Cross-Jurisdictional Signal Coordination In Phoenix And Seattle

Lessons Learned From The Metropolitan Model Deployment Initiative

Removing Barriers to Seamless Travel on Arterial Streets

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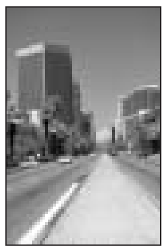
Preface

In 1996, the Secretary of Transportation announced the Operation TimeSaver goal to deploy integrated Intelligent Transportation Systems (ITS) infrastructure in 75 of the nation's largest metropolitan areas. That year, the U.S. Department of Transportation also established the Metropolitan Model Deployment Initiative (MMDI). The purpose of this effort was to create model deployments that represent integrated transportation management systems. The objectives of the initiative include determining the effects of increased deployment on traffic characteristics and operations and documenting the benefits that enabled the specific sites to be selected. The Metropolitan Model Deployment Initiative in Phoenix is called "AZTech".



Integration is one of the factors in successful ITS deployment. An integrated system is often more effective than one in which all components function separately. This case study is one of a series documenting the level of ITS integration in several major metropolitan areas. This study also provides transportation professionals with an example of how to integrate ITS components and systems, including related costs and other details.

Background

The Phoenix area, as with many metropolitan areas, is made up of several separate jurisdictions. If all trips were made within the same jurisdiction and no boundaries were ever crossed, traffic signals could be coordinated within those respective boundaries and efficient progression achieved. However, this is never actually the case.

Early on, the jurisdictions located in the East Valley of Phoenix operated their own traffic signal systems with some interjurisdictional coordination. These cities include Chandler, Gilbert, Scottsdale, Tempe, and Mesa. Regional signal coordination brought along "Smart Corridors," or corridors that allow smooth progression from one jurisdiction to the next. A Smart Corridor is a corridor in which all transportation facilities are used at their maximum efficiency during both an incident and normal periods of congestion.

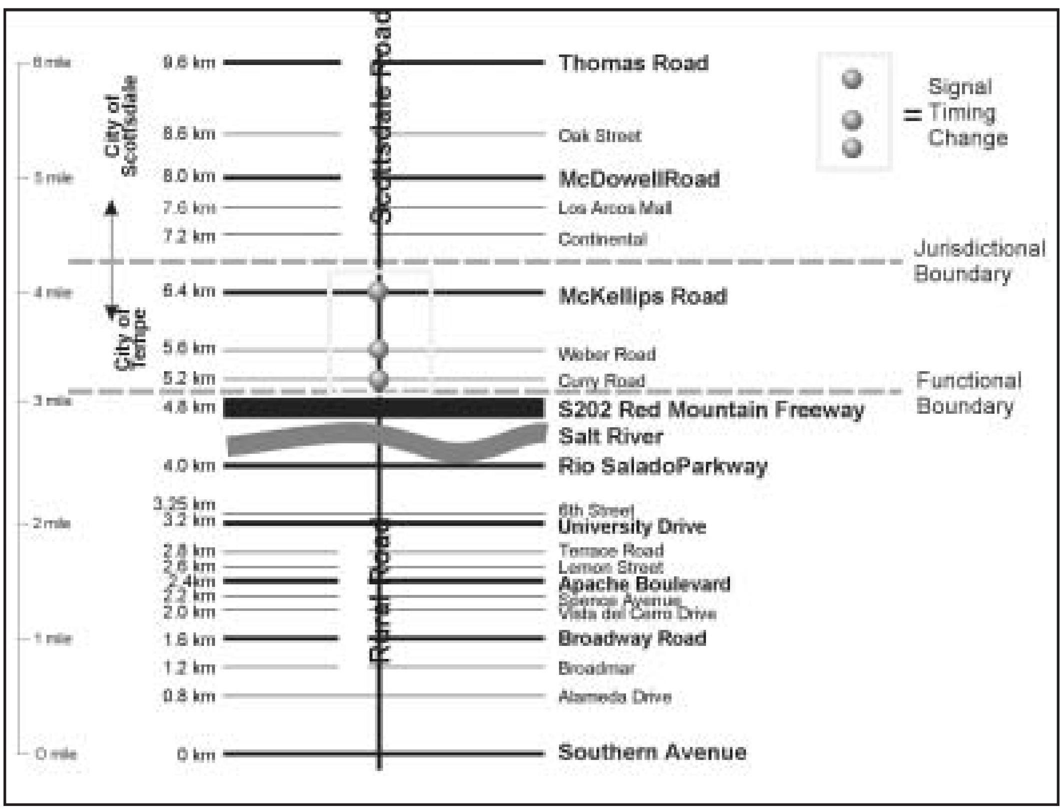
The use of regional traffic signal coordination has made commuting through several jurisdictions in Arizona easier and more economical. Many municipalities across the country use similar traffic signal cycle lengths and background cycles along arterials to help achieve smooth travel progression. A cycle length can be defined as the green, yellow, and all-red times combined for each approach. Traffic signal progression prevents unnecessary delays for motorists. Similar cycle lengths along an arterial help achieve smooth progression.

