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Developing an Integrated Traffic Corridor in Santa Fe through Intelligent Transportation Infrastructure

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ABSTRACT:

The city of Santa Fe, NM has experienced an increase in roadway traffic, congestion, and accidents, and the current traffic management infrastructure is in need of improvement to handle it all. This project inventoried the current traffic infrastructure in the Santa Fe area and investigated methods for calculating accurate travel times throughout the city, with the goal of gathering enough data to perform an analysis of implementing an integrated traffic corridor in the city of Santa Fe. The project concluded that using INRIX data for travel times was reliable and easy to integrate into current systems, and that implementing an integrated traffic corridor along two main roads in Santa Fe had an overall benefit-cost ratio of 75:1. These data will be used to provide accurate travel times to the public via roadside dynamic message signs, and potentially help the city of Santa Fe implement an integrated corridor in future years to help reduce traffic congestion and accidents, improve traffic management, and provide a more pleasurable commute for those driving in and around Santa Fe.

ACKNOWLEDGMENTS:

Our team would like to thank the following organizations and individuals for all of their valuable help and involvement throughout our project: Professors Fabio Carrera and Lauren Mathews, our advisors on this project, for all of their hard work giving us guidance and advice throughout this project. Tim Brown and John DiRuggiero of the ITS Bureau of the NMDOT, our sponsors, for all of their in-depth knowledge of the subject matter, help and expertise out in the field, and desire to do this project. Rick Devine, Head Traffic Engineer for the city of Santa Fe, for his help with all matters relating to the city of Santa Fe, including the intersections along Cerrillos Road and St. Francis Drive, and the software *Synchro*. Keith Wilson, MPO Senior Planner, for his valuable knowledge regarding the district of Santa Fe and the Santa Fe Metropolitan Planning Organization. Benjamin Lichtner for his help in further developing the City Knowledge Console for project use. The NMDOT and ITS Bureau for sponsoring this project, and the city of Santa Fe for hospitably allowing us to do this project.

Executive Summary:

Similar to the United States, the state of New Mexico is experiencing an increase in the number of vehicles on major roads and highways, which is increasing traffic congestion. New Mexico also experiences a higher amount of traffic accidents compared to the United States as a whole. There exists a need to improve traffic safety and mobility within the state.

The City of Santa Fe and the New Mexico Department of Transportation (NMDOT) have taken steps to help manage traffic and improve safety. The New Mexico Intelligent Transportation Systems (ITS) Bureau is a subdivision of the NMDOT that uses advanced traffic management technologies to provide a safe and efficient transportation system for the traveling public. They utilize infrastructure and tools such as dynamic message signs, traffic and signal cameras, and an online and mobile application called NMRoads.

There have been many improvements by the NMDOT ITS Bureau to address traffic mobility and safety issues in New Mexico. The NMDOT has spent $260,000 in the past year adding three dynamic message signs and one traffic camera to the Santa Fe area[1]. The NMDOT's inventory of their ITS devices contained some gaps and the city of Santa Fe lacked a standard, written copy of an inventory altogether. The dynamic message signs in the Santa Fe area were not being fully utilized, as many rarely displayed messages. Both agencies would like to deliver information to the drivers that will inform them during their commute, however, there is no effective method for collecting travel time data to broadcast to drivers through dynamic message signs and the NMRoads app.

The overall goal of this project was to perform an analysis of implementing an integrated corridor in the city of Santa Fe, with the intention of increasing traffic safety and mobility. An integrated corridor involves the coordination of arterial roadways into one functioning system, often bringing together different agencies and entities which are responsible for corridor mobility. Among the benefits of an integrated corridor are incident response, demand management, load balance, event response, increased safety, and travel time reduction. We planned to achieve an integrated corridor through inventorying current NMDOT and Santa Fe ITS infrastructure, assessing the best method of calculating travel times, and analyzing the implementation of an integrated corridor within Santa Fe. We inventoried in and around the city of Santa Fe and briefly in the towns of Pojoaque and Espanola, NM (see Figure 1) Within Santa Fe, we focused specifically on three main roads: the 599 Bypass, NM 14 (*Cerrillos Road*), and US 84 (*St. Francis Drive*) (see Figure 1), which would make up the integrated corridor. Throughout the time of our project, we were able to create and complete inventories and maps of the ITS infrastructure by going to Espanola, Pojoaque, the Santa Fe area, and the traffic intersections along NM 14 and US 84, evaluating different methods used to calculate travel times throughout the corridor, and gather data on the results of implementing an integrated corridor by modeling it in Synchro and creating a benefit-cost analysis.

[1] Personal Correspondence with Tim Brown. NMDOT ITS Bureau

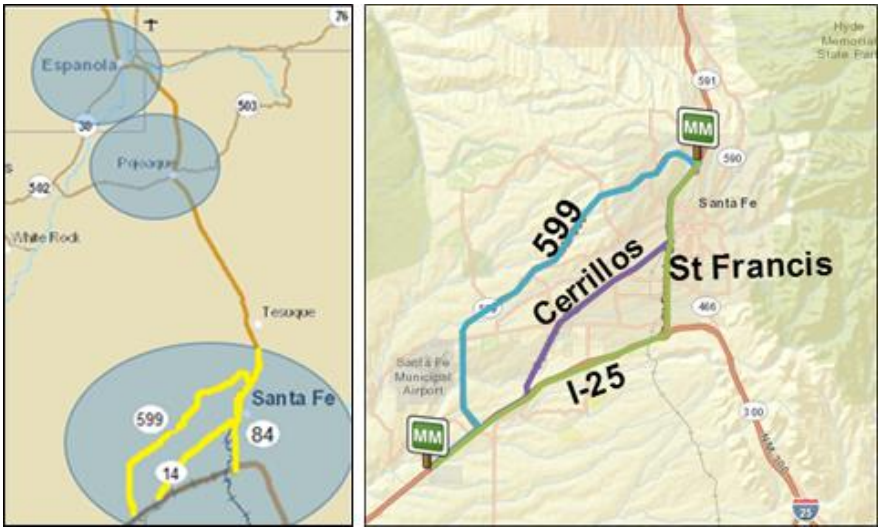

Figure 1: Locations of Santa Fe, Pojoaque, and Espanola (Left). Locations of three main roads: 599, NM 14 (Cerrillos Road), and US 84 (St. Francis Drive).

For our first objective, we inventoried current ITS infrastructure for both NMDOT and the city of Santa Fe. Our inventory for the NMDOT included six dynamic message signs, nine CCTVs, nine CCTV poles and all of the corresponding system cabinets. We inventoried a total of 33 traffic intersections for the city of Santa Fe, which included the system cabinets, traffic lights, and vehicle detection. We recorded GPS information by using the Trimble, and attribute data of the infrastructure was recorded in excel spreadsheets, which were then ported into the ArcGIS software for mapping. We also piloted an online software that combined GPS gathering with attribute recording into one form that we could access and use on our internet accessible mobile devices. The most efficient and accurate method for collecting data points was determined to be the Trimble device, as the online form was still in in beta and experienced accuracy problems. We recommend that that the NMDOT and City of Santa Fe utilize, maintain, and update our spreadsheets to keep all information in one place, and allow for easy locating and maintenance needs of the infrastructure. The maps created from the data points not only create a visual display but can also help other agencies during the construction process.

To complete our second objective, we evaluated different methods of calculating real-time travel times for each corridor of Santa Fe by looking at the coverage, cost, accessibility, and accuracy of BlueTOAD Bluetooth technology, Google Maps, and INRIX, with the ultimate intention of displaying the travel times on dynamic message signs just outside the city. We gathered travel times along the three main roads, and verified their accuracy by driving one road multiple times per day and comparing the collected travel times to that each method. We also looked at the cost of implementing each timing method, such as the price of subscriptions, if it required physical hardware, and the overall feasibility. From there, we were quickly able to determine the pros and cons of each method (see Figure 2) and ultimately choose the best option for the city of Santa Fe and the NMDOT to use. We found that Google was the most accurate, but BlueTOAD and INRIX were fairly reliable as well. We determined that INRIX was overall the best method for calculating travel times because it would be easy to integrate into the NMRoads app and NMDOT already uses INRIX data for the city of Albuquerque.

	INRIX	Google maps	BlueTOAD
Pro's	• Direct access to API for displaying travel times • Custom Routing • No hardware or installation necessary • Works well with ArcGIS maps by esri	• Large source and range of crowdsourcing • Custom routing • No hardware or installation necessary • Direct access to API for displaying travel times	• Historical and predictable data available • Travel times down to seconds of accuracy
Con's	• Inability to change API's with basic version • Less information available to make accurate time calculations	• Unclear payment options for businesses • Paying for options not needed	• Cannot output travel times to DMS directly • Hardware is in fixed position • Requires drivers to have Bluetooth enabled devices for information
Price	• $12,000 per year	• $10,000 with less than 100,000 web hits	• $4,000 per device (includes two year subscription)

Figure 2. Summary of Pros and Cons of INRIX, Google Maps, and BlueTOAD traffic time calculating software.

For our last objective, we looked into the implementation of an integrated corridor in the city of Santa Fe. We first analyzed and compared methods of reducing travel times on the main roads. We looked at how much it would cost to install an adaptive signal control system to optimally manage the traffic lights along the corridors of Cerrillos Road and St. Francis Drive. We determined that installing an adaptive signal control system at the 22 intersections along Cerrillos Road would cost an estimated $1,039,000. An alternative method to improve travel times and reduce traffic congestion is to add lanes to the roadway, however acquiring space and building more roads is becoming unfeasible and cost prohibitive. Adding two lanes to Cerrillos Road would cost $72,960,000, making the adaptive system less expensive overall. We next modeled an adaptive system to determine the amount of time saved through a software called *Synchro*. Lastly, we calculated benefits and were able to create benefit-cost ratios for installing an adaptive time signal system on just Cerrillos Road, just St. Francis Drive, or both roads. A summary of our results can be seen in Figure 3.

Annual Benefit (from Simulations)	Installing Adaptive Signal Control on Cerrillos Road		Installing Adaptive Signal Control on St. Francis Drive		Installing Adaptive Signal Control on Cerrillos Road and St. Francis Drive	
Daily Travel Time Reduction	North Bound	South Bound	North Bound	South Bound	North Bound	South Bound
Weekday AM	12.8% (67.5s)	13.3% (61.6s)	5.9% (45.5s)	6.0% (39.5s)	113.0s	101.1s
Weekday Midday	20.9% (121.8s)	15.5% (73.0s)	11.6% (68.0s)	7.2% (39.2s)	189.8s	112.2s
Weekday PM	6.6% (36.1s)	8.0% (37.1s)	19.7% (126.1s)	29.2% (229.5s)	162.2s	266.6s
Annual travel time savings per person	66 seconds*365days= 401.5 hours		91 seconds * 365days = 553.6 hours		157 seconds*365days = 955.1 hours	
Annual saving on gasoline	401.5hrs *.4 * $3.50 = $562.10		553.6hrs *.4 * $3.50= $775.04		955.1hrs * .4 * $3.50 = $1,337.14	
Roadway Annual Savings	$562.10 * 46,000 = $25.9 Million		$775.04 * 43500 = $33.7 Million		$1,337.14 * 89,500= $119.7 Million	
Project cost	$1,034,000		$550,000		$1,584,000	
Benefit Cost Ratio	**25:1**		**60:1**		**75:1**	

Figure 3. Breakdown of the calculations used for the benefit-cost ratios of implementing an adaptive signal timing system.

This project gathered enough data to make complete and reliable recommendations with regards to the best method for travel time calculations and the method in which the city of Santa Fe could implement an adaptive signal timing system in the most cost effective manner. Overall, this project created a detailed inventory and series of maps to catalogue the current infrastructure in and around the city of Santa Fe. We also concluded that using INRIX was the best option for the NMDOT, and that implementing an integrated traffic corridor on Cerrillos Road and St. Francis Drive had a benefit-cost ratio of 75:1. Overall we hope that this data will be used to provide accurate travel times to the public via dynamic message signs and potentially help the city of Santa Fe implement an integrated corridor in future years to improve traffic management and help reduce traffic congestion and accidents.

1. INTRODUCTION

In many parts of the United States, major roads and highways are becoming increasingly overcrowded. As of 2011, there were 212 million registered drivers in the United States. It is estimated that in 2011, 5.5 billion hours were spent sitting in traffic[2]. Traffic congestion is caused by weather, construction, hazardous road conditions, and accidents. In 2011 traffic congestion cost the country $121 billion, which is roughly $818 per U.S commuter in wasted time and fuel[3]. High levels of traffic congestion also decrease the overall mobility of roadways, thus increasing commuting times and risk of accidents. In 2011, more than 32,300 people were killed in traffic related accidents and over 2 million people were injured[4]. With more drivers on the road, there is an increased risk of accidents[5]. As the population of drivers increases, so does the need for better traffic management.

Similar to the rest of the United States, the roads are becoming overcrowded in New Mexico as well. The number of licensed drivers in New Mexico has increased from 1.2 million in 2002 to 1.4 million in 2012 which is a growth of 15%[6]. Compared to the United States average, New Mexico has a higher traffic fatality rate[7]. In 2011, on an average day in New Mexico, there were 118 crashes that involved 309 people, with 51 people injured and 1 person killed[8]. The New Mexico State Government has made steps to improve traffic safety and mobility by developing a system to address these issues.

To manage the increasing amount of traffic, cities and states have developed systems to collect traffic data and deliver timely information to drivers. Intelligent Transportation Systems (ITS) have been created by the departments of transportation of many states to improve mobility and keep drivers safe on roadways. In New Mexico, the ITS Bureau is a subdivision of the New Mexico Department of Transportation (NMDOT) that uses advanced technologies to "provide a safe and efficient transportation system for the traveling public"[9]. In doing so, the ITS Bureau alerts drivers of current road conditions through the deployment and management of devices such as dynamic message signs, highway cameras, and vehicle detection systems along highways and streets. One of the most advanced tools in use by the ITS Bureau is the NMRoads app. NMRoads is a mobile app in which drivers have access to up-to-date travel and traffic information in real time on their mobile device. Along with the NMRoads app, New Mexico has integrated dynamic message signs to communicate traffic information to drivers.

There have been many improvements by the NMDOT ITS Bureau to address traffic mobility and safety issues in New Mexico. The NMDOT has spent $260,000 in the past year adding three dynamic message signs and one traffic camera[10]. The main state arteries in and around Santa Fe are equipped with two NMDOT traffic cameras and four dynamic message signs. The city of Santa Fe deploys several devices in the main state arteries as they crisscross the city. The ITS infrastructure for both the NMDOT and the city of Santa Fe attempt to achieve the goal of solving traffic congestion, however, collaboration between the NMDOT and the City of Santa Fe is not as efficient as it could be. Due to the lack of effective collaboration there is a deficiency of information provided to the drivers in Santa Fe. Both agencies would like to deliver information to the drivers that will inform them during their commute, however, there is

[2] (Highway 2011)
[3] (Schrank, Eisele, and Lomax 2012)
[4] (U.S Department of Transportation 2013)
[5] (Schrage 2006)
[6] (Highway 2011)
[7] (National Motorists 2014)
[8] (New Mexico 2011)
[9] (Schrage 2006)
[10] Brown, personal communication

no effective method for collecting travel data to broadcast to drivers through dynamic message signs and the NMRoads app.

Our project created a strategic plan for implementing an integrated corridor in the city of Santa Fe. We first created a detailed inventory of all ITS devices for both Santa Fe and the NMDOT. Once the inventory was complete, we evaluated the current ITS infrastructure to determine additional resources and methods needed to calculate the most accurate travel times. Finally, we examined the implementation of an integrated corridor to coordinate the city and state ITS infrastructures, using a cost benefit analysis to be reviewed by the ITS Bureau. Our strategic plan for the implementation of an integrated corridor within Santa Fe will be used as a model for the NMDOT to use statewide.

2. BACKGROUND

In the following sections, we present the information necessary to understand our project. This information is separated into three main sections: automotive transportation, intelligent transportation systems, and traffic management. We examined the interactions and inner workings of the automotive transportation systems of New Mexico in order to learn how they operate and are managed by their respective organizations. Additionally, we explored the infrastructure and tools of the ITS Bureau and how it interacts with drivers and the city of Santa Fe. Finally we reviewed the components of developing an integrated corridor which includes, travel times, and adaptive timing systems.

2.1 Automotive Transportation

A growing population of the United States leads to increasing pressure on an already overloaded transportation network. There are over 200 million drivers in the United States, and this number continues to grow, which is overcrowding the vehicle transportation network[11]. Figure 4 illustrates the increasing trend of vehicle registrations, licensed drivers, and increasing population in the United States from 1961 to 2011[12].

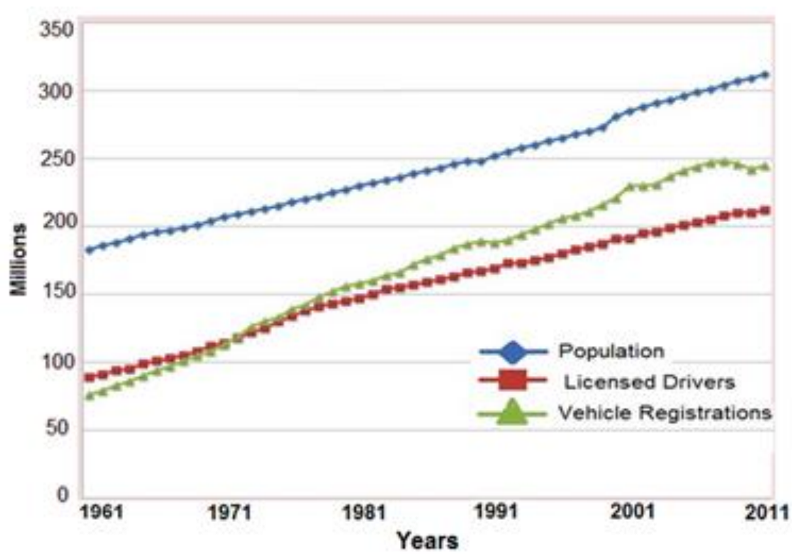

Figure 4. Trend in vehicle registrations, population, and licensed drivers from 1961-2011[13]

[11] (Highway 2011)
[12] (U.S. Department of Transportation 2011)
[13] (U.S. Department of Transportation 2011)

It has become a societal norm for most people to drive their vehicles to get from place to place in the US. Only 5% of the population in 2012 used public transportation to commute to work, as compared to the 76% of the population that drove alone, and 10% that carpooled, as shown in Figure 5[14].

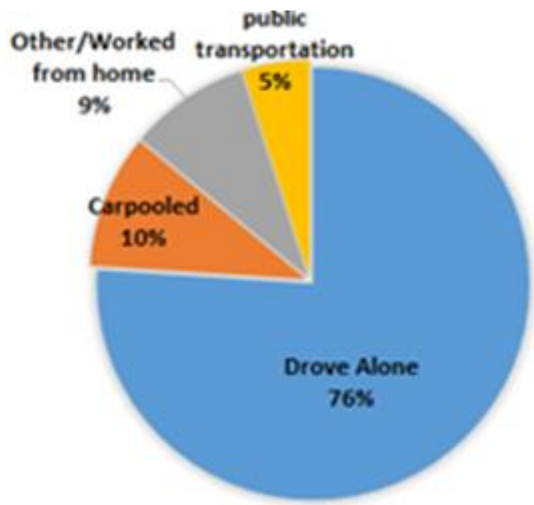

Figure 5. Commuting modes for workers in the United States in 2012[15]

Due to the heavy reliance on automotive transportation there are many associated delays and time conflicts for those on the road. In 2011, drivers spent 5.5 billion hours sitting in traffic, which translated to $121 billion spent in wasted fuel and time[16]. Some of this congestion is due to accidents. In 2011, more than 32,300 people were killed in traffic related accidents and over 2 million people were injured in the United States[17]. With more drivers on the road there is an increased risk of accidents and need to improve safety. To ensure fast, efficient, and safe transportation the Department of Transportation (DOT) was created in 1967 to develop and coordinate policies overseeing transportation systems and to manage interstate roads[18,19]. The Federal Highway Administration (FHWA) is an agency within the U.S. DOT that aids the state and local governments with design and maintenance of the national highway system. By providing financial and technical assistance, the FHWA can ensure the roads and highways are "among the safest and most technologically sound in the world"[20]. Each state has its own DOT that oversees many modes of transportation within the state including automobiles, public transit, railroads, maritime, pedestrians, roadways, and aviation[21]. Additionally, states comply with the regulations set forth by the U.S. DOT and FHWA to maintain state and interstate roadways.

