prices.

Based on the network-wide measure of effectiveness improvements identified in Table 3, the savings associated with decrease of total delay and total stops are presented in Table 6. A total of $712,433 will be saved per year by decreasing total delay and total stops within the study network through signal optimization efforts. Similar to Table 5, the daily decrease in hours and stops were multiplied by the 250 average business days in a year to calculate the annual savings.

Table 6. Motorist Cost Savings Associated with Decreased Delay and Stops

Peak Hour	Before	After	Decrease	Peak Hour (hr)	Daily Decrease	Annual Savings	Total
Total Delay							$ 712,433
AM	652	613	39	2	246	$ 615,000	
MD	479	421	58	2			
PM	705	679	26	2			
Total Stops							
AM	52701	46786	5915	2	27838	$ 97,433	
MD	36500	33413	3087	2			
PM	54308	49391	4917	2			

The fuel consumption analysis shown on Table 7 notes an annual savings of 147,000 gallons of fuel or at $4.00 per gallon this equates to $588,000 of fuel savings per year. Shorter commutes, fewer stops, and fuel savings also means that motorists will have less wear and tear on the vehicle. Although the wear and tear on vehicles is more difficult to compute because of the varying makes and models of vehicles as well as driving habits of motorists, the savings nonetheless would be substantial.

As shown in Table 7, the total annual savings of fuel, total stops and total delay for Alessandro/Central is $1,300,433. The total cost of this project is $458,410. This yielded a one-year benefit-to-cost ratio of 3 to 1. Traffic signal retiming efforts are recommended by the Institute of Transportation Engineers to be conducted at least every three years. The three-year benefit of this project would be approximately $3,901,299 while the project cost remains fixed at $458,410 producing a three-year benefit-to-cost ratio of 8 to 1. The City would continue to properly maintain the traffic signals, signal interconnect systems, and CCVT transmissions to provide optimum progression on the Alessandro/Central corridor.

Table 7. Benefit-to-Cost Ratio Analysis	
Annual Fuel Consumption Reduction (gal)	147,000
Dollar Value per Gallon	$4.00
One-Year Benefit	$588,000
Savings by Decrease of Delay and Stops	$712,433
Total Annual Savings	$1,300,433
Project Cost	$458,410
Benefit-to-Cost Ratio	3:1
Three-Year Benefit	$3,901,299
Three-Year Benefit-to-Cost Ratio	8:1

CSPI Grading

To better understand the importance of reducing emissions by optimizing signal timing, the GPS-based floating car method and its results have been associated with the Corridor Synchronization Performance Index (CSPI) rating system developed by the Orange County Transportation Authority (OCTA). The CSPI rating system was developed to analyze and compare coordinated systems as a whole and easily determine if improvements were achieved. From the *Tru-Traffic* analysis, three values were utilized to evaluate the previous and new signal timing:

- Average speed (miles per hour)
- Number of greens per red
- Number of stops per mile

The average speed is obtained directly from the *Tru-Traffic* results, but the number of greens per red and number of stops per mile needed to be calculated manually using the total number of stops, and the total distance provided in the results. The total greens are calculated by taking the total number of stops and subtracting it from the total stops in the entire corridor distance. The green to red ratio is then determined by dividing the total greens by the total stops. The number of stops per mile is calculated by dividing the total stops by the total distance along the corridor.

The CSPI rating system utilizes these three values and applies a point value for each parameter as shown in Figure 2. On the low end, average speed of 15 miles per hour or less are given eight points, green to red ratios of 1.0 or less are given eight points and 2.0 or more stops per mile are given 17 points. On the high end, average speed of 34 miles per hour or greater are given 36 points, green to red ration of 5.0 or more are given 40 points, and 0.7 stops per miles or less are given 33 points.