Project Description

The Scottsdale/Rural Road Corridor (Figure 1) is a major north/south arterial corridor in Arizona that connects Scottsdale and Tempe. Along the route there are 21 traffic signals within two jurisdictions (five located in Scottsdale and 16 located in Tempe). Prior to this project, the jurisdictional separation was a boundary for traffic signal coordination, delaying drivers with an unnecessary stop between cities. The Smart Corridor project relocated the jurisdictional boundary to a more functional setting (Loop 202), allowing the signal coordination to continue through the adjacent town. This case study reports the benefits achieved from the regional signal coordination efforts in Phoenix.

Detector stations were placed at several mid-block locations along this route to relay traffic flow and congestion information to the Traffic Management Centers in Tempe and Scottsdale. Operations personnel in each jurisdiction use this real-time information to coordinate traffic signals and provide smooth progression across jurisdictional boundaries (Figure 2). Tempe, however, is the only city that feeds vehicle count and speed data into the AZTech network.

Figure 1. Road Study Corridor



What Was Done in Phoenix

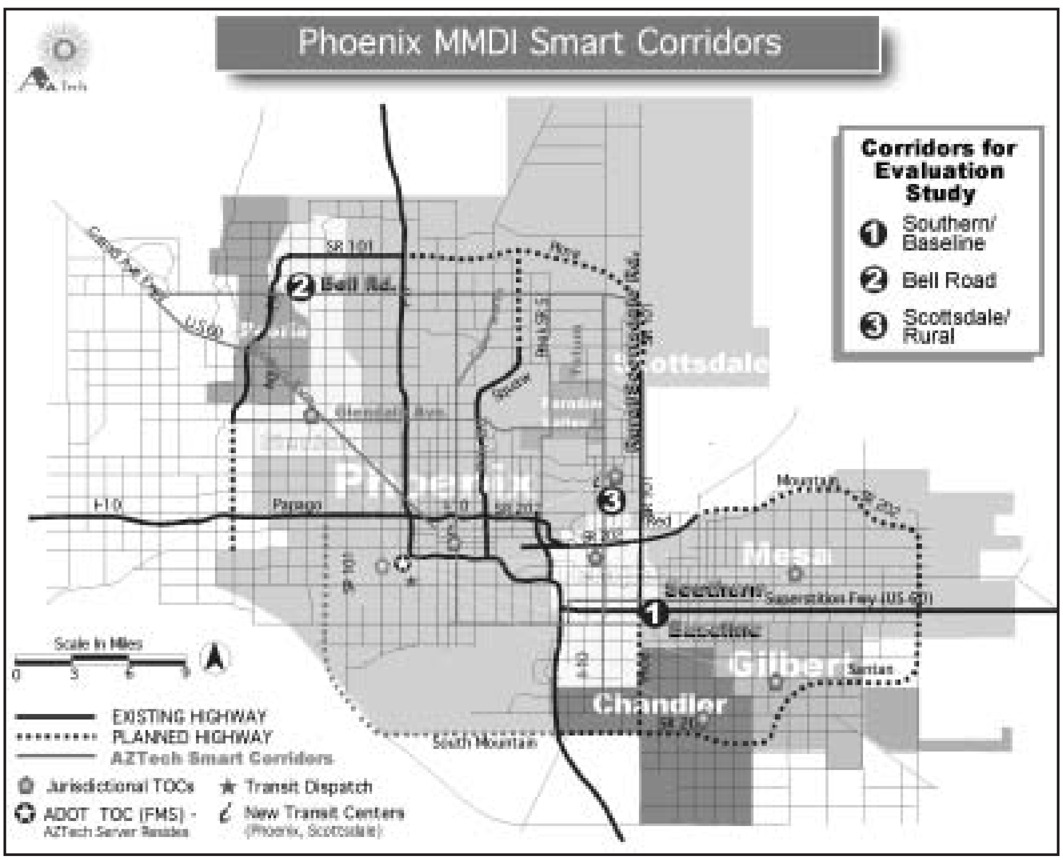
The traffic signals along the Scottsdale/Rural Road Corridor were operating at different background cycles, creating a break in progression. If all the signals along the corridor operated at similar background cycles, progression would improve. Motorists would travel through the green phase at each signal after the initial red light. The traffic signals in Tempe and Scottsdale were operating at cycle lengths of 110 and 102 seconds, respectively. Adjusting the timing of the signals to a common cycle length helped achieve smooth progression. To create the Smart Corridor, several signals along the arterial were retimed to a common background cycle and appropriate offsets were determined. Traffic detection equipment relayed information, such as traffic speed and volume, for use in signal timing updates.