[14] (Highway 2011)
[15] (Federal 2012)
[16] (Schrank, Eisele, and Lomax 2012)
[17] (USDOT 2013)
[18] (USDOT 2013)
[19] (Federal 2012)
[20] (U.S. Department of Transportation 2011)
[21] (National Motorists 2014)

2.1.1 Automotive Transportation in New Mexico

Similar to the United States, there is an increasing number of licensed drivers in the state of New Mexico. Figure 6 shows the trend over the past eight years for the number of licensed drivers and the number of registered vehicles in the State of New Mexico[22]. According to statistics gathered by the United States Census Bureau, New Mexico has consistently had over one million licensed drivers, and over 600,000 registered vehicles in the past ten years[23].

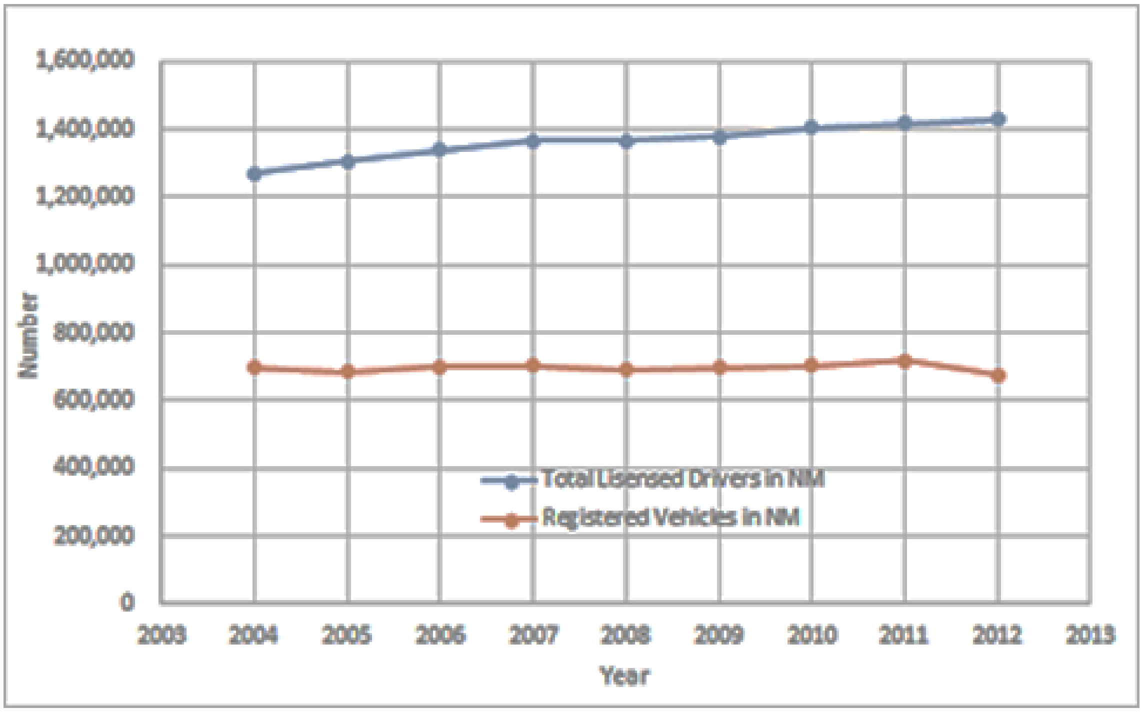

Figure 6. The total number of licensed drivers and registered vehicles in New Mexico from 2004-2012. There were over 1.4 million licensed drivers in 2012[24]

There were over 43,000 vehicle crashes in New Mexico in 2011[25]. New Mexico has a substantially higher traffic fatality rate compared to the United States as shown in Figure 7. The National Highway Safety Transportation Administration (NHSTA) determined that in 2012, New Mexico had 17.5 fatal crashes per 100,000 population which is nearly two times that of the United States[26]. This can be partially attributed to long roads and maximum highway speeds of 75 mph[27].

[22] (National Motorists 2014)
[23] (National Motorists 2014)
[24] (U.S. Department of Transportation 2011)
[25] (New Mexico 2011)
[26] (National Highway Traffic Safety)
[27] (National Highway Traffic Safety)

Figure 7. Crash-related fatality rates in New Mexico and the United States in 2011[28]

The New Mexico Department of Transportation sets the standard for safe, reliable and efficient transportation within the state. NMDOT focuses on transit, rail, aviation, and highway transportation modes. They are responsible for the maintenance of both state and interstate roads as well as ITS Infrastructure.

2.1.2 Automotive Transportation in Santa Fe

In addition to interstate Highway 25, there are three main state arteries crossing Santa Fe city boundaries (Figure 8). These three roads, which comprise the three frequently-traveled corridors of Santa Fe, are:

- NM 599, also known as the *Bypass Road or Relief Route*, a divided, 4-lane route which bypasses Santa Fe to the West.
- NM 14, also known as Cerrillos Road, which runs through the primary commercial strip in Santa Fe.
- US 84/285, also known as St. Francis Drive, which connects I-25 with Northern destinations like Espanola and Taos, cutting through the northern part of Santa Fe.

[28] (National Highway Traffic Safety)

Figure 8: The three major corridors in Santa Fe: NM 599, NM 14, and US-84 are highlighted in yellow.

Santa Fe County was ranked third among all counties in New Mexico for having the highest number of crashes in 2011[29]. That year, there were a total of 3,283 crashes within Santa Fe County[30]. A density map of the accidents within the Santa Fe city boundaries is shown in Figure 9[31]. The majority of the accidents occur along Cerrillos Road and St. Francis Drive, as indicated by the density map in Figure 9.

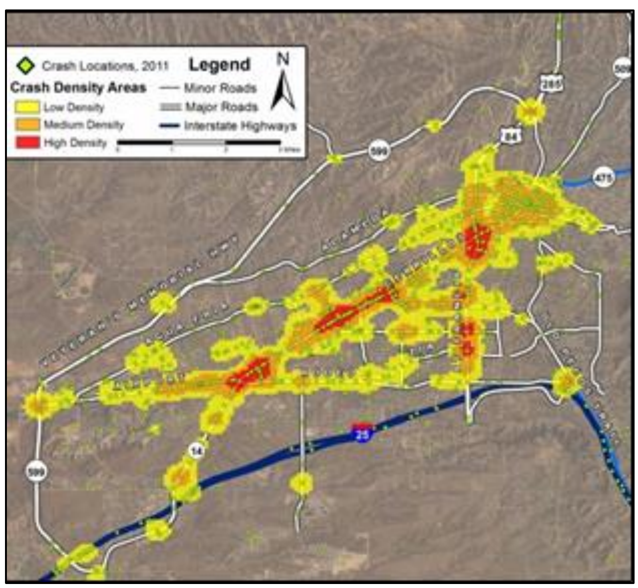

Figure 9. A density map displays where a high number of crashes occurred in Santa Fe in 2011[32]

[29] (New Mexico 2011)
[30] (New Mexico 2011)
[31] (New Mexico 2011)
[32] (New Mexico 2011)

Of the accidents along Cerrillos Road and St. Francis Drive, the majority of the accidents resulted in property damage as shown in Figure 10[33].

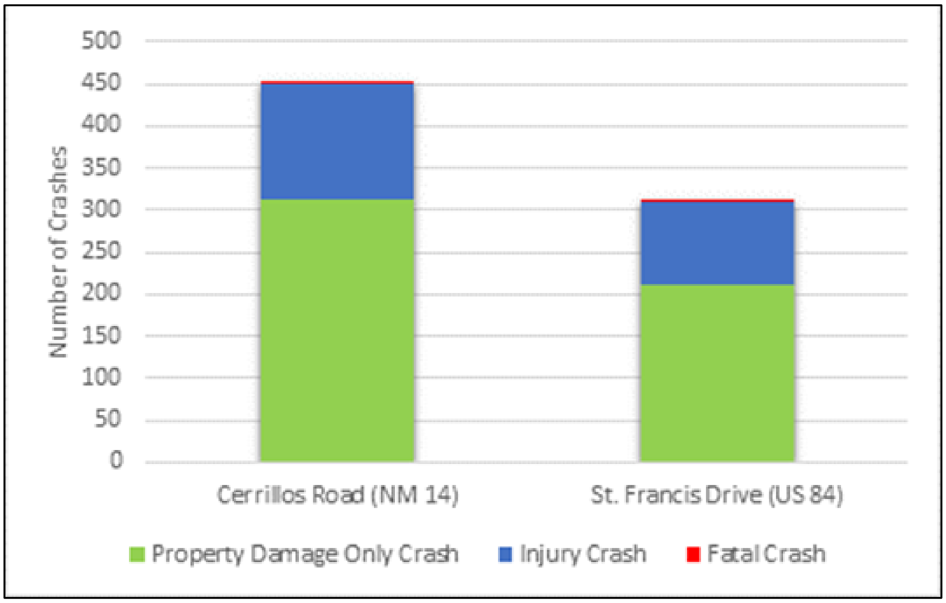

Figure 10: Severity of crashes on Cerrillos Road and St. Francis Drive in 2011

2.2 Intelligent Transportation Systems

The goal of an Intelligent Transportation System (ITS) agency is to utilize advanced communications technologies and data collection techniques to enhance the productivity of current infrastructure, thus improving transportation safety and mobility[34]. Governments with an established department of transportation often have an ITS bureau subdivision. In 1991, the United States Intermodal Surface Transportation Efficiency Act (ISTEA) established a federal program to research, develop, and test Intelligent Transportation Systems[35]. As a method of standardizing Intelligent Transportation Systems across the US, a National ITS Architecture was created. The National ITS Architecture lays out a common framework for planning, defining, and integrating Intelligent Transportation Systems, which is implemented in every state[36]. The ITS Architecture defines the responsibilities that are required for ITS. The National ITS Architecture is a foundation upon which much of the ongoing ITS standardizations are being built, as it creates a uniformity among different states, manufacturers, and users.

The United States Federal Highway Administration (FHWA) is an agency within the United States Department of Transportation (USDOT) that is responsible for maintaining the Nation's highway system. The FHWA budgeted $110 million for ITS related projects in 2012[37]. These projects are geared towards arterial management, crash prevention and safety, traffic incident management, traveler information, and driver assistance. ITS Bureaus within states provide advisories and warnings that inform drivers of current road conditions or traffic issues. Advanced technologies such as traffic cameras, inductance loops, traffic signals, and dynamic message signs allow ITS Bureaus to provide real-time information to

[33] (Casola et al. 2012)
[34] (Schrage 2006)
[35] (U.S Department of Transportation 2013)
[36] (Research and Innovative Technology 2013)
[37] (Federal 2012)

drivers. ITS infrastructure can be categorized into two groups, tools for information collection and tools for information display. Figure 11 provides a brief overview of the infrastructure that will be discussed in the following sections.

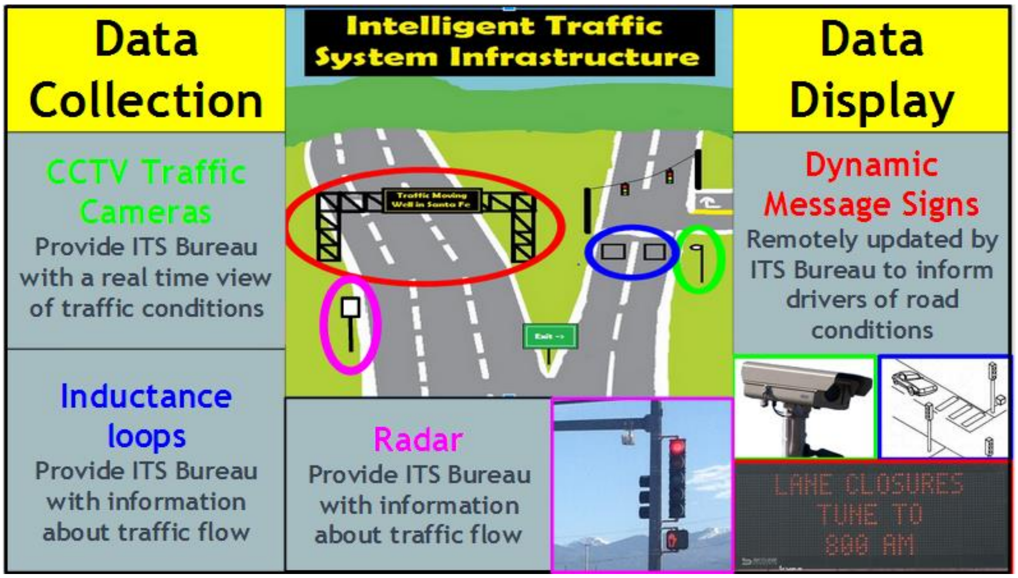

Figure 11. Intelligent traffic system infrastructure grouped by information collection and information display items.

2.2.1 Information Collection Infrastructure

Intelligent Transportation Systems infrastructure allow governments to collect traffic related information to manage the flow of traffic and communicate information to travelers. Traffic cameras, closed circuit televisions, inductance loops, and radar are devices currently in use by ITS bureaus. As technology advances, new methods for collecting and distributing information emerges. This section examines the tools and infrastructure used to collect information for intelligent transportation systems.

Traffic cameras provide real-time information based on the region of interest[38]. Closed-circuit television (CCTV) cameras are emerging as the standard for traffic monitoring in real-time. Traffic cameras are placed above roadways attached to traffic signals or poles that have the ability to scan a wide area[39]. Often, these cameras are Pan-Tilt-Zoom (PTZ) so they can be oriented remotely to focus on specific locations. According to the United States DOT, traffic cameras – especially if remotely controllable- can detect and verify incidents, monitor traffic conditions and oversee incident clearance[40]. The live camera feed is viewed by traffic managers who monitor traffic conditions and relay information to drivers. In addition CCTV systems assist real time traffic monitoring through different types of image processing, however there are limitations. Occlusion, (visual obstruction), often occurs because these cameras are installed on low angles, which limits the abilities of the cameras[41]. Cameras in general suffer under extreme lighting conditions (too much glare during the day and too dark at night) and are also negatively affected by precipitation (rain or snow) and icing.

[38] (Pratishtha, Purohit, and Amrita 2012)
[39] (Reijmers 1980)
[40] (New Mexico 2011)
[41] (Yin 2008)

Figure 12. COHU Closed Circuit Television Camera

Signal Cameras are video or CCTV cameras that are placed over signalized intersections for the sole purpose of detecting the presence of vehicles in order to provide the best distribution of green lights to increase traffic flow[42]. Signal cameras are typically fixed (not PTZ), but can be cost-effective replacements for in-ground inductance loops that are cut into the pavement, which can easily be damaged and require maintenance[43]. As vehicles enter intersections the cameras are not focused on the driver but rather a defined area or zone within the cameras view as shown in Figure 13[44]. Once the camera processor detects a change in the "zone" a signal is sent to the traffic light control box saying a vehicle is requesting a green light for the desired direction[45]. Like all cameras, signal cameras are negatively affected by glare and darkness, as well as by rain, snow, and ice.

Figure 13. CCTV used for detecting vehicles at intersections to manage traffic light signals (Left). Video camera zones used in traffic signaling detection (Right).

42 (Department of Transportation 2013)
43 (Department of Transportation 2013)
44 (Department of Transportation 2013)
45 (Department of Transportation 2013)

Inductance Loop Detectors have become one of the most utilized tools in traffic management since their implementation beginning in the 1960s[46]. An inductance loop is an electrical wire that is grooved into the pavement in a closed shape forming a loop, as seen in Figure 14. When a vehicle passes over the loop, there is a change in current that can be measured by a roadside unit. These in-roadway sensors can be used for traffic light timing, vehicle detection, traffic volume and density detection, and turning lane queue detection[47] as seen in Figure 14. Inductance loops have many applications and can be placed in any section of a paved roadway, but are most commonly found in the vicinity of intersections. Inductance loops are very resilient, but can be damaged in the course of road repairs.

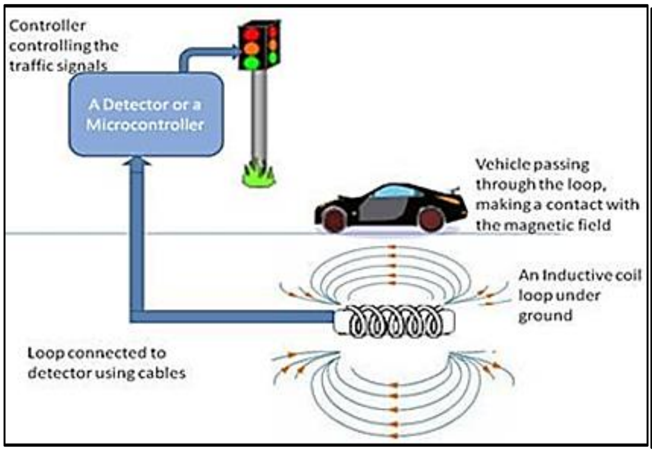

Figure 14. Diagram of Inductance Loop System[48] (Left). Inductance loop in pavement (Right).

Radar was developed in World War II to detect foreign objects. Radar emits radio waves or a laser beam which reflects off of vehicles and receives an echo from objects of interest. The change in frequency observed or the return time of the reflection can be used to determine the vehicles speed[49]. Radar sensors are usually mounted on traffic poles. There are several products available, and one of the most common radar used is made by Wavetronix. The sensors produced by Wavetronix are often used for intersection management due to the sensors ability to detect vehicles within a field of view shown in purple in Figure 15[50].

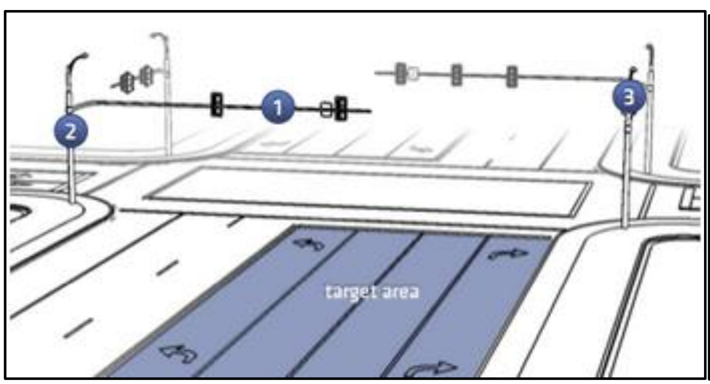

Figure 15. Detection zone of Wavetronix radar sensors[51] (Left). Wavetronix Radar sensor mounted to traffic pole (Right).

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[46] (Federal 2012)

[47] (Federal 2012)

[48] http://www.elprocus.com/dynamic-road-traffic-signal-control/

[49] (Federal 2013)

[50] (Wavetronix 2014)

[51] (Wavetronix 2014)

2.2.2 Information Delivery Infrastructure and Tools

As soon as traffic related data is collected, the ITS bureau disseminates appropriate information to drivers, typically through remote-controlled signs and via mobile apps and phone services. Dynamic message signs and the 511 call service are respectively ITS infrastructure and tools that are currently in broad use. This section examines the infrastructure and tools that are used to deliver information to drivers.