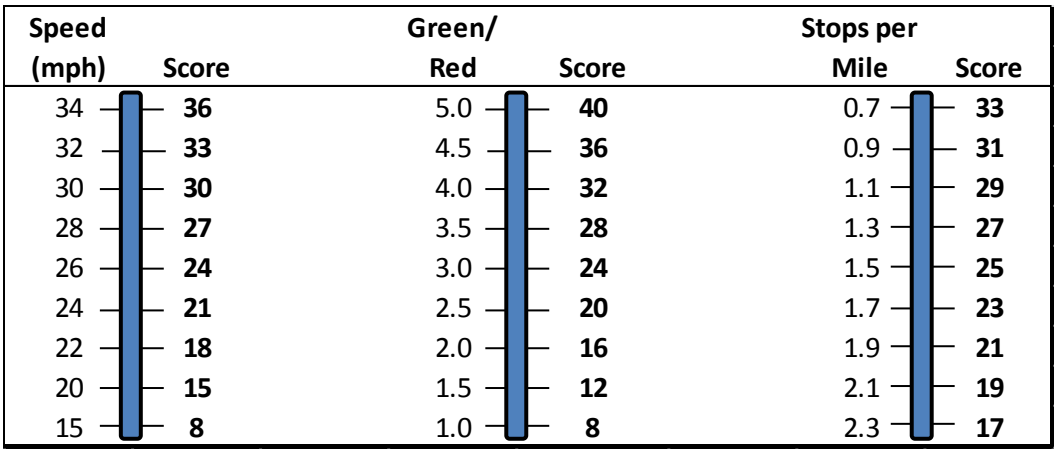

Figure 2. OCTA's CSPI Rating System

All three combined points gives the CSPI score. Figure 3 shows OCTA's grading scale for CSPI scores. A score of 69 and below indicates a necessary improvement in signal timing and a letter grade of D or F. A CSPI value of 70 and above is considered above average and signal timing is optimal.

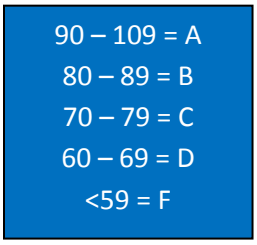

Figure 3. OCTA's CSPI Grading Scale

On the Alessandro/Central corridor the CSPI values were calculated for each peak period. Table 8 displays the calculated CSPI values based on the total number of stops per vehicle, total driving distance, total number of signalized intersections and the average speed. The total distance for Alessandro/Central is 9.3 miles and has a total of 35 signalized intersections. Table 9 uses the values from Table 8 and analyzes them based on the rating system in Figure 2. A grade was then assigned based on the total scores and the grading scale in Figure 3.

Table 8. CSPI Analysis

Parameters	AM		MD		PM	
	Before	After	Before	After	Before	After
Average Speed (mph)	31.9	33.8	31.9	33.5	28.9	29.6
Greens per Red	3.3	4.6	3.7	4.4	3.7	3.4
Stops per Mile	0.9	0.7	0.8	0.7	0.8	0.9

Table 9. CSPI Grading and Results						
Parameters	AM		MD		PM	
	Before	After	Before	After	Before	After
Average Speed (points)	33	36	33	36	28.5	30
Greens per Red (points)	26.4	36.8	29.6	35.2	29.6	27.2
Stops per Mile (points)	31	33	32	31	32	31
SCORE	**90.4**	**105.8**	**94.6**	**102.2**	**90.1**	**88.2**
GRADE	**A**	**A**	**A**	**A**	**A**	**B**

Table 9 shows the resulting CSPI values for the morning, midday, and evening peak hours before and after signal timing changes were implemented on Alessandro/Central. The scores show an overall improvement of the corridor coordination with a slight drop in score for the evening peak.

Summary

The Alessandro/Central Corridor from Frederick Street to Magnolia Avenue was retimed as part of an MSRC Grant Project to yield economic and social benefits by reducing delay, improving safety, and reducing vehicle emissions and fuel consumption. The City of Riverside partnered with the City of Moreno Valley to install updated traffic signal controllers, traffic signal controller software, CCTV equipment, count stations, signal interconnect radios and devices in order to deploy and implement signal timing coordination plans that will allow motorists to seamlessly travel through both jurisdictions in an efficient manner. Wireless radios, CCTV cameras and count station equipment will facilitate City forces to retime the corridors every three to five years as recommended. Data from the count stations will be evaluated on a monthly basis to track volume increases and determine when the corridors warrant updated traffic signal timing plans. Furthermore, the City of Riverside along with Caltrans has current construction projects on Central Avenue at the intersection with the SR-91 freeway that once completed may be easily integrated into the existing signal timing plans. Those segments within the Caltrans project limits would require wireless point-to-point radios to integrate them into the Alessandro/Central corridor and further enhance and extend the synchronization of the corridor.