Institutional Issues

Institutional integration had to precede integrating the components of each technical system in the East Valley of Phoenix. The AZTech Technical Oversight Committee provided an interagency model approach to regional traffic issues for this effort.

Transportation specialists from each of the five cities form the East Valley Task Force, which is responsible for identifying areas for improvement. Standards were established for interagency coordination, and solutions were developed to increase coordination between jurisdictions. For this particular study, the task force's goal was to synchronize the last traffic signal in one jurisdiction with the first signal in the adjacent jurisdiction.

Figure 2. Phoenix Metropolitan Model Deployment Initiative Smart Corridors



Integration

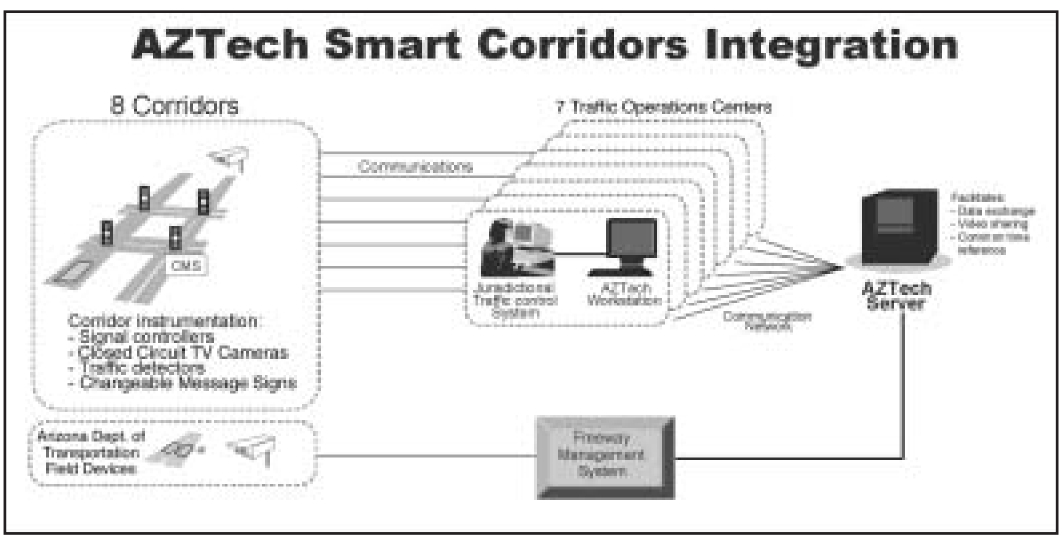
To achieve full technical integration, some Smart Corridor components were linked to the AZTech server to facilitate data exchange (Figure 3). Implementing a communications infrastructure allowed information flow between jurisdictions. Also, traffic signal controllers, surveillance equipment, and detection devices were installed or upgraded to collect information. Workstations were installed at the Traffic Operations Centers (TOCs) in each jurisdiction to allow sharing of the traffic information, which in turn provided each jurisdiction with the opportunity to update signal-timing plans to reflect real-time changes in traffic patterns.

Developing a regional traffic control and management plan was also a factor in integration. This plan includes traffic signal timing plans for some of the Smart Corridors, as well as procedures for coordinating traffic management activities between jurisdictions. The integration of these components played a key role in interagency communication and coordination.

"AZTech has built a lot of positive working relationships and rapport between these municipalities so that you look at the big picture rather than just what your own needs might be."