Dynamic message signs (DMS) provide drivers with important information about road conditions and travel times. As opposed to standard road signs, DMS can be updated remotely by traffic managers to alert drivers of changing conditions and real time information. DMS can be stationary or mobile either placed above highways or on the side of the road. Generally DMS are placed at major decision points such as exit ramps or at the intersection of major routes, in high-accident areas, or where regional information concerning weather conditions is essential[52]. The delivery of information is standardized by a protocol within the National Transportation Communications for ITS Protocol (NTCIP).The protocol specific to DMS, NTCIP 1203, dictates the communication method in which the images on the DMS can be altered by the traffic manager[53].

The main intention for this standardization was to create an environment in which DMS and communication software developed by different companies could be interoperable, meaning there would be no need to modify the displayed information in order for different companies' software and hardware to communicate[54]. The protocol dictates that the manager is able to communicate with the DMS through three different mediums: a central computer located in a traffic management center, a local computer that is portable and can directly connect to a port at the DMS sign controller, and locally through a physical interface mounted at the DMS sign controller itself[55]. The telecommunications capabilities of DMS can be wireless or wired, and DMS uses Simple Network Management Protocol (SNMP) as its communications standard[56]. Additionally, NTCIP dictates the standard of DMS display settings[57].

Figure 16. Roadside Dynamic Message Sign

[52] (New Mexico 2013)
[53] (National Transportation Communications 2012)
[54] (National Transportation Communications 2012)
[55] (National Transportation Communications 2012)
[56] (National Transportation Communications 2012)
[57] (National Transportation Communications 2012)

511 is the nation's three-digit transportation and traffic hotline that can be dialed from anywhere across the country. A large amount of information is collected by ITS each day and 511 allows drivers to access this information. When dialed, regardless of location, 511 gives choices to travelers based on the travel times of different roads, best mode of transportation, and best route to travel, saving lives, time, and money. As of February 2014, all but 11 states have 511 services as shown in Figure 17. New Mexico implemented the 511 service in 2007[58].

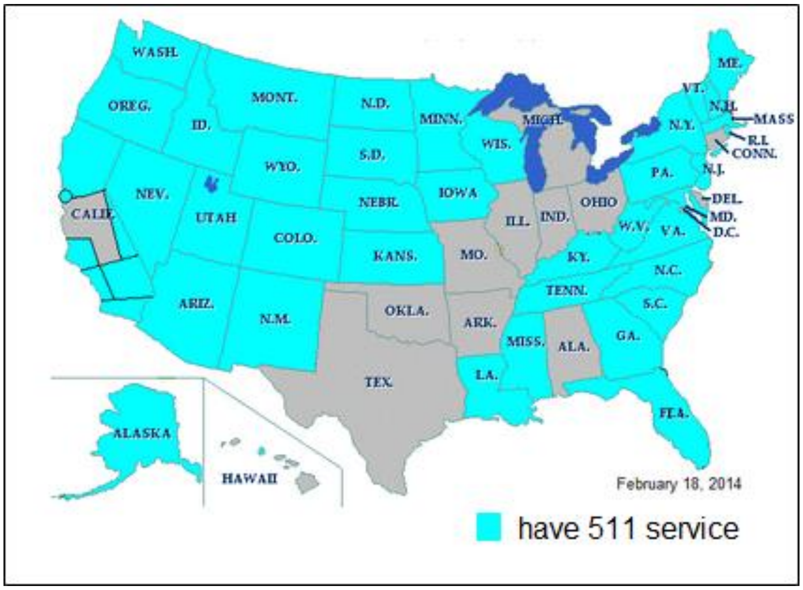

Figure 17. US Map that shows the states with the 511 service[59]

Mobile apps have taken driving and traveling into a whole new era. For the first time drivers can get real time information about designated routes, saving time and money. The locations of heavy traffic or, accidents, weather reports, and rerouting information is now available at any time. The most popular traffic and navigation apps are Waze Social GPS, Maps & Traffic and Google Maps. Waze incorporates social interaction among app users to benefit each other and work toward a common goal of outsmarting traffic issues. When approaching police, accidents, road hazards, or traffic jams, users of the app can alert other app-using drivers about current issues on the road ahead. Waze adjusts routes based on user generated reports of hazards in order to give drivers the best available driving option. Along with generating real-time traffic information, Waze also provides the cheapest gas stations along the user's route.

Google Maps provides comprehensive, extensive maps with GPS voice-guided navigation in over 200 countries. Google Maps provides live traffic, incident reports, and dynamic rerouting to its users. It also uses crowdsourcing, which is using GPS enabled cell phones to gather information. Crowdsourcing is a community or "crowd" organized online, that invites people to submit information for an organization[60]. Crowdsourcing seeks to generate large volumes of information to inform others about information in a specific area. Google Maps uses information gathered by thousands of active cell phones to determine mobility of traffic through a given location. Locations with crowded, slow moving traffic show up as a red line along the given road map while smooth flowing traffic shows up green.

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[58] (511 2014)

[59] http://www.fhwa.dot.gov/trafficinfo/511.htm#Assist

[60] (Shepherd 2012)

2.2.3 Intelligent Transportation Systems in New Mexico

The ITS Bureau is a subdivision of the NMDOT. Created in 2007, the ITS Bureau of New Mexico aims to improve safety for residents, visitors and travelers as well as to make the drivers of New Mexico better informed of road conditions[61]. Currently there are four cities in New Mexico that have an ITS Bureau: Santa Fe, Albuquerque, Farmington, and Las Cruces. Throughout the state there are 64 DMS and 85 traffic cameras owned and managed by the ITS Bureau of NMDOT.

The New Mexico ITS Bureau informs the public with real-time traffic information through communication outlets such as dynamic message signs and their online tool and app, NMRoads[62].

NMRoads is an online and mobile application developed by the ITS Bureau to deliver real time traffic information to the citizens of New Mexico. It consists of an interactive map that displays crucial information such as traffic accidents, traffic speeds, and road conditions to drivers. Drivers can view live camera feeds at over 70 locations and can access over 30 DMS that provide information to drivers[63]. The interactive map shows roads that are closed and indicates the severity of driving conditions due to weather and other causes. The features of NMRoads help drivers become aware of unsafe driving conditions, thus allowing travelers to adjust travel plans before or during a trip. The ability to convey traffic information can greatly reduce accidents and save people time from sitting in traffic.

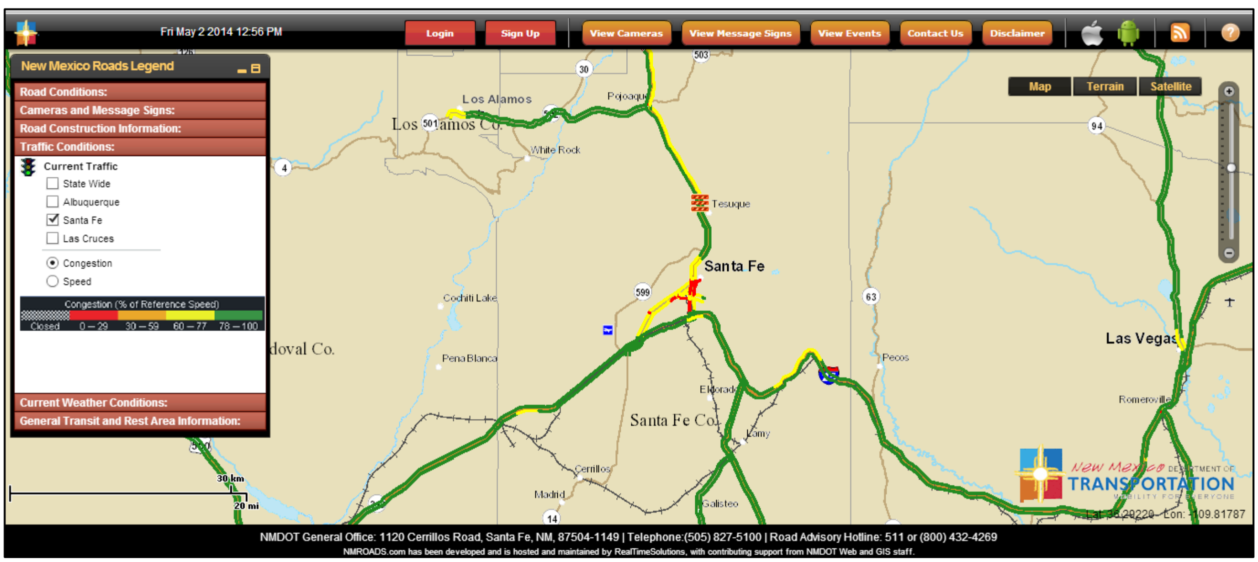

Figure 18: NMRoads web application

The ITS Bureau of New Mexico is responsible for knowing where their infrastructure is along with where the utility lines are underground. Therefore, a detailed inventory of the ITS infrastructure is needed for this service. **The 811 System** is a federally mandated "Call before You Dig" number that was created as a free tool for consumers to use before digging in order to avoid hitting underground utility lines. Consumers can dial 8-1-1 anywhere in the country 24-72 hours prior to digging in order to find out where their underground utilities lie[64]. The call is routed to a local One Call Center and information such as the location of the dig and the type of work that will be done at the dig is provided by the consumer. The Center will then notify the local utilities companies and request a locator crew from a

[61] (Shepherd 2012)
[62] (Shepherd 2012)
[63] (State Guides 2014)
[64] (Common Ground 2014)4

local utility company to mark the approximate location of underground lines, pipes, and cables[65]. The New Mexico 811 One Call, Inc. uses an online form for regular submission, and a phone line for emergency requests[66]. In addition to the 811 line, there are also Albuquerque and statewide phone numbers to use during regular business hours[67]. The New Mexico 811 has received high marks on the 2013 survey results for customer satisfaction[68].

2.2.4 Intelligent Transportation Systems in Santa Fe

Based on the National ITS Architecture, District 5 (which makes up the Santa Fe region) implemented a Regional ITS Architecture that laid out a 15 year plan for transportation system integration in the Santa Fe region. The Regional ITS Architecture was developed in April 2005 and updated in December 2011 was developed cooperatively through all of the different transportation agencies in the Santa Fe region including the Santa Fe Metropolitan Planning Organization (SFMPO), the County, and the NMDOT. Through this Regional ITS Architecture, a plan to integrate the systems of each agency was developed. Essentially, this Regional ITS Architecture provides a plan to create a singular transportation system in a cost-effective manner out of the transportation agencies of the Santa Fe region[69]. This Regional ITS Architecture plan will be used by transportation planning agencies and organizations, operating and implementing agencies, and any other organizations and individuals that use the transportation system in the Santa Fe Region[70] Additionally, the Santa Fe Metropolitan Planning Organization (SFMPO) organizes transportation decision-making in the Santa Fe metropolitan area including the budget.

Currently, the ITS Bureau of New Mexico has four DMS and two CCTV along the three major corridors of Santa Fe (NM 599, Cerrillos Road, St. Francis Drive). The city of Santa Fe has 35 traffic signal intersections along the Cerrillos and St. Francis roadways, managed by the city’s traffic engineer. In 2012, a WPI research team analyzed six years of traffic data to produce the top twenty-five most hazardous intersections in the Santa Fe area as shown in Figure 19. The majority of the hazardous intersections are on Cerrillos Road and St. Francis Drive.

[65] (Common Ground 2014)
[66] (New Mexico)
[67] (NM811 2014)
[68] (Sloman 2014)
[69] (Santa Fe 2012)
[70] (Santa Fe 2011)

RANK	INTERSECTION
1	BERRY AVE @ 5TH ST
2	BECKNER ROAD @ CERRILLOS RD
3	COTTONWOOD AVE @ AGUA FRIA ST NM 588
4	ST FRANCIS DR US 84/285 @ CERRILLOS RD
5	JEMEZ RD @ RUFINA ST
6	RICHARDS AVE @ CERRILLOS RD
7	BARCELONA RD @ DON GASPAR AVE
8	SIRINGO RD @ YUCCA ST
9	ST MICHAELS DR @ PACHECO ST
10	BACA ST @ CERRILLOS RD
11	COUNTRY CLUB RD @ AIRPORT RD NM 284
12	RODEO RD NM 300 @ CERRILLOS RD
13	SILER PARK LN @ SILER RD
14	ZAFARINO DR @ CERRILLOS RD
15	OLD PECOS TRAIL @ RODEO RD NM 300
16	RICHARDS AVE @ RODEO RD NM 300
17	ST FRANCIS DR US 84/285 @ ZIA RD
18	ZEPOL RD @ AIRPORT RD NM 284
19	SILER RD @ RUFINA ST
20	CORDOVA RD @ ST FRANCIS DR US 84/285
21	CERRILLOS RD @ ST MICHAELS DR
22	SAN MATEO RD @ ST FRANCIS DR US 84/285
23	WAGON RD @ CERRILLOS RD
24	CAMINO CARLOS REY @ ZIA RD
25	SAWMILL RD @ ST FRANCIS DR US 84/285

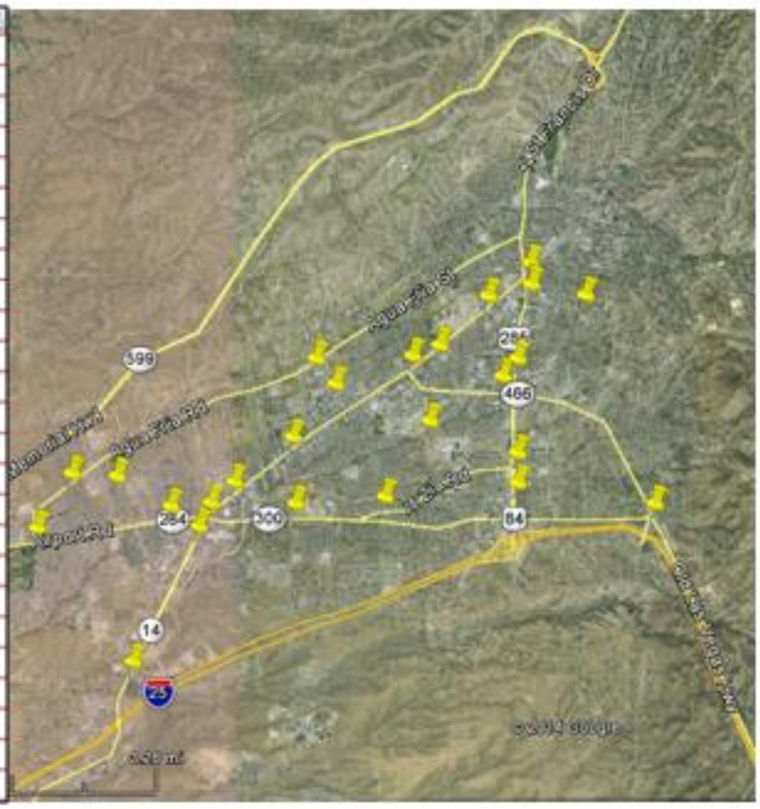

Figure 19: Top 25 hazardous intersections in Santa Fe[71].

2.3 Traffic Management

To manage the collection and delivery of traffic related information, ITS bureaus have developed traffic management centers. Traffic managers must provide up-to-the minute information to drivers about roadways including weather, traffic incidents, and road construction, all of which ultimately contribute to the most critical information: travel times[72]. Travel time information and traffic related updates are delivered to drivers via communication outlets such as dynamic message signs along the highways, traffic apps, and 511 traveler information phone system. This section explores the tools and infrastructure used in traffic management including traffic signals, adaptive systems, and the calculation of travel times. Additionally, we discuss the components of creating an integrated corridor.

Traffic management centers (TMC) are the hubs of highway monitoring and operations[73]. Such centers typically have a wall of video screens and desktop monitors connected to a network of cameras and road sensors[74]. TMC are managed by engineers, radio operators, and staff who are often referred to as traffic managers[75].

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[71] (Casola et al. 2012)
[72] (Washington 2014)
[73] (Washington 2014)
[74] (Washington 2014)
[75] (Washington 2014)

Figure 20: NMDOT traffic management center in Albuquerque

2.3.1 Traffic Signals

Traffic signals are designed to effectively and efficiently distribute the green light for the movements of traffic at intersections, provide accessibility for pedestrians, and reduce crashes. In the United States there are more than 300,000 traffic signals[76]. In the 2007 National Traffic Signal Report Card, the nation's traffic signal management and operations received a letter grade of "D", estimating that poor traffic signal timing is a large contributor to traffic congestion[77]. Currently there are various systems in use in the United States[78]. These systems are managed by traffic engineers who are responsible for the timing of the lights to handle traffic demands. Traffic signals operate in either pre-timed or actuated modes[79]. Pre-timed control consists of intervals that are fixed in duration while actuated control consists of intervals that respond to vehicle detectors[80].

Figure 21. Traffic Signal

[76] (Federal 2013)
[77] (Federal) 2009
[78] (Federal) 2009
[79] (Federal) 2009
[80] (Federal) 2009

Conventional signal timing systems have predetermined timing plans for particular times of the day, which assume consistency of traffic patterns[81]. Conventional timing systems are unable to account for unpredictable or variable traffic demand because they are limited to preset intervals, usually set for specific times of the day[82]. Advantages of pre-timed control include minimal maintenance and training to set up the traffic signal[83]. However, the conventional signal retiming process may only be repeated every three to five years because the process is time consuming and the traffic data must be collected manually[84]. Tools such as **Synchro** offer assistance to updating traffic signal timing patterns. This software uses the collected data to simulate traffic and calculate new timing patterns based on the model. Synchro scan also be used to analyze different conditions of the roadway. The operator of the software can adjust settings such as type of driver, vehicle classification concentrations, and phase optimization. Updating and retiming traffic signals is important to keep up with changing traffic patterns as well as provide shorter commute times, reduce driver frustration, and fuel consumption[85].

Actuated signal control is a type of signal control where each time phase is controlled by a detector, which is best used for intersections with irregular traffic volumes[86]. An actuated signal control typically has four hardware components: detector, controller unit, traffic lights, and the connecting cables[87]. The detectors are most commonly signal cameras or inductance loops, which are used to provide information about the traffic demand to the controller[88]. The duration of each traffic signal phase is determined in combination by the detector input and the controller parameters[89]. The actuated control can be characterized as fully-actuated or semi-actuated depending on the number of traffic movements that are detected[90]. **Semi-actuated control** uses detection only for minor movements whereas fully-actuated control requires detection for all traffic. Advantages of semi and **full actuated control** include reducing phase delay, which is part of a signal cycle allotted to one or more traffic movements receiving the right of way. This occurs because the system is responsive to traffic demand and changes in traffic patterns. However, both require more training than pre-timed control and are more expensive due to ongoing maintenance needs[91]. There are also traffic signal priority systems known as signal **preemption** devices (see Figure 22), which allow certain vehicles, typically emergency vehicles, to request light timings to be changed in their favor[92]. Emergency vehicles change light timings by using infrared transmitters[93].

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[81] (Pratishtha, Purohit, and Amrita 2012)
[82] (Federal) 2009
[83] (Federal) 2009
[84] (Federal) 2009
[85] (New Mexico 2011)
[86] (Yin 2008)
[87] (Lendido 2012)
[88] (Lendido 2012)
[89] (Federal 2009)
[90] (Federal 2009)
[91] (Federal 2009)
[92] (McHale 2002)
[93] (Federal 2012)

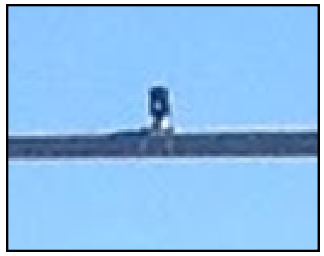

Figure 22. Preemption device placed on traffic signal poles to detect approaching emergency vehicles.