Comparing “before” and “after” travel-time and delay studies, the Project is anticipated to reduce pollutants by 6% and provide motorists with more efficient commutes, fewer stops, decreased delay and less stress as they travel on Alessandro Boulevard and Central Avenue. The annual savings in fuel, total delay, and vehicle stops is projected to be approximately $1.30M with a three year benefit of $3.91M and a benefit to cost ratio to exceed 8:1. Other improvements that the project will generate include:

- Emergency vehicle, public transportation buses and commercial vehicles will save time
- The number of severe collisions on Alessandro Blvd/ Central Ave may be reduced by producing smoother traffic flow and fewer stops which decrease stress and/or motorist frustration.
- Minimize cut-through traffic to local and residential neighborhoods
- Improved air quality
- Reduces the pavement wear and tear

Through the implementation of the project, Alessandro/Central will meet the demands of the roadway users including motorized vehicles, bicycles and pedestrians. By optimizing the operations of signalized intersections in relation to each other, platoons or groups of vehicles can travel through a series of signal with minimal or no stopping. This project greatly benefits the City of Riverside and City of Moreno Valley as Alessandro is a major arterial that carries close to 45,000 motorists, not to mention any additional vehicles from the SR-91 and I-215 freeways. The project is a great example of a collective partnership between the South Coast Air Quality Management District, City of Riverside and City of Moreno Valley to bring traffic congestion relief to the Inland Empire.

Press Release

Residents in the City of Riverside have become aware of the City's efforts to provide a safer commute every day, within and outside of the city. A press release titled, "Four Major Traffic Corridors Modified…" has been published on the City of Riverside's website (www.riversideca.gov). In the article, information about the Project and notable improvements have been presented and released to the public. By the public becoming aware of these improvements residents and non-residents have an opportunity to "test-out" their daily route along the Alessandro Boulevard and Central Avenue corridors. The article is also an effective way to present residents with a time-saving solution for their commute as it demonstrates that improvements in signal timing have led to an increase in cost savings and fuel efficiency. The City anticipates that the public will be more inclined to use these arterials and will experience fewer traffic incidents, delays, and fuel usage.

Appendix A – Press Release

City of Arts & Innovation

News Release

FOR IMMEDIATE RELEASE:
Wednesday, May 15, 2013

Contact:
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Four major traffic corridors modified – cuts drive time by up to 10 minutes

RIVERSIDE, Calif. – Thanks to a grant provided by the Mobile Source Air Pollution Reduction Review Committee (MSRC), getting to a destination in Riverside just got easier due to recent signal timing improvements along Alessandro Boulevard/Central Avenue, Van Buren Boulevard, Trautwein Road, and Magnolia Avenue/Market Street.

Some of these corridors including Van Buren Boulevard, Alessandro Boulevard and Magnolia Avenue extend into neighboring jurisdictions including Riverside County and Cities of Moreno Valley and Corona respectively. Signals within these corridors have been synchronized; optimizing travel time, decreasing stops which is more efficient and less stressful for drivers.

These corridors are some of the busiest arterials within the City and were re-timed under a grant provided by the AQMD Mobile Source Air Pollution Reduction Review Committee (MSRC). This Grant Project will improve safety and reduce travel time, fuel consumption, air pollution and emissions. Approximately $14 million is used for programs administered by the MSRC annually.

The City was able to synchronize 157 signals along a roadway network of 41.8 miles by working and coordinating this effort with Riverside County, City of Moreno Valley, City of Corona and Caltrans. Two of these corridors, Alessandro Boulevard and Van Buren Boulevard, carry an excess of 50,000 motorists daily. These figures often increase with freeway incidents where drivers use local streets and major corridors to bypass freeway congestion. This project will be able to handle unexpected freeway incidents and detours due to accidents and major “spikes” in traffic volumes. In addition, motorists will save between 7-10 minutes in their daily commute with the synchronized signals.

Local neighborhoods will encounter less cut-through traffic as motorists will opt to use the arterials to reach their destination as they provide the most convenient and shorter commute alternative.

Membership of the MSRC is made up of representatives from the transportation agencies of Riverside, Los Angeles, San Bernardino and Orange County, as well as the Southern California Association of Governments, Southern California Rideshare, California Air Resources Board and the South Coast Air Quality Management District.

Appendix B – Photographs


Traffic Signals Synchronized on Alessandro
Funded by:
CITY OF RIVERSIDE
City of Arts & Innovation
MORENO VALLEY
WHERE DREAMS SOAR
Clean Transportation
Funding from the MSRC
Mobile Source Air Pollution Reduction Review Committee
RCTC


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