– Brian Latte
Signal Systems Engineer
City of Chandler

Figure 3. AZTech Smart Corridors Integration



Deployment Costs

The main capital cost for this project involved the purchase of traffic detection equipment (Table 1). Other costs included the jurisdictional share of the Traffic Operations Center planning, development and implementation, staffing, and hardware maintenance. Each of eight regions involved with implementing cross-jurisdictional signal coordination is responsible for 12.5 percent of the operating costs of the Traffic Operations Center. Annual operations and maintenance costs for the project have been estimated to equal 5 percent of the initial non-labor deployment costs. Table 1 illustrates a breakdown of the costs associated with the Scottsdale/Rural Road project.

Data Collection

Two data collection efforts were conducted for this evaluation in January and February 1999. One effort involved collecting traffic counts and turning-movement data at several traffic signals both before and after the signal timings were changed. The second effort involved the use of Global Positioning System (GPS) satellite receivers in vehicles that traveled along the arterial, also before and after the timing changes. Variables such as vehicle location and speed were recorded on a real-time basis, and the data were used to calculate travel time, delay, and vehicle accelerations.

Table 1. Development Costs of Scottsdale/Rural Road Corridor

Equipment Description	Fixed Costs	Annual Costs
Detection devices (6 x 6 Loops)	$65,625	
Maricopa County Department of Transportation planning (.33 full-time employee)	41,250	
Loop maintenance @ 10% of capital cost		5,381
Camera maintenance @ 2% of capital cost		984
12.5% Share of Traffic Operations Center's development, acquisition, and installation	84,527	
4% Share of AZTech hardware and software	2,734	
4% Share of Wide Area Network/Codec	14,594	
4% Share of video switch expansion	810	
4% Share of TRW systems engineering and project management	46,666	
4% Share of Traffic Operations Center operator training	2,891	
12.5% Share of Traffic Operations Center's communications costs		15,686
4% Share of AZTech server equipment replacement		4,281
4% Share of AZTech server operations and maintenance staff (1 full-time employee)		4,100
Totals	$259,097	$30,432

Results from Phoenix

Several operational benefits were observed through the large-scale signal coordination effort, including increases in average travel speed (Figures 4 and 5). The afternoon peak period (southbound) experienced a more substantial increase in average travel speed at the three retimed intersections (shown by the dashed red lines). The large gaps between the two southbound speed profile curves show an increase in speed at the intersections with retimed signals. McKellips Road experienced an increase in average speed of almost 10 miles per hour. The green dashed line shows the location of a railroad grade crossing.

The previously mentioned variables were used to determine the overall effects of the signal timing changes in terms of throughput