Due to the variability of traffic demand on primary arterial systems, which are main roads, local and state agencies are often unable to update traffic signal timings so that they operate efficiently without causing congestion or delays to travelers. By using real-time optimization, adaptive signal control allows the network to react to volume variations and current traffic patterns by adjusting when green lights start and end[94,95]. The main benefits of **Adaptive Signal Control Technology** (ASCT) include reducing congestion and fuel consumption, automatically adapting to unexpected changes in traffic conditions, prolong effectiveness of traffic signal timing, and improving travel time reliability[96]. ASCT work by receiving and processing data from sensors to optimize and update signal timing settings every few minutes[97]. In the United States, there are several adaptive systems available from different vendors, each being unique in how it approaches the adaptive control concept[98]. The widely used adaptive traffic control systems are Split Cycle Offset Optimization Technique (SCOOT), Sydney Co-ordinated Adaptive Traffic System (SCATS), and InSync[99].

2.3.2 Travel Time Calculation

Reliability of travel time information is very important to travelers across the country, whether they are vehicle drivers, transit riders, or freight shippers. Business and personal travelers need reliable travel times because it allows them to make better use of their time by seeking a faster route. Freight carriers require predictable travel times in order to make money. Reliability is very important for transportation system users, and travel time estimates need to be considered as a key performance measure to decision makers or transportation planners.

In calculating travel times, a common ITS infrastructure used is **Bluetooth detection.** Bluetooth detection technology has been around for nearly twenty years, but Bluetooth detection for travel data collection has only emerged as a viable option in recent years[100]. The option for Bluetooth data collection has only emerged because of the rapid growth in the number of Bluetooth-enabled devices such as phones, tablets, laptops and some GPS devices, each of which may be used to harvest traffic information[101]. Bluetooth devices communicate with each other through radio frequency over short distances. In order for a Bluetooth detection system to work the device must be turned on with Bluetooth enabled[102]. Since each device has its own personal media access control (MAC) address, Bluetooth detection systems can determine vehicle travel times and speeds by calculating the time it takes the Bluetooth-enabled device to travel between two Bluetooth detectors located at a known

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[94] (Federal 2009)
[95] (Federal 2013)
[96] (Federal 2013)
[97] (Federal 2013)
[98] (Federal 2013)
[99] (Department of Transportation 2013)
[100] (Federal 2013)
[101] (Federal 2013)
[102] (Federal 2013)

distance apart[103]. The placement of Bluetooth sensors is simple, which enables them to be placed at various locations as long as there are no major line-of-sight barriers[104]. The reliable detection distance can reach up to 328 feet (100 meters) which allows for flexibility in placement[105]. The ideal height for the mounted sensor is between 12-15 feet above the monitored road, and no more than four miles apart[106]. Bluetooth units can be pole-mounted or fastened to existing infrastructure or power systems such as batteries and solar panels[107]. There are currently three *BlueTOAD* brand Bluetooth sensors located along Cerrillos Road in Santa Fe as shown in Figure 23. The three locations of the Bluetooth sensors, from south to north, are at the intersections of Cerrillos & Airport, Cerrillos & Ashbaugh Park, and Cerrillos & Camino Consuelo.

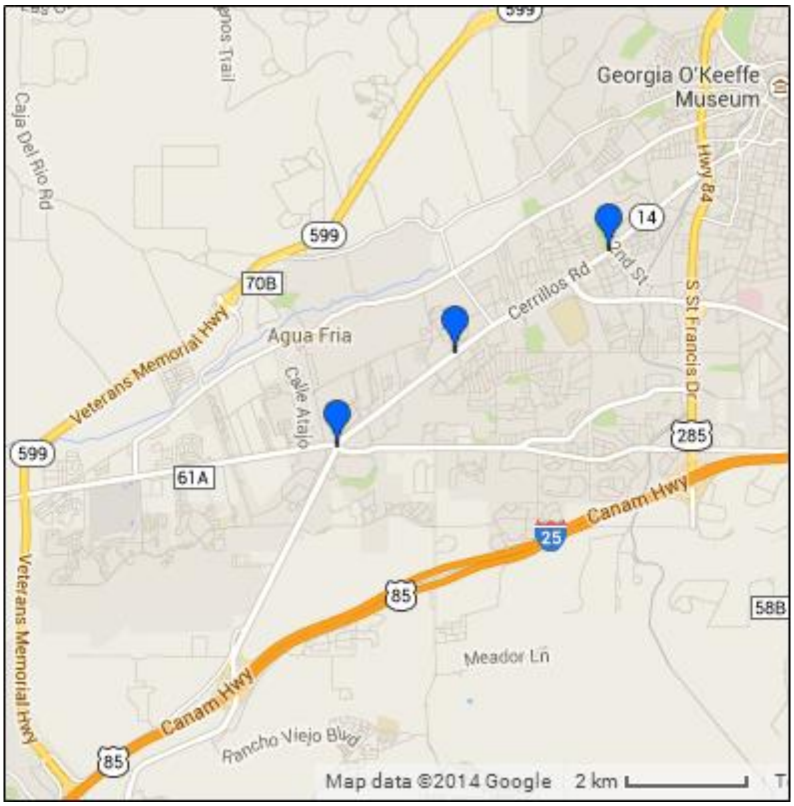

Figure 23. This google map image displays the locations of the three Bluetooth detectors along Cerrillos Road in Santa Fe.

Another common resource used in calculating travel times is **INRIX data**. INRIX is a company that provides traffic data services to both public and private organizations. INRIX compiles roadway and traffic information from mobile phones, fleet vehicles equipped with GPS locator devices, and consumer cellular-based devices that can use browsers such as smartphones[108]. Their collected data on traffic information covers one million miles of roads in North America and one million kilometers in 28 European countries, which is enough distance to circle the globe 64 times[109]. The data is processed in real-time via sophisticated, proprietary algorithms, which provide up-to-date traffic speed information

103 (Federal 2013)
104 (Federal 2013)
105 (Federal 2013)
106 (Federal 2013)
107 (Federal 2013)
108 (INRIX 2014)
109 (Department of Transportation 2013)

that can then be delivered to the consumer[110]. INRIX can also calculate future and historical traffic information for most highways, arterial roadways, city streets, and secondary roads in 30 countries. INRIX offers applications and tools to help develop and integrate INRIX traffic data into other programs through tools such as INRIX DevZone[111]. INRIX DevZone allows users to select segments of roadways to view travel times and congestion[112]. INRIX also offers a traffic app for smartphones, which helps collect and deliver traffic data, send congestion alerts, real-time and predictive traffic flow, traffic cameras, and journalistic incident data[113]. INRIX sells their data for a fee, which varies based on the specific use of the proposed data. The NMDOT ITS uses INRIX data in Albuquerque for travel times, but does not currently purchase INRIX data for Santa Fe[114].

Google Maps calculates travel times with current traffic conditions by crowdsourcing data from mobile devices. Crowdsourcing is a community or "crowd" organized online, that invites people to submit information for an organization[115]. When Google Maps with My Location is enabled on mobile devices, Google receives anonymous bits of data telling them how fast the vehicle is moving, which is then used in calculating travel times along roadways[116]. Currently Google Maps covers over 200 countries worldwide.

2.3.3 Integrated Corridor

An integrated corridor coordinates arterial roadways into one functioning system, often bringing together different agencies and entities which are responsible for corridor mobility[117]. Among the benefits of an integrated corridor are incident response, demand management, load balance, event response, increase safety, and travel time reduction[118]. The success of such a corridor can be measured by safety, mobility, reliability, emissions, and fuel consumptions[119]. Technical complexity and interagency coordination are some of the challenges of integrated corridors[120]. In the United States there are currently two cities with implemented integrated corridor systems: San Diego, California and Dallas, Texas. In 2006, the USDOT released an implementation guide that explained the process of creating and installing an integrated corridor in a major city. The pioneer cities, implementation guide, and integrated corridor tools will be explained more in the following paragraphs.

San Diego launched its ICM system in September 2011 for one of its interstate highways,, I-15. Weekday traveler numbers for this interstate typically exceeds 175,000 vehicles. The San Diego Association of Governments contributed $2.2 million of the $10.9 million project[121]. San Diego saw a benefit-cost ratio of 10:1 with improvements of travel time reliability of 10.6% based on analysis, modeling, and simulation of the integrated corridor[122]. Dallas launched its ICM system in January 2012 for the interstate highway, US-75, that connects downtown Dallas to the suburbs north of the city[123]. Over 250,000 vehicles typically travel this highway during a given weekday[124]. Based on initial analysis,

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[110] (INRIX 2014)
[111] (Department of Transportation 2013)
[112] (Department of Transportation 2013)
[113] (INRIX 2014)
[114] DiRuggiero. Personal communication
[115] (Shepherd 2012)
[116] (Barth 2009)
[117] (Anonymous 2013)
[118] (Anonymous 2013)
[119] (Brian et al. 2010)
[120] (Anonymous 2013)
[121] (Anonymous 2013)
[122] (Vassili et al. 2008)
[123] (Anonymous 2013)
[124] (Anonymous 2013)

simulation, and modeling, Dallas saw a Benefit-Cost Ratio of 20:1[125]. Dallas citizens have saved 740,000 personal hours and 981,000 gallons of fuel annually because of the ICM system[126]. The Dallas Area Rapid Transit funded roughly $3 million of the $8.3 million project[127].

Both San Diego and Dallas followed the ICM implementation guide that was released by the USDOT. This guide explains the seven phase process to implement an integrated corridor[128]. The seven phases are:

1. *Getting Started*: This phase includes identifying and coordinating the participants and information necessary to plan an ICM project.
2. *Establishing Goals*: This phase includes initiating the planning for an ICM project as well as informing stakeholders.
3. *Plan for Success*: This phase includes organizing the management and technical programming of ICM. This phase is divided into three main parts: the project management plan, the systems engineering management plan, and the concept of operations. The project management plan includes developing the project scope, tasks, schedule, and costs. The systems engineering management plan is developed to manage the complexity of the project, while the concept of operations is defining the ICM system that will be built.
4. *Specify and Design*: This phase includes the specifications and design of the ICM, which is broken down into three divisions: architecture, system requirements, and system design. The architecture step includes the modeling of the system, while the detailed design accounts for the physical components such as hardware, software, and items.
5. *Build and Test*: This phase begins the implementation of the system after the detailed design has been approved.
6. *Operate and Maintain*: This phase includes operating the system, performing diagnostics, and making repairs or updates to the system.
7. *Retire/Replace*: This phase includes replacing some or all of the ICM system.

Currently both pioneer sites are in phase six, the “operate and maintain” phase. Examples and lessons learned from each site are included in the implementation guide to assist any organization looking to implement their own integrated corridor[129]. The full implementation guide can be found online via the link provided in Appendix 1. In this project, we focused on phases three and four.

[125] (*Integrated corridor management* 2008)
[126] (Brian et al. 2010)
[127] (Anonymous 2013)
[128] (Anonymous 2013)
[129] (Anonymous 2013)

3. METHODOLOGY

The goal of this project is to initiate a strategic plan to implement an integrated corridor in the city of Santa Fe, with the expectation that this will ultimately increase traffic safety and mobility. To complete this mission, our team set the following objectives:

1. To inventory all of the ITS and related infrastructure in and around Santa Fe
2. To evaluate different methods of calculating travel times for each corridor of Santa Fe
3. To perform an analysis of implementing an integrated corridor in Santa Fe

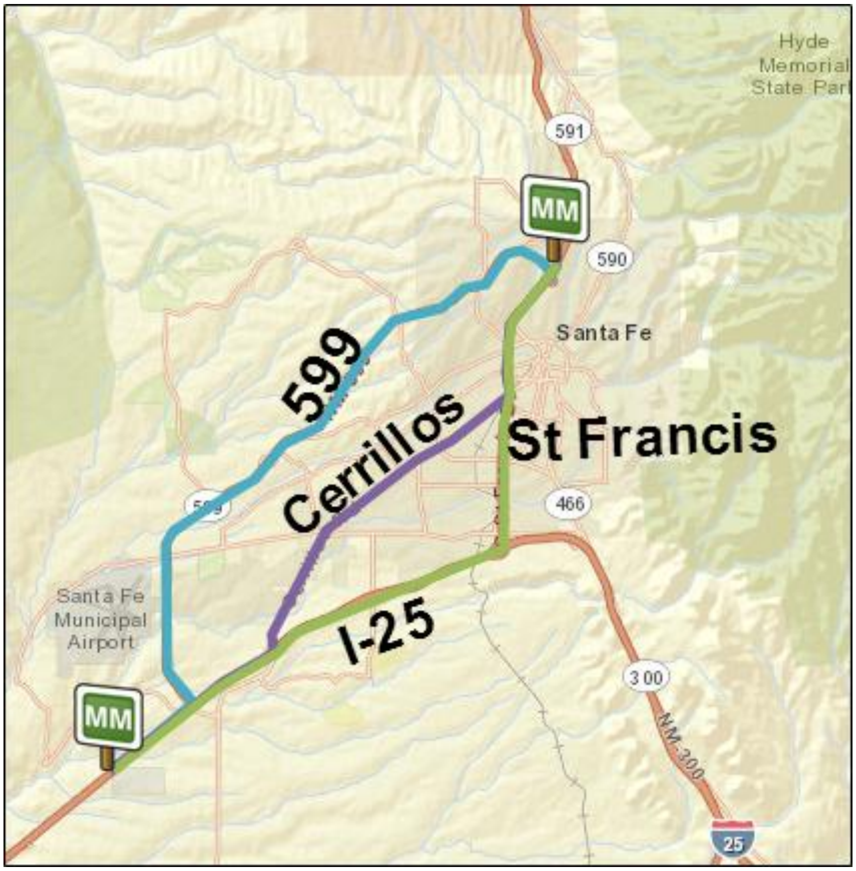

Figure 24. The study area of our project includes the region in and around Santa Fe. Our main focus was on the three corridors within Santa Fe: NM 599, NM 14 or Cerrillos Road, and US-84 or St Francis which are highlighted.

We completed our project between March 16th, 2014 and May 9th, 2014. During this time in Santa Fe, we operated in the area depicted in Figure 24. The following sections detail the methods we adopted to achieve each of the objectives listed above.

3.1 Inventorying the Santa Fe ITS and Related Infrastructure

The NMDOT currently inventories CCTV traffic cameras, CCTV traffic camera poles, and DMS that are owned and maintained by the NMDOT, but did not have a detailed inventory for their items in the Santa Fe area. The Traffic Engineering Department of the City of Santa Fe is responsible for keeping an inventory of its own infrastructure, and knew the current status of all of its equipment, but did not have a detailed written inventory. During our time in Santa Fe, we created a detailed inventory for both the NMDOT and the City of Santa Fe's ITS infrastructure modeled on the spreadsheets provided by our sponsors. Some information collected includes item name, GPS location, serial number, hardware devices, and photos. We inventoried NMDOT equipment along I-25 and US-85. For the City of Santa Fe, we inventoried Santa Fe equipment at the intersections along Cerrillos Road and St. Francis Drive. Additionally the GPS location was used to create maps for the infrastructure using ArcGIS, an online mapping software. The following sections describe our methods for inventorying the ITS infrastructure for the NMDOT and the City of Santa Fe.

3.1.1 Creating an Inventory

The first stage in creating an integrated corridor is to obtain a detailed inventory of the current infrastructure in use. In creating the inventory we used Microsoft Excel spreadsheets, some of which were provided to us by our sponsors and others we created on our own. The items we inventoried were:

- DMS
- CCTV Traffic Cameras
- CCTV Traffic Camera Poles
- Traffic Signals
- Signal Poles
- System Cabinets
- Meters
- Communication Hardware
- Vehicle Detection

Spreadsheets for the DMS, CCTV traffic cameras, and CCTV traffic camera poles were directly provided to us by our sponsors. Specific attributes for these items and the completed spreadsheets themselves can be found in Appendix 2. Information gathered for the intersections along Cerrillos Road and St. Francis Drive, as well as specific attributes for each item, can be found in Appendix 3. The system Cabinets inventory sheets for Cerrillos Road and St. Francis Drive were provided to us by our sponsors, and the traffic signal intersections inventory sheets for Cerrillos Road and St. Francis Drive were created by this IQP team. Additionally, information on all infrastructure was accurate and detailed enough to be used by 811 call before you dig services.

Tasked with creating an accurate and detailed inventory, we took the opportunity to pilot a new portable online form (from the *City Knowledge* Console) for inventorying the intersections along Cerrillos Road and St. Francis Drive. We compared the utility of this form with data that we simultaneously collected with Trimble™ GPS device and spreadsheets. Since Trimble™ devices are costly, we hoped that our alternative method might serve as a more economical way for the NMDOT to collect field data in the future.

The current method used by the NMDOT for collecting infrastructure information is to examine the final building plans that are on file or have a state worker go out to the site equipped with a Trimble™ GPS device and a computer. The Trimble™ device can cost upwards of $5,000. A Trimble™ device collects the GPS locations of each infrastructure item. Data collected by the Trimble™ must go through a processing period where the accuracy of the information is enhanced before it can be downloaded.

Additional information about the infrastructure item must be recorded using the computer and uploaded at a later time. This method of collecting and enhancing the data is a time consuming process.

Figure 25 Trimble™ device used for obtaining GPS locations while inventorying

The online form was created using the City Knowledge Console, to increase the efficiency of data collection. With the help of Mr. Benny Lichtner, a programmer responsible for coding the City Knowledge online form, we developed and tested this collection method. The online form was constructed to operate through a web tool known as the City Knowledge Console that is being developed by Professor Fabio Carrera, based on his doctoral research at MIT. This form is accessible on any device with a web browser, such as smartphone, which is provided to all NMDOT employees. Our portable inventory forms utilized the smartphone's GPS location triangulated through local cell phone towers and wireless networks. The forms also featured drop down menu options as well as a way to embed a picture. Once an item was inventoried with the online form, it was automatically added to a master data sheet for that type of infrastructure. This eliminated the step of having to download the Trimble™ data and upload it to the web. Using the City Knowledge console, the ITS infrastructure item was automatically populated into the correct map. We expect that these features of the online form would greatly increase the efficiency as well as reduce the cost of inventorying the infrastructure. Thus, we used this online form to compare its accuracy against that of the Trimble™ device, specifically with respect to GPS location data.

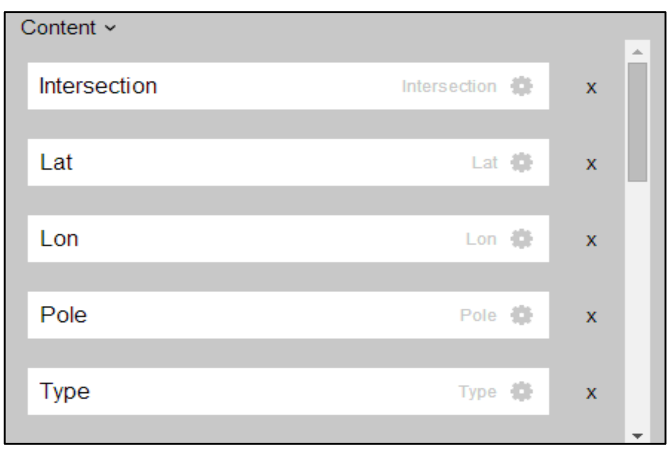

Figure 26: City Knowledge online form used while inventorying traffic lights

3.1.2 Inventorying NMDOT and City of Santa Fe Infrastructure

We confirmed and expanded the existing inventory of NMDOT ITS infrastructure by revisiting all CCTV traffic camera sites and DMS located in the greater Santa Fe area between March 28, 2014 and April 1, 2014. This included Espanola, Pojoaque, and the City of Santa Fe (Figure 27).