Figure 4. Northbound Speed Profile Comparison

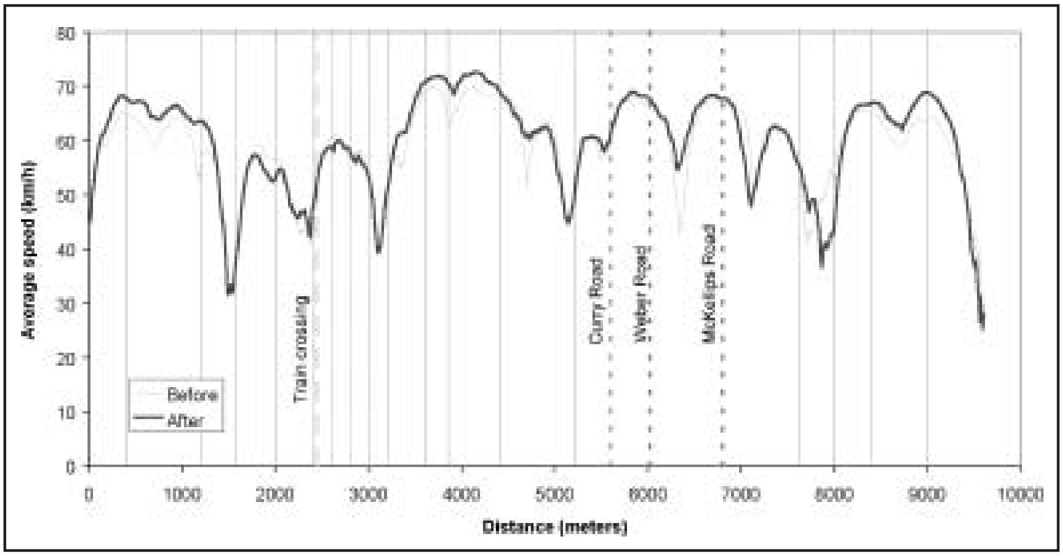
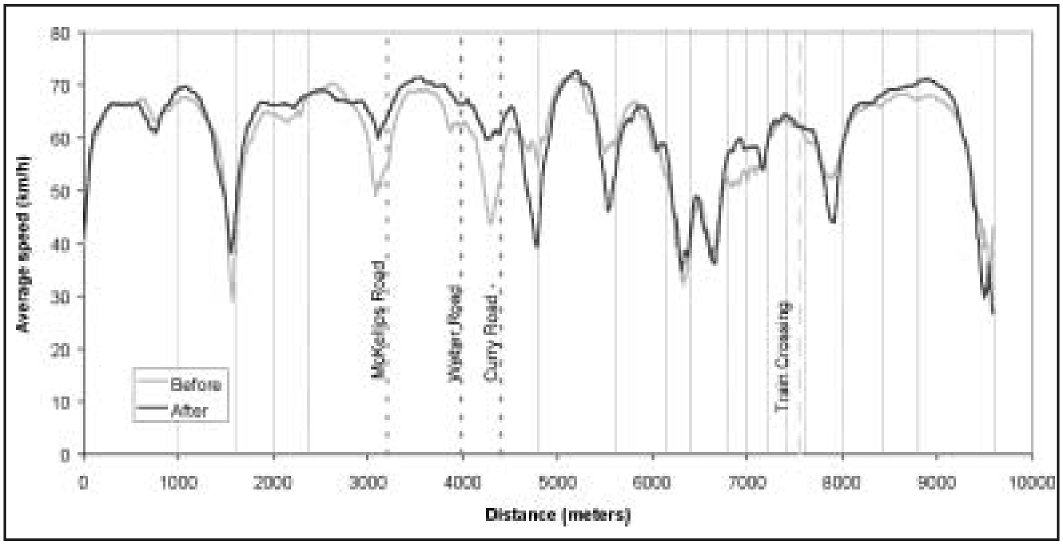


Figure 5. Southbound Speed Profile Comparison



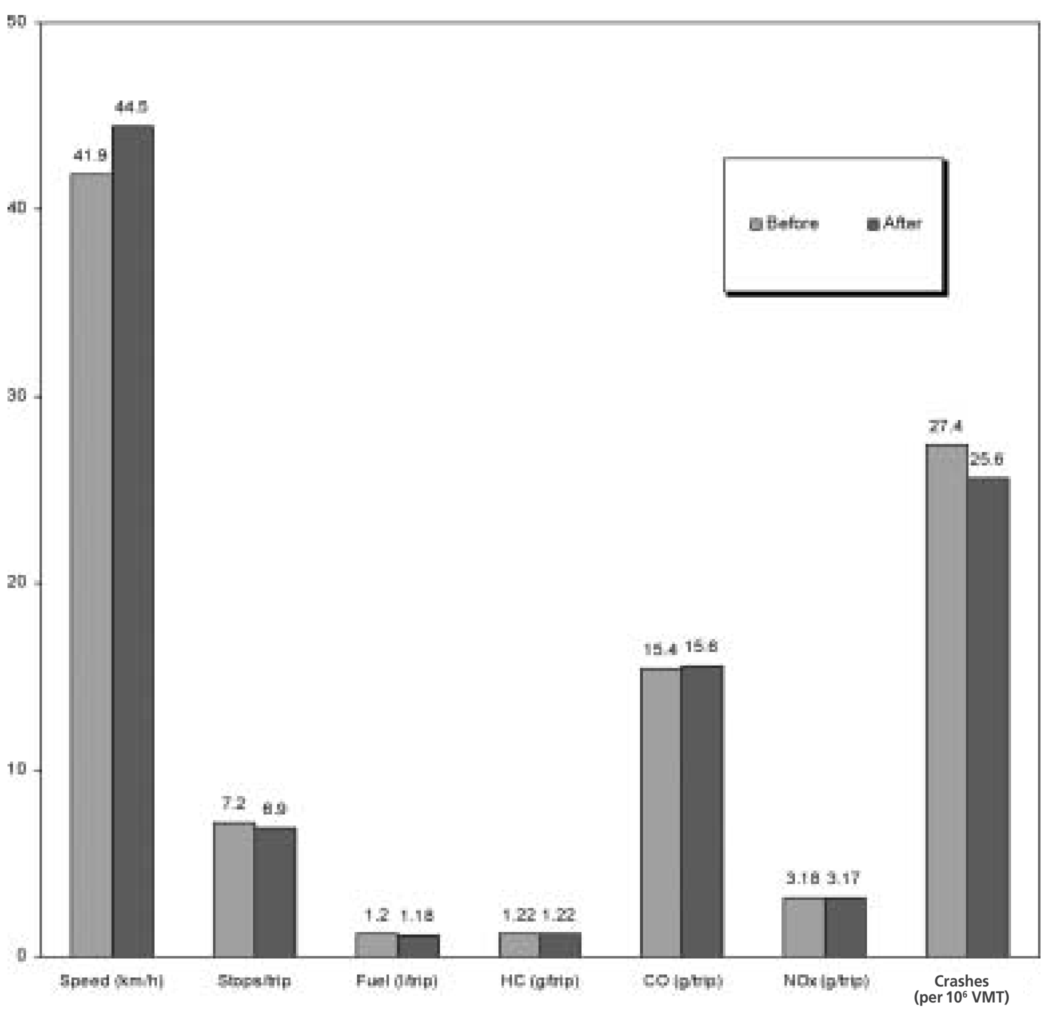
and efficiency. Figures 6 and 7 show the effects of signal coordination with respect to Global Positioning System data analysis.