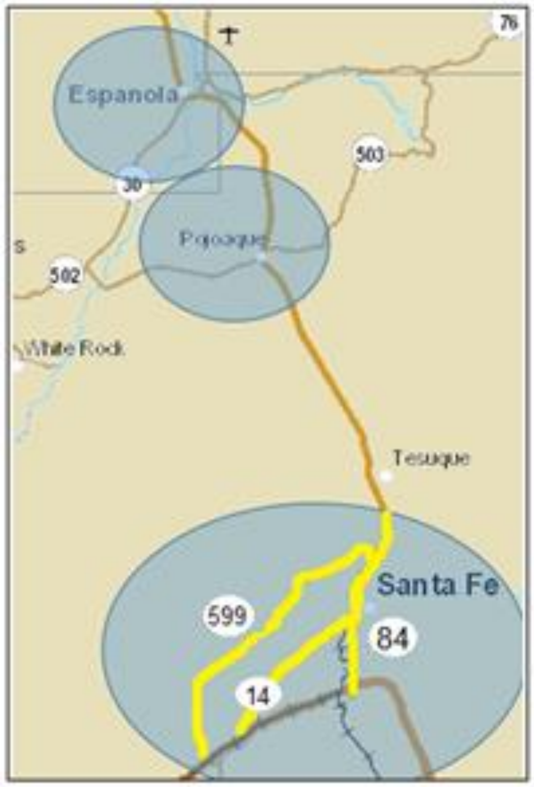

Figure 27.Map detailing the locations of Santa Fe, Espanola, and Pojoaque, and the three main roads through the city of Santa Fe

Additionally we created the new inventory for the ITS-related infrastructure owned by the City of Santa Fe. We inventoried 22 traffic intersections along NM 14 (also known as *Cerrillos Road*) between April 5, 2014 and April 11, 2014. Similarly we inventoried 11 traffic intersections along US-84 (also known as *St. Francis Drive*) between April 14, 2014 and April 17, 2014. The ITS infrastructure inventoried at each traffic intersection included: traffic cabinets, traffic lights, inductance loops, BlueTOAD devices, radar, signal cameras, and controllers.

The DMS, CCTV traffic cameras, CCTV traffic camera poles, system cabinets, and traffic signal intersections each had their own Excel spreadsheet. While out in the field, we used a computer to populate the Excel spreadsheet for each infrastructure item for the NMDOT infrastructure. The online form was still under development when we inventoried NMDOT equipment, so we were not able to use this method. For the Santa Fe infrastructure, we pilot-tested the online form, so we entered the data both into the form and the Excel spreadsheets. Our team used the Trimble™ device to acquire the GPS locations for the NMDOT infrastructure items and both the Trimble™ device and the online form to obtain the GPS locations for the City of Santa Fe infrastructure items. This was done to further compare the two methods.

After completing our inventories, we compared two methods of collecting data in the field: the Trimble™ device and Excel spreadsheet method and the online form. From there we made a recommendation. The factors we considered were cost, accuracy, time, and user friendliness. Accuracy was evaluated by comparing the GPS location data from both the Trimble™ device and the online form by mapping the actual location of the inventory items using the latitude and longitude coordinates in ArcGIS.

3.1.3 Mapping the ITS Infrastructure

In addition to the standard data spreadsheets inventory, our inventory also contained a mapping component to help visualize the location information. We were able to use data from both the Trimble™ and the online form, and then used these maps as part of our evaluation of inventory methods. Once the GPS location was collected for each infrastructure item throughout Santa Fe and the surrounding area, the location for each item was mapped using ArcGIS. Trimble™ data was downloaded off of the device and then sent through processing at the NMDOT to increase the accuracy of each point recorded. After the points were finalized and processed, the data was then converted into shape files and returned to us. We took each shape file that we uploaded and made different layers on the map that we later manipulated to create layers specific to each infrastructure item.

We also mapped the data by using the information collected from our online forms. As previously mentioned, this only covered the City of Santa Fe ITS infrastructure, as the form was not yet developed when we inventoried the NMDOT infrastructure. These maps were automatically generated within the City Knowledge online software from which the forms were created. The latitudinal and longitudinal data were collected automatically by the form in real time while we were out in the field and it was this data that was then mapped. The maps themselves could be accessed online.

3.2 Determining and Displaying Travel Times

A common use of DMS across the United States is to display travel times to travelers. Our sponsors asked us to produce recommendations to maximize the effectiveness of the DMS currently deployed in the Santa Fe area. These signs are currently located before major decision points on I-25 and US-84 where travelers can take either NM 599, Cerrillos Road, or St. Francis Drive to pass through the city of Santa Fe. In order to do this, we first needed to determine the best method to calculate travel times. We describe the methods we used to do this in the sections below.

3.2.1 Comparing Travel Time Estimates

We determined the travel times of the each arterial roadway by picking a time in the morning, afternoon, and evening during weekdays when traffic congestion exists. This is based on the standard assumption of times for morning and evening rush hours as well as a general time during the day. We collected travel times on May 6, 2014. Originally we had planned to use a Dashboard widget to automatically collect the travel times. The Dashboard technology consists of widgets that are fully customizable for the user. The user has the ability to rearrange, remove, and add widgets as they see fit, making the technology user friendly. Unfortunately the application programming interface (API) could not be accessed to collect and store the travel times, which gave us a short time frame to collect data.

We collected data on travel times in the locations shown in Figure 28. For the blue segment labeled “A”, we collected travel time data using three methods (Google Maps, INRIX, and BlueTOAD devices already in place) to compare against empirical data we collected from actual drive times during our field tests. This was the only section of road for which we were able to do a full comparison, because of the limited placement of the BlueTOAD devices. For the black segment labeled “B”, we did the comparison of Google Maps and INRIX data against field tests. Due to logistical limitations we were unable to collect field test data for NM 599 and St. Francis Drive. We chose to focus our efforts on Cerrillos Road because the BlueTOAD devices were placed along this route and it is the most congested road with the largest number of traffic intersections.

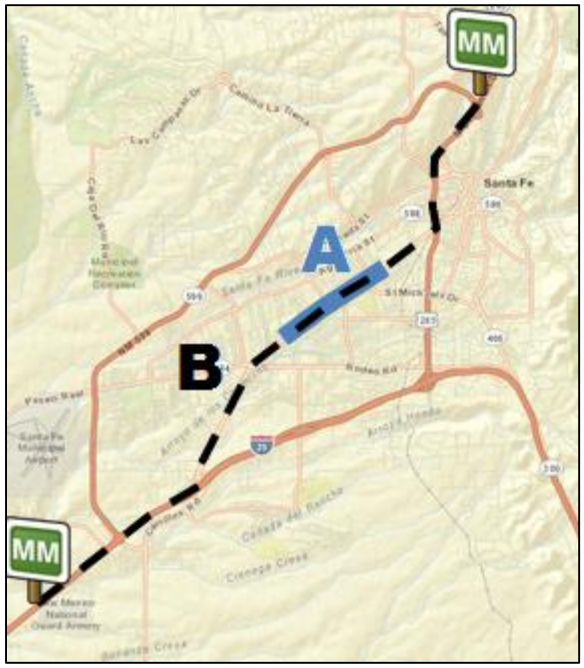

Figure 28: Locations of where travel times were collected in Santa Fe. "A" represents the segment of Cerrillos covered by BlueTOAD devices while "B" is the entire Cerrillos corridor between each DMS.

In Santa Fe, travel times are currently calculated using BlueTOAD Bluetooth technology. The area covered by BlueTOAD is a small segment of Cerrillos Road covering about 3.3 miles from Cerrillos & Airport Road to Cerrillos & Ashbaugh Park (labeled "A" in Figure 28) so this was the region we used to carry out our pilot test comparing the accuracy of alternative methods. Using each method at the same point in time, we calculated the travel times from Cerrillos & Airport Road to Cerrillos & Ashbaugh Park. We were given access to the BlueTOAD data, which allowed us to access the travel time information for the segment of Bluetooth sensors placed along Cerrillos Road. To obtain the travel times we had to click on the segment of the road and the travel time for that specific segment along with the current speed would be displayed on the side panel as shown in Figure 29.

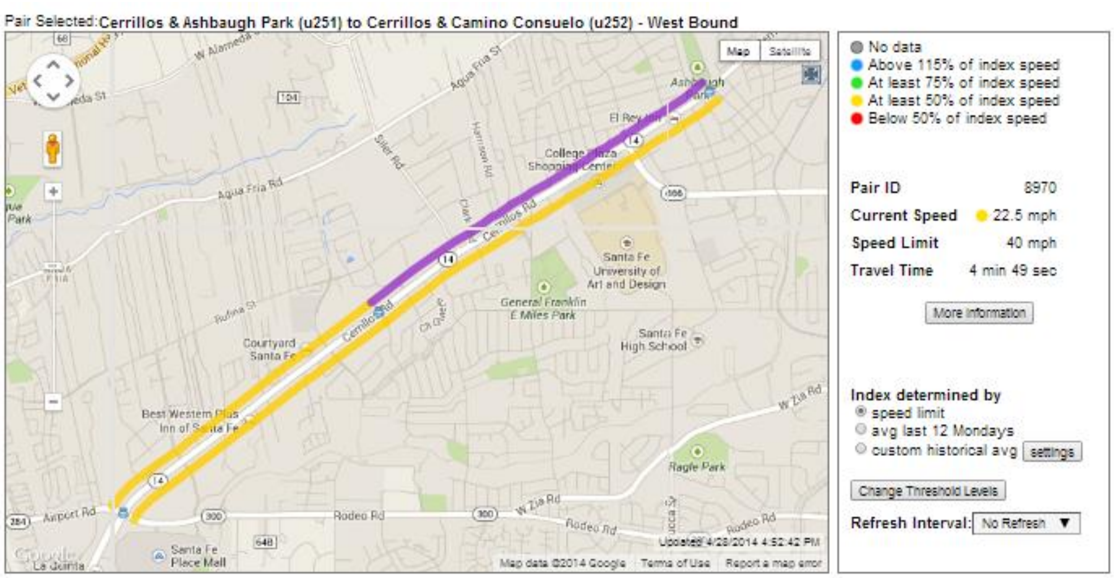

Figure 29. Calculation of travel times using BlueTOAD traffic cast website.

We determined the travel times for the identical segments via Google Maps by inserting the GPS location of the BlueTOAD devices and selecting the road segment. The GPS location of the BlueTOAD devices were obtained from our inventory. The travel times given the current traffic conditions is displayed on the panel for the selected route as shown in Figure 30. We obtained both northbound and southbound direction by reversing the coordinates.

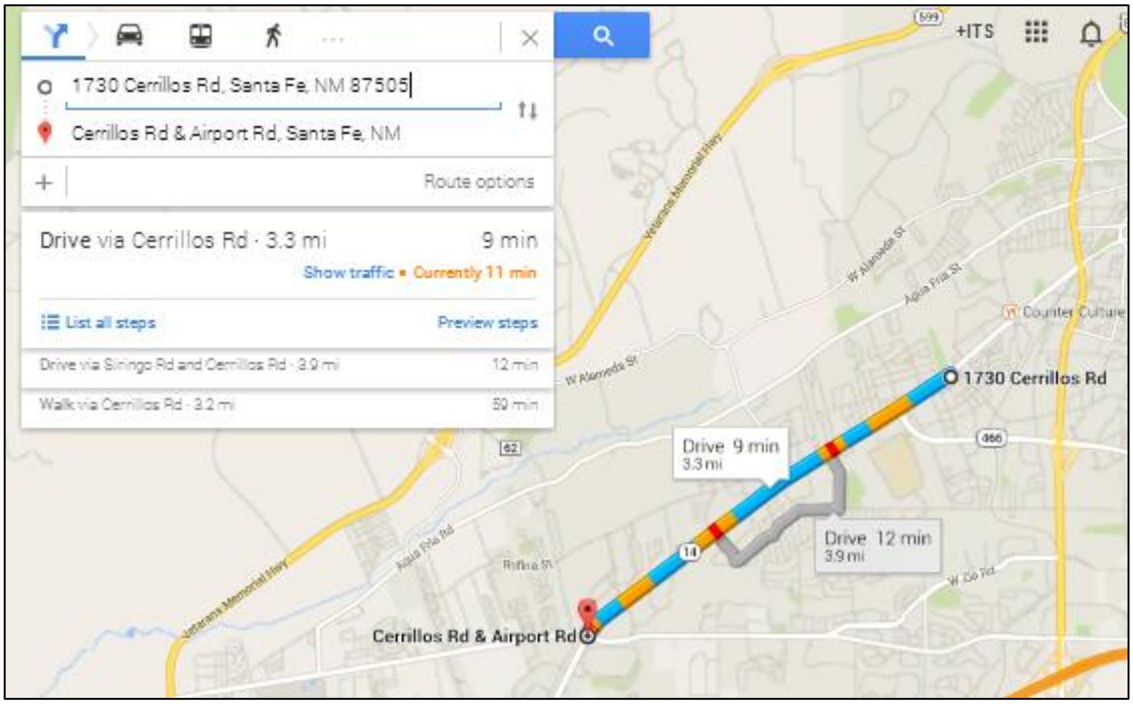

Figure 30: Calculation of travel times using Google Maps

We used our demonstration access of INRIX DevZone to acquire the travel time data for the same segment on Cerrillos Road. Within INRIX DevZone we calculated the travel times along the segment by inserting the GPS locations of the BlueTOAD devices and selecting the segment in either northbound or southbound direction. Each route was then saved in the program for ease of recording travel times at a later time. The INRIX data provides current travel times along with uncongested travel times for each route as shown in Figure 31.

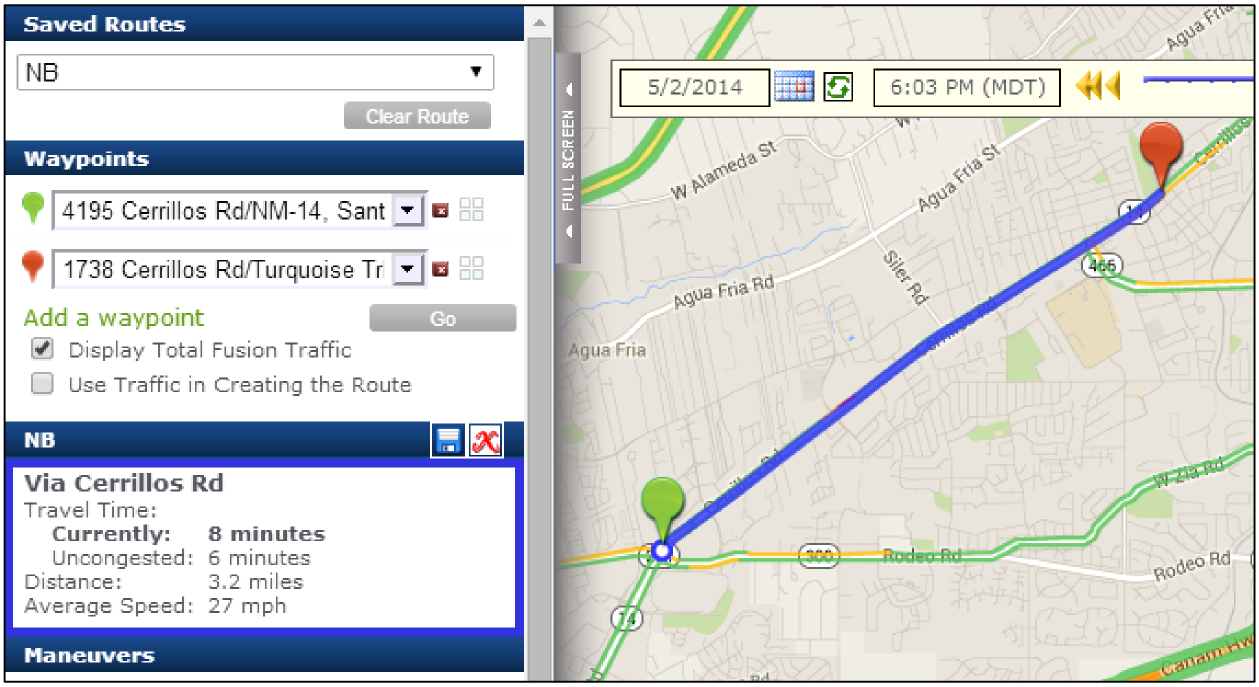

Figure 31. Calculation of travel times using demonstration access of INRIX DevZone.

In our field test, we drove the segment of Cerrillos & Airport Road to Cerrillos & Ashbaugh Park. We drove the posted speed limit of the road in both southbound and northbound directions. Each person of our team was assigned a task to either drive, time the driving with a stopwatch, or record the travel times using Google, INRIX, and BlueTOAD. Our field testing was completed to have a baseline for comparing the accuracy of the other methods.

To record the travel times of Google, INRIX, and BlueTOAD, we took a screenshot of each captured travel time, which would later be compiled into a table along with our recorded driving time. We then compared the data to see which of the three methods was closest to our field test travel time. We filled in Table 1, which allowed us to analyze the data more easily.

Table 1: Comparison of travel times collected for northbound (NB) and southbound (SB) along Cerrillos Road at different time points using Google Maps, INRIX, BlueTOAD, and Field testing.

	Morning 1		Afternoon 1		Evening 1	
	NB Cerrillos	SB Cerrillos	NB Cerrillos	SB Cerrillos	NB Cerrillos	SB Cerrillos
BlueTOAD						
INRIX						
Google						
Field Test						

Our full comparison of all three methods was limited to the small area covered by the BlueTOAD devices Figure 28. Therefore, we still needed to obtain travel times for the arterial roadways. We calculated the travel times from the location of the DMS on I-25 to the DMS on US-84 via Cerrillos Road, which is labeled "B" in Figure 28. Unfortunately due to a time constraint we were only able to field test Cerrillos Road. The location of each DMS was obtained from our inventory. While two members of the team conducted a field test by driving and recording their travel times as described above, two stayed at home to record the travel times via Google and INRIX.

We determined the travel times via Google Maps using the same method described above by inserting the GPS location of the DMS and selecting the corridor. Additionally, we used demonstration access to INRIX DevZone the same method as described above to obtain the travel times by inserting the GPS locations of the DMS and selecting the corridor in either northbound or southbound direction.

We took a screenshot of both Google and INRIX travel times and filled in Table 2 with the recorded times as well as the times recorded from our field test.

Table 2: Comparison of travel times collected for northbound (NB) and southbound (SB) along Cerrillos Road at different time points using Google Maps, INRIX, and field test data.

	Morning 1		Afternoon 1		Evening 1	
	NB Cerrillos	SB Cerrillos	NB Cerrillos	SB Cerrillos	NB Cerrillos	SB Cerrillos
INRIX						
Google						
Field Test						

In addition to accuracy of data the cost of the data was obtained for each method and considered in our recommendation to our sponsors. The estimated cost for each method was obtained by contacting BlueTOAD, Google, and INRIX.

3.3 Assessing the Implementation of an Integrated Corridor

With hopes of reducing traffic congestion, cities across the United States have started to implement integrated corridor systems. An integrated corridor coordinates several transportation networks into one functioning roadway system often combining resources from multiple agencies. Our sponsors asked us to perform an analysis of creating an integrated corridor within Santa Fe. In order to this, we needed to determine the feasibility of implementing an adaptive timing system for traffic signals along the proposed corridor and perform a benefit-cost analysis. We describe the methods we used to do this in the sections below.

3.3.1 Assessing the Adoption of Adaptive Signal Control Technology

An adaptive signal control system uses real-time optimization to react to traffic demand by continuously updating when green lights start and end. An adaptive system works by receiving and processing data from sensors to optimize and update the signal timing setting every few minutes. In creating an integrated corridor the adaptive system adjusts to handle changes in traffic demand, which is important in accident management. If there was an accident on one of the arterial roadways, the adaptive system could accommodate the change in traffic demand. Our sponsors asked us to determine the feasibility of implementing the adaptive system InSync from Rhythm Engineering[130].