The results show a 6 percent increase in the average speed between the before and after conditions, which is deemed statistically significant. As a result, vehicles stopped 4.3 percent less. The results from a microscopic simulation model were similar in nature and were in accordance with these results.

Figure 7 illustrates the small environmental and pollution-related effects of the project. However, the project positively affected travel speeds, number of stops, and crash risk. Travel speeds increased by approximately 3 miles per hour, and the number of stops decreased significantly. Crash risk also decreased by 6.7 percent.

The mean value of each variable did not significantly change from the before period to the after period. However, over the three analysis periods (A.M., P.M., and

Figure 6. Average Measure of Efficiency Comparison



HC=Hydrocarbons CO=Carbon Monoxide NO_x=Nitrous Oxides VMT=Vehicle Miles Traveled midday), the mainline throughput increased by 13 percent. Throughput is defined as the number of trips per unit time, or the number of person trips processed by the system. This increase suggests that the system is more efficient due to the signal timing changes.

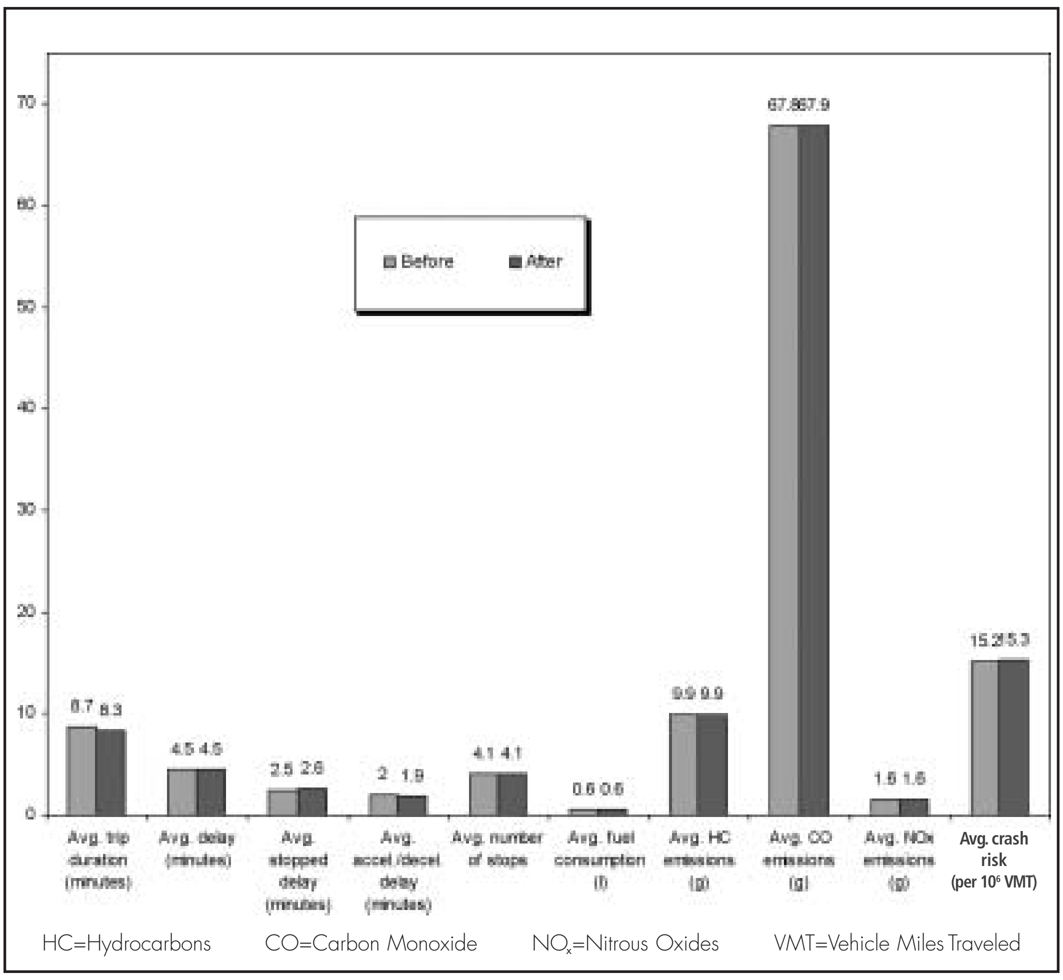
Reduced fuel consumption was another benefit of this project. In fact, fuel consumption was reduced by 1.6 percent, resulting in fuel savings of more than 260,000 liters per year.*