To determine the feasibility of implementing InSync, we used our inventory of Cerrillos Road and St. Francis Drive to understand the type of vehicle detection, communication, and traffic controllers in use at each intersection. Once we knew the existing infrastructure, we conducted an informal interview with two of Rhythm engineering's sales representatives, Chuck O'Connor and Charles Whitfield, on April 15, 2014. We asked the following questions:

- How feasible is it to implement InSync with an existing system?
    - This question was intended to determine if we needed to replace the entire traffic signal system at each intersection or if the adaptive system could integrate with current parts of the existing system.
- What hardware will be needed to install the adaptive system? Santa Fe has two different controllers in use, is this alright?
    - This question was intended to determine what hardware would need to be purchased and installed in addition to the existing infrastructure to implement the adaptive timing system.
- What type of communication between traffic intersections is needed to install InSync? Currently Santa Fe has a mixture of communication lines.
    - We needed this information to evaluate if the current communication system in place between traffic intersections was sufficient or if the communication system would need to be upgraded.
- Will you be able to use the existing vehicle detection methods (radar, inductance loops, cameras, etc.) already in use in Santa Fe?
    - This question was intended to determine if existing vehicle detection methods could be utilized to ultimately save money in installing the adaptive signal control system.
- Is InSync a ring based system?
    - This question was intended to determine how the adaptive system serves the vehicles in queue. A traditional ring based system serves vehicles a green light in a repeated pattern.
- How difficult it is to implement an adaptive system when one or more coordinated corridors intersect the one using an adaptive system?
    - This question was intended to determine if the adaptive system would function even though it intersects with arterial roads that are not managed by an adaptive system.
- One of the intersections intersects with a train, will this affect the progression of the adaptive system?
    - We needed this information to determine if and how the adaptive system could handle interruptions by the Rail Runner Train.
- How quickly does InSync update its timing patterns?
    - We needed this information to determine if the adaptive system could improve Santa Fe's peak travel times which last approximately fifteen minutes.
- Can you do vehicle classification with InSync cameras/equipment?

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[130] (Federal 2013)

    - We needed this information to determine if the NMDOT can utilize the technology to obtain vehicle classification, which state governments are required to report to FHWA.
- What is the cost to implement and install InSync?
    - We needed this information to determine the cost of implementing the adaptive system and to perform a benefit-cost analysis.
- Where any safety studies conducted after implementing InSync?
    - We needed this information to evaluate the benefits of implementing InSync, which could be later used in the benefit-cost analysis.

- What improvements have been seen in the performance and wait time after implementing InSync?
    - We needed this information to estimate how beneficial implementing the adaptive system would be.

From our interview we determined the feasibility of implementing an adaptive system. The feasibility analysis took into account what pre-existing infrastructure could be utilized as well as the cost of implementing the hardware that needs to be purchased for installation. We did this by comparing the hardware requirements of the adaptive system to the existing infrastructure at each intersection we inventoried. The hardware requirements of the adaptive system included communication lines and vehicle detection methods. We also looked at the associated cost with implementing the adaptive system by upgrading communications or purchasing vehicle detection for each intersection along Cerrillos Road and St. Francis Drive.

3.3.2 Calculating the Benefits and Costs of an Integrated Corridor

There are several benefits provided by an integrated corridor. Benefits include demand management, load balance, peak spreading, incident response, and improvements in traffic safety and mobility[131]. The intent of implementation of the integrated corridor is that the benefits outweigh the cost to complete and maintain the project. In our analysis, it is important to note that we estimated the costs that would accrue to the NMDOT and the benefits that would accrue to the citizens.

The first stage in creating a benefit-cost analysis was to determine the cost for each arterial roadway of the integrated corridor as well as the total system. We examined the costs for the following sections:

- Adaptive signal timing system installed on Cerrillos Road
- Adaptive signal timing system installed on St. Francis Drive
- Adaptive signal timing system on both Cerrillos Road and St. Francis Drive

The calculations were based on figures provided by Ted Trepanier of Rhythm Engineering[132]. These prices included the cost of hardware installation as well as the price for updating the communications between each traffic intersection. Additionally there was a $5,000 project overhead cost that was calculated in the final total for project management dues.

To compare the installation costs of the adaptive signal control system to more traditional ways of reducing congestion, we estimated the cost of adding a lane in either direction on Cerrillos Road. The Department of Transportation for the State of Florida has a cost break down of roadway construction per mile (see Appendix 4). Using the spreadsheet provided by the Florida DOT in Appendix 4, we estimated the cost of adding two lanes of urban roadway for 8 miles, which is approximately the length of Cerrillos

[131] (Anonymous 2013)
[132] Trepanier. Personal Communication

Road. We also included the cost of repairing and installing inductance loops at each intersection, which are currently used for vehicle detection at most traffic intersections along Cerrillos Road and St. Francis Drive. The inductance loops would also be used to obtain traffic counts, which must be submitted to the FHWA. After counting the number of inductance loops that would need to be replaced or installed from our completed inventory, we determined the price to install them by using the Equipment Cost for Roadside Detection table found on the USDOT website see Appendix 5).

Before the benefits for the benefit-cost analysis can be calculated, the integrated corridor must be simulated, however it often difficult to model certain features. With the resources available to our group, we were unable to simulate the effect of posting travel times to the DMS's already in place. This is due to the complexity in modeling human behavior. We were able to simulate the impacts of the installation of the adaptive signal control systems for segments of Cerrillos Road and St. Francis Drive using Synchro™. The software uses the traffic count information along with the existing traffic signal timing specific to the City of Santa Fe to provide a more accurate analysis. We first simulated the current timing pattern for the given road segment of Cerrillos Road and St. Francis Drive. Reports were generated for morning, midday, and evening because different times of day have different signal timing patterns and traffic demands. The reports contained valuable information about the roadways including intersection level of service, travel times, average speed, and distance.

Appendix 6 contains all the generated reports. In order to model the adaptive signal control system, we conducted two different simulations, one for northbound optimization and another for southbound optimization. We optimized the northbound and southbound travel on the road segment by setting all left turns to permissible and manually placing focus on the desired travel direction's signal phases for each intersection. This was a method suggested by Rhythm Engineering to model their system. By optimizing one direction at a time in Synchro™ we were able to mimic the demand oriented adaptive signal control system. Reports were generated for morning, midday, and evening after running the simulation for these new settings. These reports can also be found in Appendix 7. After we gathered all the necessary reports to analyze the roadways of the corridor, we began comparing the data to determine travel time reductions. The travel times for the northbound travel on the optimized northbound report was compared to the northbound travel times for the current timing pattern. Similarly, the travel times for the southbound travel on the optimized southbound report was compared to the southbound travel times for the current timing pattern. These comparisons were used to calculate the difference in travel times as well as the percent reduction in travel time.

After modeling and simulating the installation of the adaptive signal timing system for each Cerrillos Road and St. Francis Drive, we calculated the benefits. In order to calculate the benefits, we first determined the average annual travel time savings per vehicle. Average annual travel time savings per vehicle was computed through the following equation:

$$AS = \frac{TS * 365\ days}{60}$$

Where,

TS= average travel time savings in seconds

AS= average annual travel time savings per vehicle in hours

365 is the number of days in one year

60 is the number of seconds in one minute

From this calculation we were able to calculate the annual savings in gasoline per vehicle. The following equation was used to estimate the annual savings in gasoline per vehicle:

$$GS = AS * 0.4 * \$3.50$$

Where,
GS= annual savings in gasoline per vehicle
0.4 is the amount of a gallon of gas consumed idling for one hour for a 2 to 3 liter engine according to the US department of energy[133]
$3.50 is the regional average price for a gallon of gasoline in 2014[134]

After the annual savings in gasoline per vehicle was calculated, we could apply this figure to the estimated total savings on the roadway. Using the 2011 traffic count data, collected by the SFMPO, we multiplied the annual savings in gasoline per vehicle and the daily roadway traffic volume to obtain the total annual savings on the roadway (see Appendix 6).

The resulting equation is as follows:

$$RS = GS * T$$

Where,
RS = annual roadway savings
GS= annual savings in gasoline per vehicle
T= average daily traffic counts for that segment of the integrated corridor

Finally the annual roadway savings was then compared to the cost of installing the adaptive timing system to produce the benefit-cost ratio. The benefit cost ratio measures the effectiveness of the investment relative to its cost.

[133] (US Department 2014)
[134] (Admiistration 2014)

4. RESULTS AND ANALYSIS

In this chapter we describe all of the results to be delivered at the end of the project. These results include:

- An inventory of all the ITS and related traffic infrastructure for NMDOT and the city of Santa Fe cataloged in Microsoft Excel
- The creation of ITS and related traffic infrastructure maps for NMDOT
- A recommendation for future inventorying methods
- A recommendation of the best method to calculate travel times for each corridor in Santa Fe.
- The feasibility of implementing an adaptive system in Santa Fe
- A benefit-cost analysis of implementing an integrated corridor

4.1 Inventory of NMDOT and Santa Fe Traffic Infrastructure

In this section we describe our inventories of the ITS infrastructure in and around the city of Santa Fe, for both the NMDOT ITS Bureau and for the Santa Fe Traffic Department.

Figure 32: ArcGIS map showing NMDOT infrastructure in blue and the city of Santa Fe infrastructure in red.

4.1.1 NMDOT Infrastructure

We collected information on six DMS, nine CCTVs, nine CCTV poles and all of the corresponding system cabinets along I-25 and US-84. We compiled this data into Microsoft Excel spreadsheets, which were then ported into the ArcGIS software for mapping.

Spreadsheets were used in the field to collect information about the infrastructure items including serial numbers, model numbers, features of the items, and types of communication. The GPS location of each infrastructure item was recorded using the Trimble™ device and was later added to the spreadsheets once the data was downloaded by the NMDOT. The spreadsheets for the DMS, CCTV, CCTV poles, and all of their system cabinets can be found in Appendix 2.

Maps were incorporated to visualize the location of the items inventoried. They were created as described above in section 3.1.3. We created different layers plotting the locations of the DMS, CCTVs, system cabinets of the DMS and CCTVs, and the electricity meters of the DMS and CCTVs.

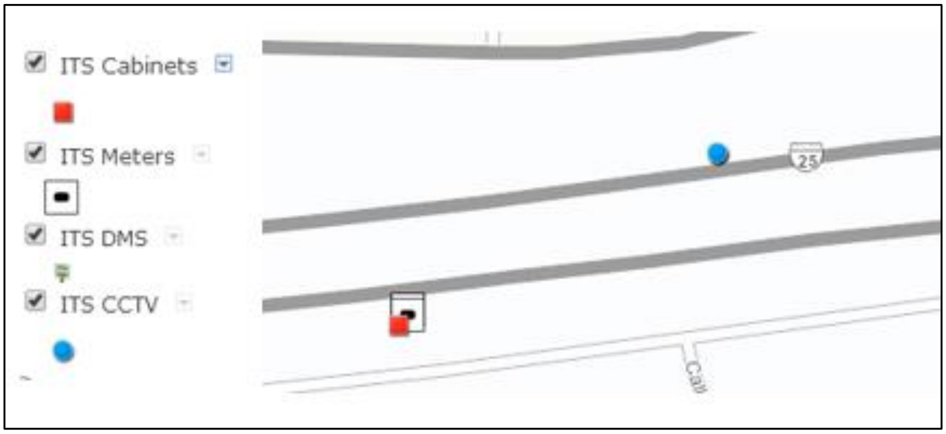


Figure 33: ITS infrastructure within the Santa Fe area mapped using ArcGIS. This section of I-25 contains a CCTV in blue, cabinet in red, and the electricity meter is marked in black.

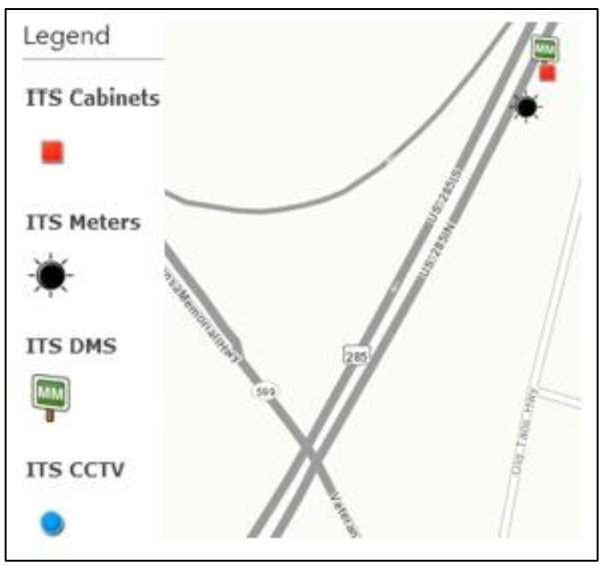


Figure 34: This section of US-84 mapped using ArcGIS contains a DMS marked by the green sign, cabinet in red, and the electricity meter in black. The DMS is located before NM 599 and is intended to display travel times for each corridor going southbound through Santa Fe.

4.1.2 City of Santa Fe Infrastructure

As with the NMDOT infrastructure, we inventoried the Santa Fe ITS infrastructure, added them to a detailed spreadsheet, and plotted them using ArcGIS. We also created maps through the data collected with the City Knowledge Console online forms. We inventoried two main roads, Cerrillos Road and St. Francis Drive. The data we collected was from 22 intersections on Cerrillos Road and 11 intersections on St. Francis Drive as shown in Figure 35.

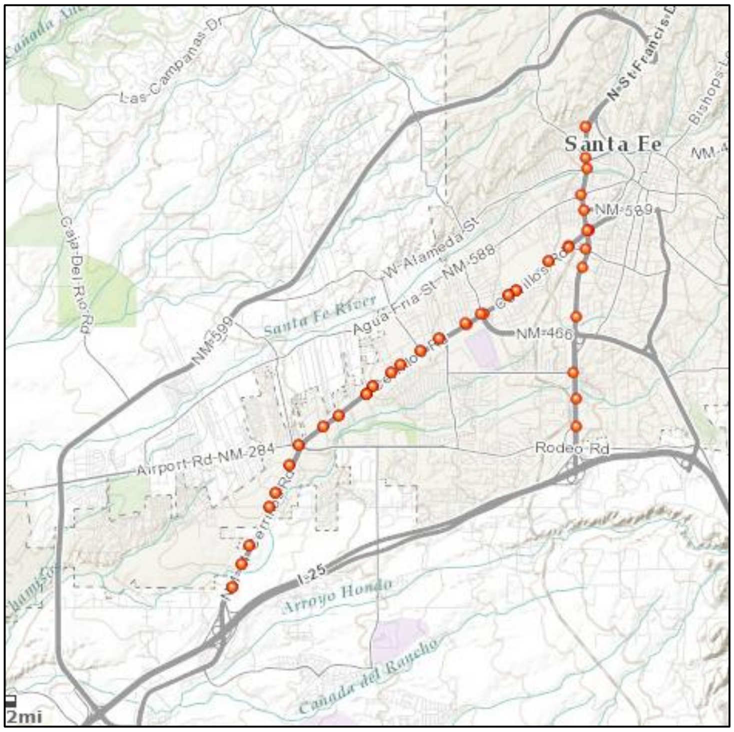


Figure 35: A total of 22 intersections along Cerrillos Road and 11 intersections along St. Francis Drive were inventoried. These intersections are mapped using ArcGIS.

We inventoried system cabinets, electricity meters, traffic lights, traffic poles, preemption detection for emergency vehicles, and all forms of car detection used at each intersection (which included Bluetooth, radar, CCTV, and inductance loops).

Spreadsheets for the system cabinets and traffic lights at each intersection were created for both Cerrillos Road and St. Francis Drive. The system cabinet's spreadsheets include data regarding the location of the cabinet, forms of car detection at each intersection, serial number of the traffic controller, preemption detection for emergency vehicles, traffic controller manufacturer, and type of communication used. The traffic light spreadsheets include data regarding the type of traffic pole, traffic signal size, pre-emption detection for emergency vehicles, and all forms of car detection. Both of these spreadsheets can be found in Appendix 3 for both Cerrillos Road and St. Francis Drive.

Maps were created via ArcGIS and the City Knowledge Console through use of online forms as described in section 3.1.2 and 3.1.3. Unfortunately errors occurred while out in the field when saving the online form while inventorying St. Francis Drive. No data was collected using the online form, and as a result no maps were created for St. Francis Drive using the online console tool. However, over 500 data points were collected and mapped for both street's intersections using the Trimble™ device. Due to the overwhelming number of data points and large number of intersections, an example intersection of Cerrillos Road and St. Francis Drive are displayed below in Figure 37 and Figure 38 mapped using ArcGIS.

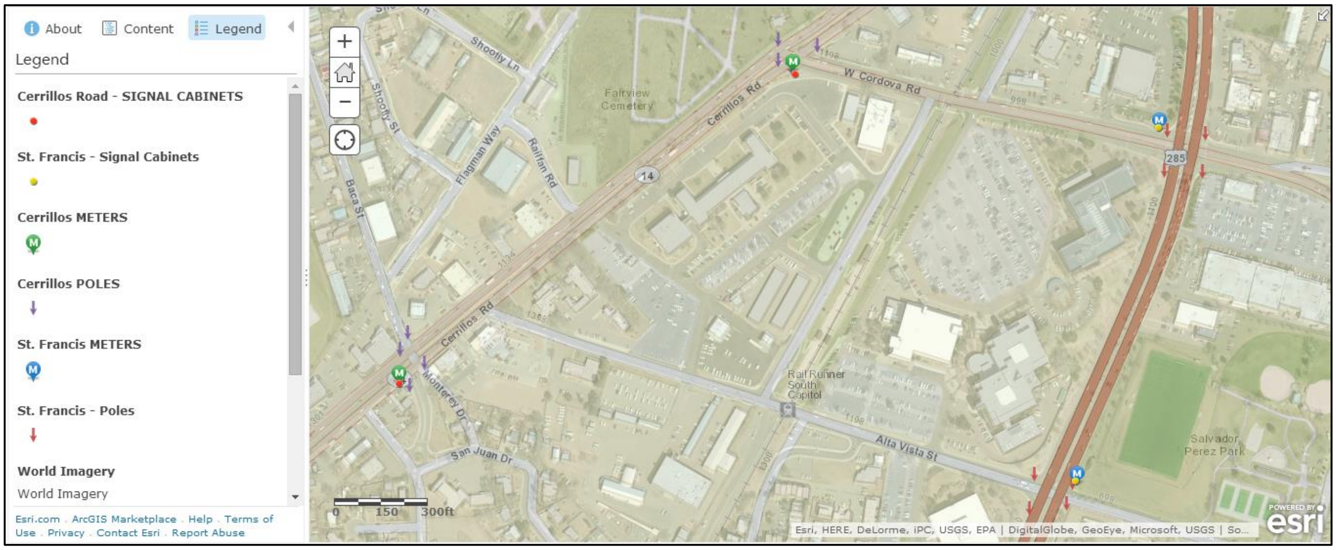


Figure 36: Intersections on Cerrillos Road and St. Francis Drive mapped with ArcGIS showing the different types of infrastructure in use in Santa Fe.

Figure 37: The intersection of Cerrillos Road and Airport Road mapped with ArcGIS showing the different types infrastructure in Santa Fe.