Findings from a Similar Deployment

The Seattle Smart Trek ITS Deployment involved a similar study to determine the benefits that could be achieved through cross-jurisdictional signal coordination. However, only simulation modeling was used to analyze the proposed signal timing changes. None of the signals in Seattle was physically retimed in the field.

The evaluation examined the potential effects of retiming signals using a coordinated fixed timing plan along two major arterials (SR 99 and SR 522) in North Seattle. As in the study in Phoenix, several measures of effectiveness were evaluated

Figure 7. Comparison of Means



*Based on assumptions made by researchers at Virginia Polytechnic Institute.

> ***"Signal integration will always be an ongoing process. We've made many improvements already, but it's a continual process, because traffic is always changing."***
>
> *– Jan Siedler*
> *Signal Systems Supervisor*
> *City of Mesa Chairperson*
> *East Valley Task Force*

to determine the effects that the new timing plans would have on traffic flow.

The results from the modeling effort were consistent with those from Phoenix. The model predicted a 7 percent reduction in average vehicle delay during morning peak conditions. The results also showed a 2.5 percent decrease in crash risk, as well as negligible changes in throughput. No adverse impacts were predicted for perpendicular streets crossing SR 99 and SR 522, primarily because the cross streets would have the same phase split using both baseline and coordinated plans.

Lessons Learned

Large-scale signal coordination efforts can not only provide traveler benefits, but can also substantially increase levels of inter-agency communication. A communications infrastructure links jurisdictions in the Phoenix Area, allowing them to share real-time traffic operations information and update signal plans accordingly. The idea of a multijurisdictional system allows regional goals to be initiated and achieved.

Signal coordination requires careful planning for maximum efficiency. In the Scottsdale/ Tempe Area, the boundary for coordination previously existed at a jurisdictional separation. Moving this coordination boundary to a more functional boundary (Loop 202) has provided a seamless commute from one jurisdiction to the next. A functional boundary is an area at which traffic signal coordination is less of an issue. For the Phoenix area, regional traffic signal coordination has been achieved through careful planning and increased coordination efforts.

Local participants predict that careful coordination and cooperation will have a long-range impact on traffic operations in the East Valley, and that maintaining and updating coordination and communication efforts will provide increased benefits in the future. Ideas such as this can provide municipalities with the framework needed to deploy similar Smart Corridor systems.

ITS Web Resources

ITS Joint Program Office:
www.its.dot.gov

ITS Cooperative Deployment Network:
www.nawgits.com/icdn.html

ITS Electronic Document Library (EDL):
www.its.dot.gov/itsweb/welcome.htm

ITS Professional Capacity Building Program:
www.pcb.its.dot.gov

Federal Transit Administration
Transit ITS Program:
www.fta.dot.gov/research/fleet/its/its.htm

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