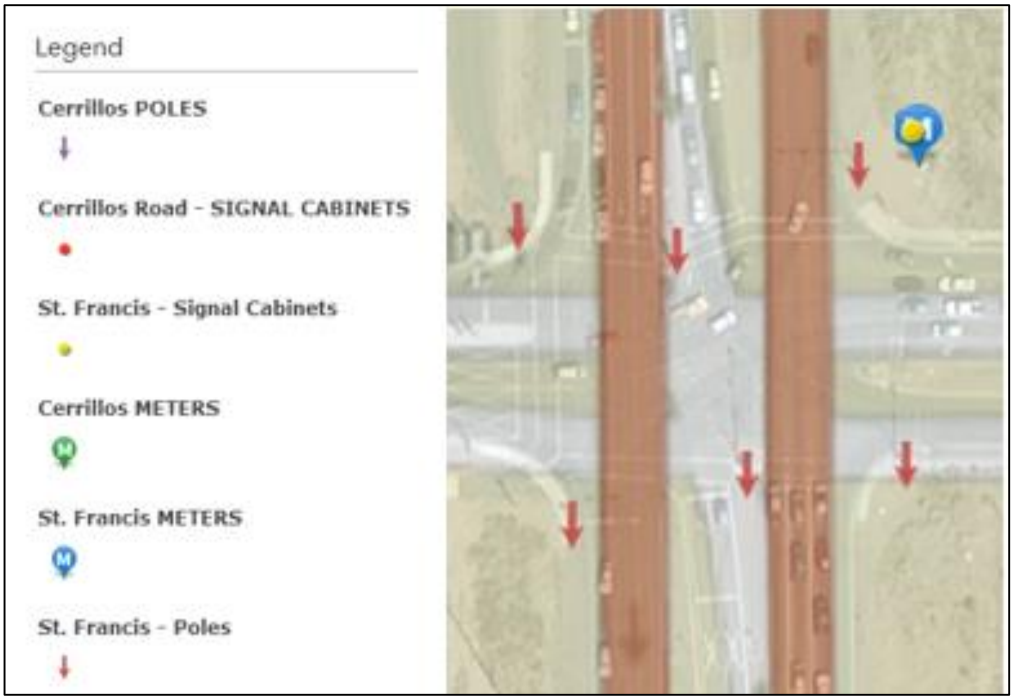


Figure 38: The intersection of St. Francis Drive and Zia Road mapped with ArcGIS showing the different types infrastructure in Santa Fe.

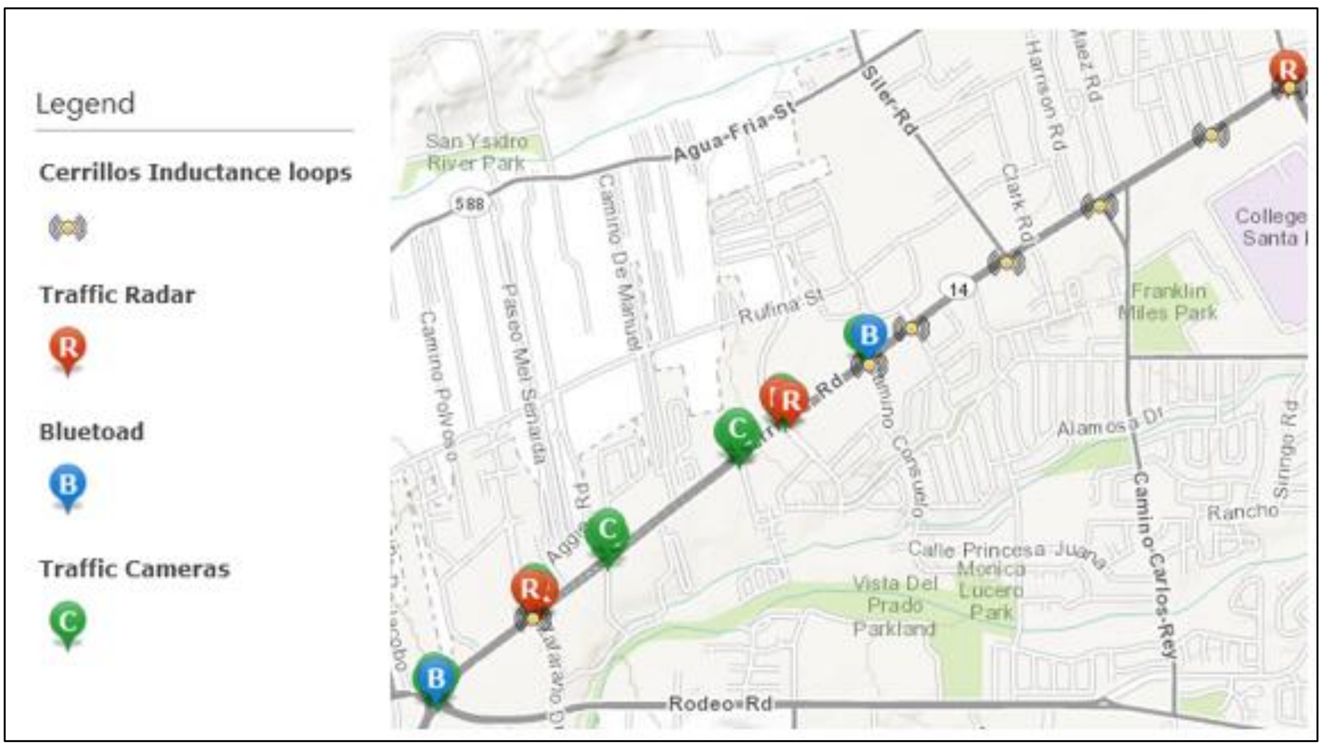


Figure 39: The various types of traffic signal detection used at each intersection along Cerrillos Road are mapped using ArcGIS. Detection includes inductance loops, radar, BlueTOAD devices, and traffic cameras.

Due to errors saving the online form, we were only able to map the system cabinets along Cerrillos Road using the Online Console as seen in Figure 40. We were able to upload the pictures of each system cabinet to the respective point on the map.

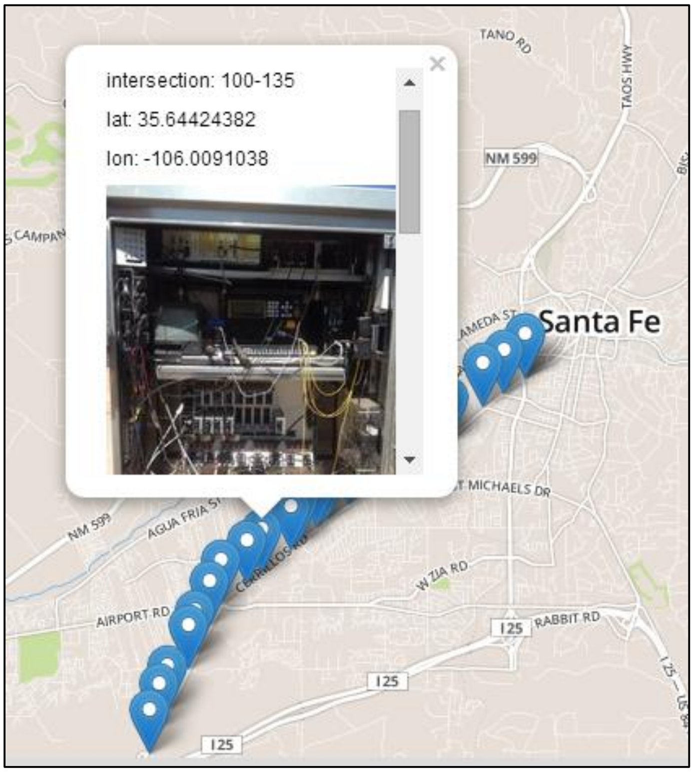


Figure 40: Traffic signal cabinets along Cerrillos Road mapped using the City Knowledge Console. When a pin is clicked, the information about the traffic signal cabinet including the intersection name, latitude and longitude coordinates, and photo appear.

4.1.3 Evaluation of Inventorying Tools

In the field we used two tools to obtain the GPS locations of the ITS Infrastructure: a Trimble™ device and the City Knowledge Console online forms. In comparing these methods, the factors we considered were accuracy, user friendliness, time, and cost. At the end of our evaluation a recommendation was made for future inventorying. While the online forms were not ready in time to be used for our entire inventory, we did use both methods to inventory the intersections along Cerrillos Road and St. Francis Drive for the City of Santa Fe Traffic Department.

The first tool that we used to gather data for our inventory was a Trimble™ device. As stated on the Trimble™, its recorded accuracy range was within 36 inches of deviation of the physical location of the inventory item, as long as satellite signals were acquired by the device. There were many times when satellites could not be reached due to loss of satellite coverage, as a result the accuracy deviated more than three feet from the recorded point. However, when the data was downloaded from the device, the post processing of the information by the NMDOT helped to fix these inaccuracies, making the deviation of the physical location typically between 11-20 inches. The Trimble™ itself was easy to use once we received basic training from our sponsors. Post processing of the data was completed by the NMDOT Geospatial Team. The time it took to obtain the data collected from the Trimble™ often took over a day, as the information had to be downloaded and then processed for greater accuracy. Along with a lengthy wait time for data, a Trimble™ device is an expensive tool, typically costing $5,000 per unit. In review, collecting data using a Trimble™ device is costly and time consuming, however it is very accurate and user friendly once basic training is received.

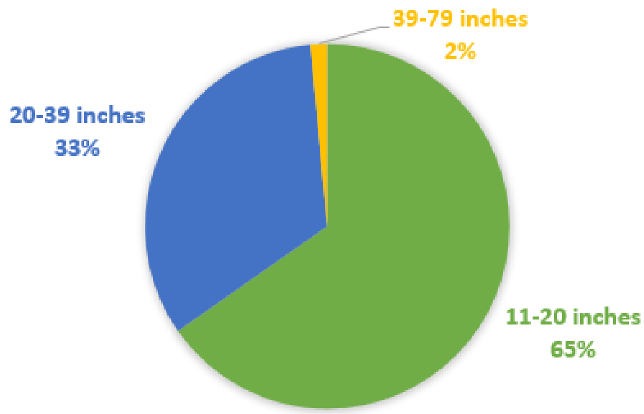


Figure 41: Post processed estimated accuracies for corrected GPS positions obtained by the Trimble

The second tool we used to acquire GPS data for our inventories was the online form created with the City Knowledge Console. With the help of Benjamin Lichtner, the City Knowledge Console's online form was able to retrieve a cell phone's GPS location and automatically upload it to a datasheet in conjunction with user inputted information. Through a comparison of the Trimble™ collected data and the City Knowledge Console collected data, it can be seen that the cell phone GPS location was very inaccurate. While the Trimble™ was within three feet of the actual location, the City Knowledge Console location was typically 348 feet away from the actual location, which is 4176 inches. This is a 20780% percent error as compared to the Trimble™.

$$\left(\frac{|20-4176|}{20}\right) * 100 = 20780\%$$

Figure 42 shows a screenshot of the varying distances between the recorded points collected by the City Knowledge Console and the Trimble™ device. These distances were measured using an ArcGIS ruler tool.

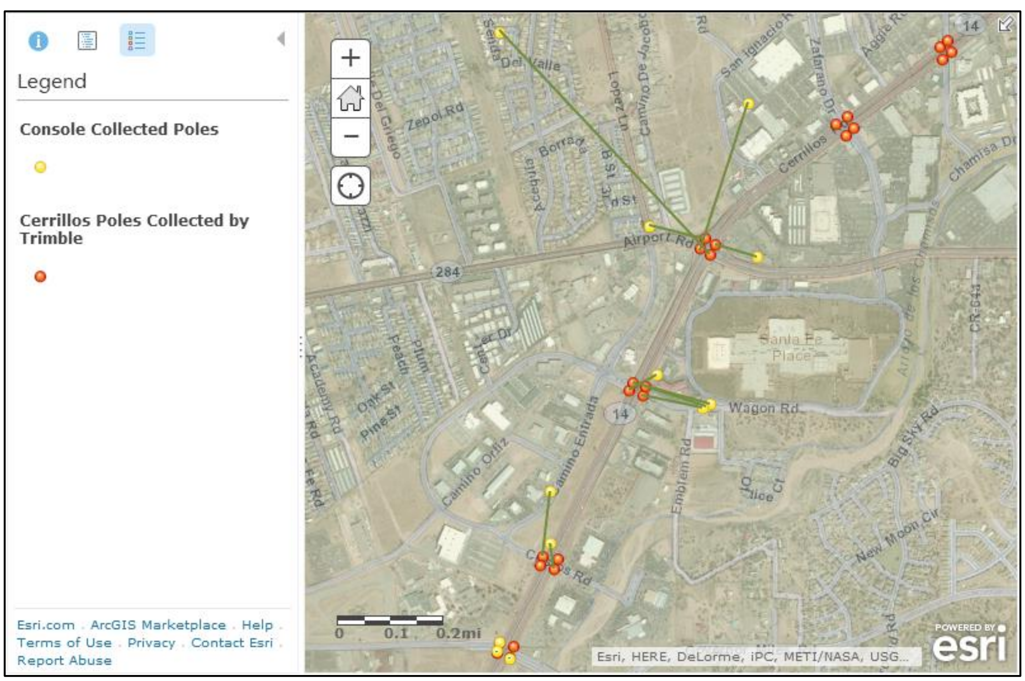


Figure 42: Map displaying the differences between the Trimble™ collected data points in red and the City Knowledge Console data points in yellow. Each line connects the same point collected by the different method.

A whisker and box plot was created to show the analysis of the 42 distances that were calculated from the City Knowledge Console data point to the same data point collected by the Trimble™. Figure 43 displays the whisker and box plot along with critical calculations including mean, median, minimum, maximum, and possible outliers.

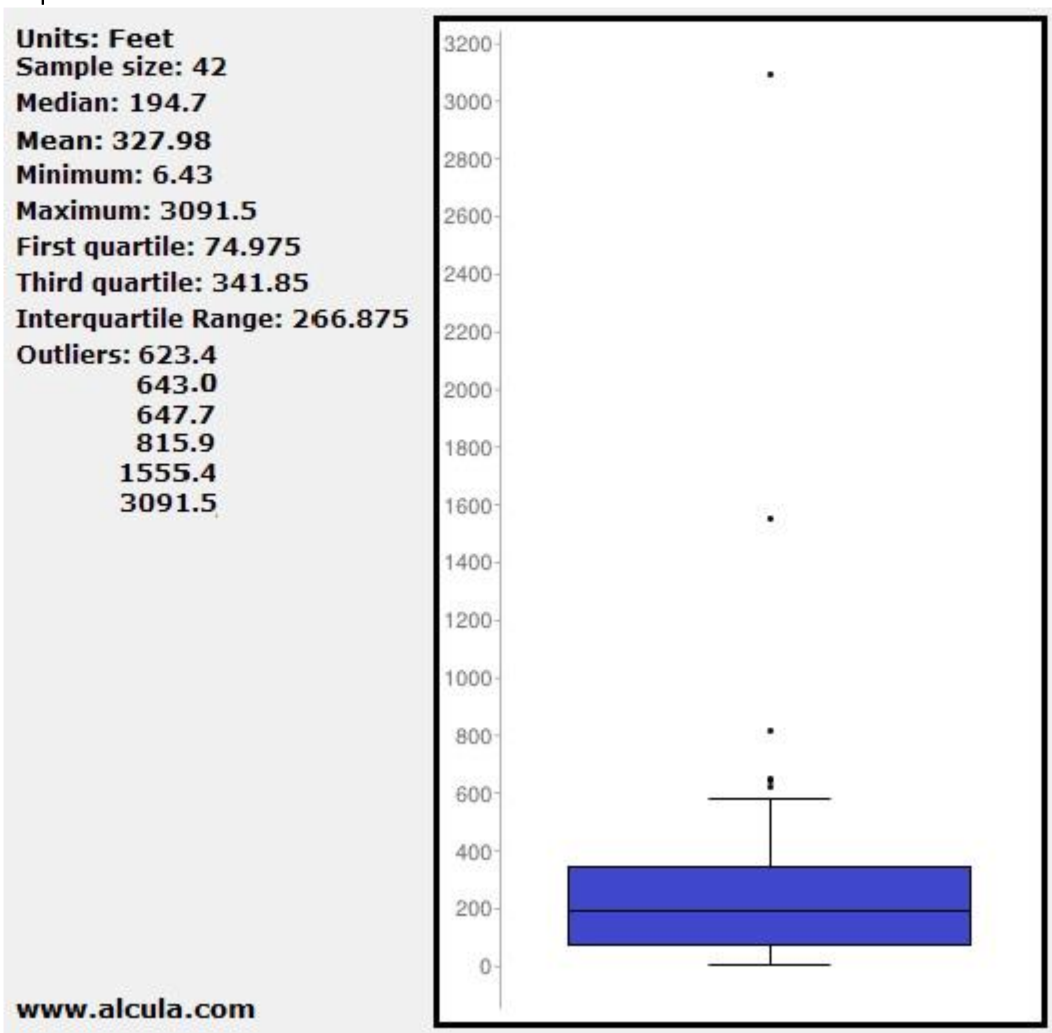


Figure 43: A whisker and box plot is shown on the right. Critical values analyzing the 42 distances that were calculated between the same data points collected via the Trimble™ and the City Knowledge Console online form are shown on the left. Generated using www.alcula.com.

In addition to problems with accuracy, we found the City Knowledge Console and its online form difficult to use. This technology contained many glitches and should be considered still in its beta phase. Issues discovered included formatting, missing data entries, incomplete features, and poor operation manuals. The time it took to get the data imported into a mapping software using the City Knowledge Console was significantly less than using the Trimble™, however the time it took to check and manipulate the City Knowledge Console collected data took just as much time, if not more time, as the entire Trimble™ collection and post processing method. The only advantage that the City Knowledge Console had over the Trimble™ was the cost. Since the City Knowledge Console online form only requires a cell phone with web browser, there is no additional cost to an agency that supplies their employees with cell phones. In review using City Knowledge Console very cost efficient, however is very inaccurate, time consuming, and not user friendly.

4.2 Calculation of Travel Times

In this section we analyzed the results of our data collection of travel times via Google Maps, INRIX, BlueTOAD, and field testing. Figures were compiled for comparison of the travel times using each method. The cost as well as the quality of the data was considered in making our recommendation to our sponsors.

4.2.1 Evaluation of Travel Time Data

The calculated travel times for the segment of Cerrillos Road are shown below in Figure 44. We compared the BlueTOAD, Google, and INRIX travel times to our field test. In order to do the comparison we conducted a percent deviation calculation. For each travel time recorded through INRIX, BlueTOAD and Google we subtracted those times from the field test then divided the difference by the field test time.

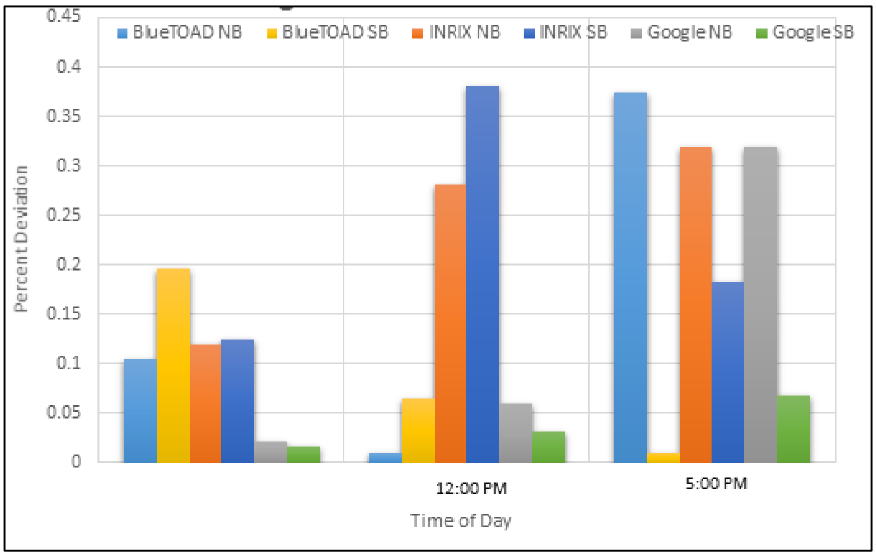


Figure 44. Percent Deviation graphs comparing INRIX, Google Maps, and BlueTOAD to the field test.

After the comparison of travel times along the 3.3 mile stretch of Cerrillos Google and BlueTOAD registered the closest times to that of the field test. The bar graph above shows that Google and BlueTOAD consistently had the smallest bars which means they were the closest to the field times. The morning times were much closer to the field test which can be due to pedestrian traffic. Throughout the day pedestrians are walking to lunch or just running errands through town. Pedestrians crossing streets, using the crosswalk can affect the signal timing greatly and the crowdsourcing information from INRIX or google may have not picked up the additional time.

We calculated both the segment and the entire roadway of Cerrillos Road because while in the process of collecting data we determined that BlueTOAD data was not comparable to Google Maps and INRIX. The BlueTOAD detection sensors are limited and only cover 3.3 of the total 8 miles of Cerrillos Road as shown in **Error! Reference source not found.**. Google Maps and INRIX cover the entirety of Cerrillos Road and can currently calculate the complete travel times from the desired DMS on I-25 to the DMS on US-84 via NM 599, Cerrillos Road, and St. Francis Drive.

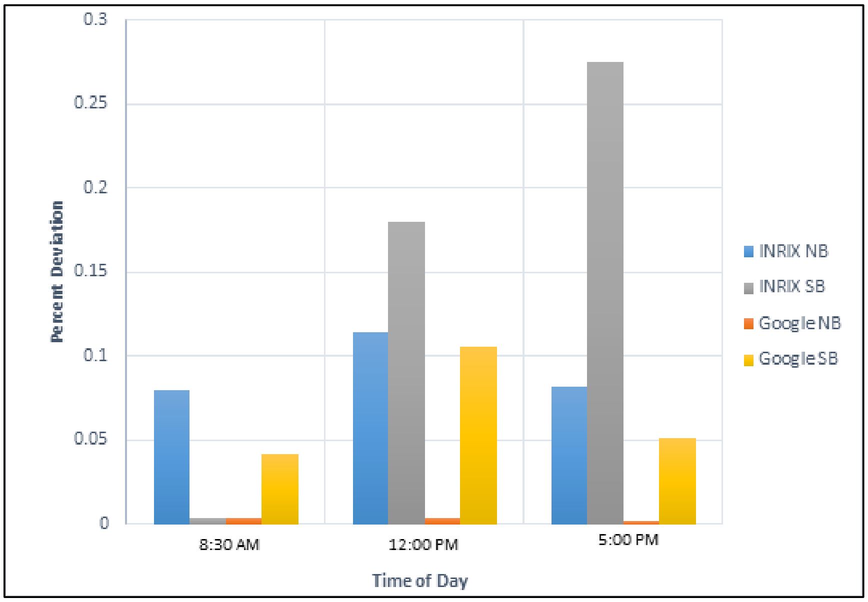


Figure 45. Percent deviation from field test on Cerrillos Corridor

To get complete travel times from BlueTOAD via NM 599, Cerrillos Road, and St. Francis Drive more BlueTOAD devices would need to be installed. Currently only 3.3 miles of Cerrillos Road is covered by BlueTOAD devices while NM 599 and St. Francis Drive lack coverage altogether. It is recommended that Bluetooth sensors are placed no more than 4 miles apart[135]. Given the road length of NM 599, Cerrillos Road, and St. Francis we determined that a total of 13 BlueTOAD devices need to be installed along the three corridors to get complete travel time information from the DMS on I-25 to the DMS on US-84 via the three arterial corridors as shown in Figure 46.

[135] (TrafficCast 2014)

Figure 46. A total of 13 BlueTOAD devices would need to be installed along the three corridors to get full travel time data. The existing BlueTOAD devices are shown in blue, the needed BlueTOAD devices are shown in red, and the flags represent the DMS where the travel times would be displayed.

Each BlueTOAD device initially cost $4,000, which includes the hardware and a two year subscription to the travel data. After the two years, the subscription costs less than $2,000 per device[136]. There are currently three BlueTOAD devices installed in Santa Fe and three more that are scheduled to be installed. To get complete travel time data for the Santa Fe area, seven additional BlueTOAD devices need to be purchased, which will cost $28,000. Currently the city of Santa Fe needs to renew their subscription to already purchased devices, which will cost less than $2,000[137].

Unlike BlueTOAD, Google Maps and INRIX can calculate the travel times for entire corridors without having to install and maintain devices. The travel times of both northbound and southbound directions of Cerrillos Road were compared using Google Maps and INRIX to our field test data. The results were compiled in Table 3.

[136] Personal Correspondence with Rick Devine. Santa Fe Traffic Department

[137] Personal Correspondence with Rick Devine. Santa Fe Traffic Department

Table 3. Comparison of travel times using INRIX, Google, and field testing for the entire Cerrillos Road corridor

	Morning 1		Afternoon 1		Evening 1	
	NB Cerrillos	SB Cerrillos	NB Cerrillos	SB Cerrillos	NB Cerrillos	SB Cerrillos
INRIX	22:00	22:00	24:00:00	22:00	27:00:00	22:00
Google	24:00:00	21:00	27:00:00	24:00:00	25:00:00	24:00:00
Field Test	23.55	21.55	27:05:00	26:50:00	24:58:00	25:18:00

The results were very similar in the Corridor field test to that of the Cerrillos road segment. INRIX recorded its best overall times in the morning but seemed to falter off in the afternoon and evening. Google was much more consistent throughout the day and recorded travel times very close to field test.

We compared the pros and cons of each method as shown in Figure 47. After talking to sales reps and conducting field tests we were able to provide a chart based on research and user experience. Overall we found it easier to obtain and use data from INRIX. The INRIX data would integrate seamlessly with NMRoads and is already being used in Albuquerque during the construction of Paseo I-25 project. Google obtains their travel times from a larger source, however, it was difficult to obtain a definitive answer and clear payment options. Unlike Google and INRIX, BlueTOAD requires devices to be installed along roadways to calculate travel times. To obtain travel times of additional arterial roadways, BlueTOAD devices must first be installed along these roads.

	INRIX	Google maps	BlueTOAD
Pro's	• Direct access to API for displaying travel times • Custom Routing • No hardware or installation necessary • Works well with ArcGIS maps by esri	• Large source and range of crowdsourcing • Custom routing • No hardware or installation necessary • Direct access to API for displaying travel times	• Historical and predictable data available • Travel times down to seconds of accuracy
Con's	• Inability to change API's with basic version • Less information available to make accurate time calculations	• Unclear payment options for businesses • Paying for options not needed	• Cannot output travel times to DMS directly • Hardware is in fixed position • Requires drivers to have Bluetooth enabled devices for information
Price	• $12,000 per year	• $10,000 with less than 100,000 web hits	• $4,000 per device (includes two year subscription)

Figure 47. Summary of the pros and cons of BlueTOAD, Google Maps, and INRIX data.

Google Maps is accessible for businesses and everyday users to use, however, it does have the potential to charge the user. Depending on the number of consecutive page views, and the type of work that will be done (internally accessible only or publically accessible) with the Google Maps APIs, Google may enter into a contract with the user. Users can also sign up for automatic bill-pay if their usage warrants a bill from Google[138].

If the NMDOT wants to use Google Maps APIs, it must make the maps freely and publically accessible to the end user. The NMDOT would then be able to access and use Google Maps data for free, as long as the number of page views per day did not exceed 25,000 for 90 consecutive days[139]. Since the NMDOT would only use the traffic information internally for displaying travel times, they would have to sign a license for Google Maps APIs for Business. A Google Maps APIs for Business license would allow them to use Google Maps APIs internally and not require them to make their maps and data publically accessible. The Google Maps APIs for Business would provide access to services such as Google Street View, directions, Google Analytics, technical support, control of advertising, and static maps, among other things. A full list can be seen in Appendix 9. After talking to a Google representative, we determined that the base price for a Google Maps API for business license is $10,000 per year, and that would grant 100,000 requests for page views per day[140]. After consulting with one of our sponsors, we determined that the ITS Bureau of New Mexico would most likely load maps and view the page once per minute, that is, 1440 times per day[141]. However, during times of inclement weather or serious traffic issues the rate of viewing would[142]. Even with the increase in map traffic, it seemed unlikely that the ITS would reach the maximum usage threshold of 100,000 page requests per day.

INRIX data fees are variable based on the specific use case. According to Ted Trepanier, the senior director of INRIX, for travel information for the three arterial corridors of interest, the annual costs could range from approximately $12,000 to $32,000 per year. Mr. Trepanier informed us that the lower price end is for basic corridor based travel times to be posted on DMS and/or traveler information systems including the web, while the upper price end includes direct API access to individual segment speeds and associated travel times with broad rights. For the short term project goal, which is to provide travel times to the public, the NMDOT would only need to purchase the basic INRIX data[143]. For analysis of the effectiveness of signal timing changes or installation of an adaptive system, then the more expensive alternative would be necessary.

138 (Google 2014)
139 (Google 2014)
140 Bia, personal communication
141 DiRuggiero, personal communication
142 DiRuggiero, personal communication
143 DiRuggiero, personal communication

The cost for each data method was obtained and compiled into Table 4**Error! Reference source not found.Error! Reference source not found.** for comparison.

Table 4. Comparison of cost to calculate travel times

	BlueTOAD	Google Basic	INRIX Basic	INRIX Advanced
Subscription	$2,000 per device for 2 years	$10,000**/ year	$12,000/ year	$32,000/year
Hardware	$4,000 per device	X	X	X
Total Cost for all corridors in Santa Fe	**$40,000 ***	**$10,000****	**$12,000**	**$32,000**

* Price calculated with subscription renewal of six devices and installation of seven new devices

** This is a base price. It increases with different license packages

We projected the cumulative cost of using each method over the next 10 years as shown in Figure 48 by adding the cost of renewing subscriptions each year to the previous total. The cheapest option is Google, if we adhere to business requirements. The most expensive option for travel times is INRIX advanced data.

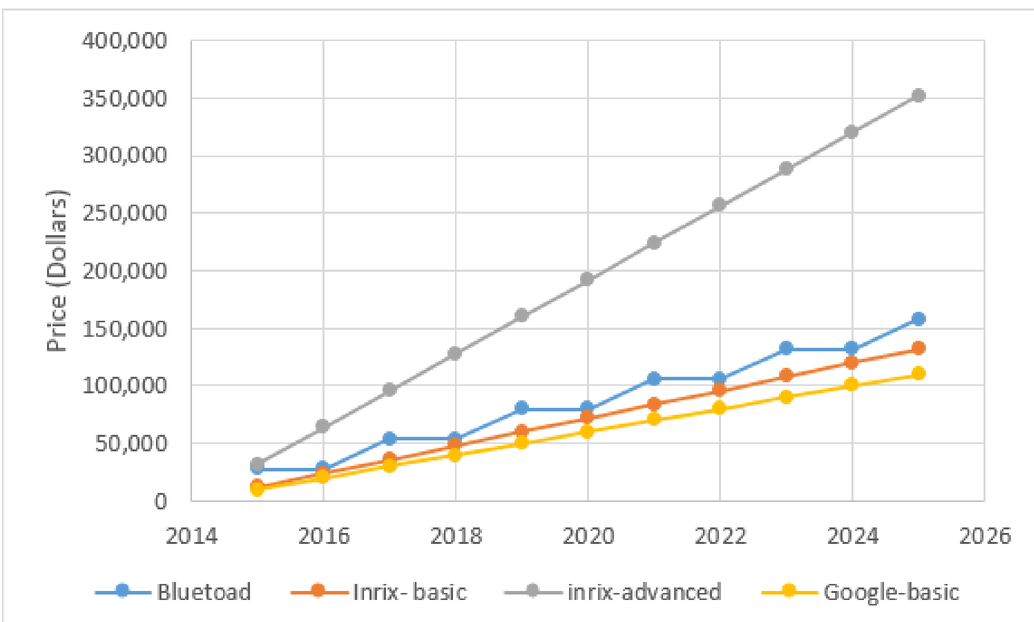


Figure 48: The projected costs of each travel time method over 10 years

4.3 Analysis of Integrated Corridor Implementation

In this section we perform an analysis of implementing an integrated corridor in Santa Fe. We evaluated the feasibility of implementing an adaptive system and conducted a benefit-cost analysis.

4.3.1 Feasibility of Implementing an Adaptive System

In our interview with Rhythm engineering we gained a basic understanding for what an adaptive system is and what we need to implement it. The formal questions can be found in Appendix 10.

From our interview we determined that we need to upgrade the communication between traffic intersections as well as purchase or upgrade the existing CCTV signal cameras for detection. Rhythm engineering recommends purchasing their CCTV signal cameras, however, InSync can use already existing signal cameras. From our inventory we examined the communication between each intersection and determined what intersections need communication connectivity.

4.3.2 Benefit Cost Analysis

The benefit-cost analysis was completed in several stages. First, the costs were calculated for installing the adaptive signal timing system for only Cerrillos Road, then only for St. Francis Drive, and then finally the total cost on both arterial roadways.
Table 5 displays the calculated costs described.

Table 5: Cost breakdown of installing Adaptive Signal Timing System

Cost Breakdown	Cerrillos Road	St. Francis Drive	Cerrillos Road and St. Francis Drive
Number of Intersections	22	11	33
Cost of Install per Intersection	35,000	35,000	35,000
Cost of Communication Upgrade per Intersection	12,000	15,000	12,000-15,000
Project Subtotal	1,034,000	550,000	1,584,000
Additional Project Costs	5,000	5,000	5,000
Total:	**1,039,000**	**555,000**	**1,589,000**

Installing the adaptive signal timing system on Cerrillos Road is nearly double the price of installation on St. Francis Drive. This is due to the cost being driven by number of intersections, of which Cerrillos Road has double that of St. Francis Drive. St. Francis Drive has a higher price for the communication upgrades because the intersections of St. Francis Drive are further apart and use more primitive modes of communication than the intersections of Cerrillos Road. The total cost for installation on both arterial roadways should be considered for a complete implementation of the Integrated Corridor in Santa Fe.

Although these prices seem high, the alternative way of adding a lane to reduce travel times is significantly more expensive. Using the Florida Department of Transportation's "Roadway Cost Per Centerline Mile" table (see Appendix 4) and the USDOT's Equipment Cost for Roadside Detection table (see Appendix 5) a total cost was estimated for adding two lanes of urban roadway to the 8 miles of

Cerrillos Road with replacement of all inductive detection loops. Table 6 displays the estimated costs for this project.

Table 6: Construction Cost of adding two lanes of urban roadway to Cerrillos Road

Cerrillos Construction	Addition of 2 lanes	Inductive Loop Replacement
Number of Units	8 Miles	120 inductive loop pairs
Unit Price	$9 million per mile	$8 thousand per pair
Subtotal	$72 million	$960 thousand
Total: $72,960,000		

The estimated total cost of this construction project, $72,960,000, is roughly 70 times more expensive than installing the adaptive signal timing system on just Cerrillos Road, and it is about 45 times more expensive than installing the adaptive signal timing system on both arterial roadways.

The adaptive signal timing system was modeled for segments of Cerrillos Road and St. Francis Drive. Using Synchro, reports were generated for the respective simulations (see Appendix 6 and Appendix 7). These reports were then compared to gather information about travel time reduction. The benefits were calculated from these figures and then compared to the costs from Table 6. The resulting benefit-cost analysis can be found in Table 7.

Table 7. Benefit-cost analysis for different arterial roadways in integrated corridor

Annual Benefit (from Simulations)	**Installing Adaptive Signal Control on Cerrillos Road**		**Installing Adaptive Signal Control on St. Francis Drive**		**Installing Adaptive Signal Control on Cerrillos Road and St. Francis Drive**	
Daily Travel Time Reduction	North Bound	South Bound	North Bound	South Bound	North Bound	South Bound
Weekday AM	12.8% (67.5s)	13.3% (61.6s)	5.9% (45.5s)	6.0% (39.5s)	113.0s	101.1s
Weekday Midday	20.9% (121.8s)	15.5% (73.0s)	11.6% (68.0s)	7.2% (39.2s)	189.8s	112.2s
Weekday PM	6.6% (36.1s)	8.0% (37.1s)	19.7% (126.1s)	29.2% (229.5s)	162.2s	266.6s
Annual travel time savings per person	66 seconds*365days= 401.5 hours		91 seconds * 365days = 553.6 hours		157 seconds*365days = 955.1 hours	
Annual saving on gasoline	401.5hrs *.4 * $3.50 = $562.10		553.6hrs *.4 * $3.50= $775.04		955.1hrs * .4 * $3.50 = $1,337.14	
Roadway Annual Savings	$562.10 * 46,000 = $25.9 Million		$775.04 * 43500 = $33.7 Million		$1,337.14 * 89,500= $119.7 Million	
Project cost	$1,034,000		$550,000		$1,584,000	
Benefit Cost Ratio	**25:1**		**60:1**		**75:1**	

On average we saw a travel time reduction of about 13%. This is consistent with the same adaptive signal control system that was implemented on Alameda Blvd. in Bernalillo County. Post-analysis of that roadway showed reductions up to 25% with an average of 10.5%. Reports of Alameda Blvd. Synchro system can be found in Appendix 11. The calculations we completed to determine the annual roadway savings were used, along with the previously estimated project costs, to produce the benefit cost ratio of each roadway segment. St. Francis Drive saw a greater benefit cost ratio because it had a greater average in travel time savings, as well as a lower cost for the project. The total implementation of the adaptive signal timing system experienced the greatest benefit-cost ratio because more drivers were affected than each roadway individually.

5. RECOMMENDATIONS

After analyzing our results, we have created some recommendations with regards to our three objectives. These include both suggested methods, as well as recommendations for future use.

5.1 Inventorying Tools and Methods of Use

We recommend that the NMDOT and the City of Santa Fe continue to use, update, and add to our currently created inventory spreadsheets and ArcGIS maps. They have detailed data about each item and system cabinets have links to corresponding photos. These spreadsheets are fairly straightforward to use, and the NMDOT already uses ArcGIS and ESRI maps, making incorporation of our maps a simple task. The ArcGIS maps also provide a visual representation of where the current infrastructure is, making it easier to find current infrastructure and plan for future developments.

We also recommend that for all future inventorying endeavors, the Trimble™ and Excel spreadsheets are used, rather than the online tool City Knowledge. The Trimble™ had was more accurate in its location mapping and was fairly user friendly after some basic training. The City Knowledge console, while still fairly user friendly, was still in beta, resulting in lost data and unreliable use. Due to the fact that City Knowledge uses cellular service, and wireless internet connections, the locations that it recorded were also unreliable. However, both methods both required the same amount of time to obtain useable data due to post processing requirements. If further improvements are made to the City Knowledge Console to improve GPS accuracy and user friendliness, this could be a potential tool for future use.

5.2 Travel Time Calculation Method Recommendations

We recommend that the NMDOT calculates travel times by using INRIX data. While both Google Maps and INRIX were fairly comparable in their accuracy and crowdsourcing, the NMDOT already uses INRIX data in its calculations for Albuquerque and NMRoads. It would therefore be easier to incorporate INRIX into their current systems of Santa Fe. Google Maps was a bit cheaper, but the NMDOT would have to enter into a contract that provided many more features than the NMDOT would need or use, making Google Maps cost-ineffective. The NMDOT would also have to reprogram the maps in its NMRoads application, as NMRoads currently uses ESRI maps to display mapping data. BlueTOAD bluetooth detection, while very accurate, is not currently deployed in enough locations around Santa Fe, and buying more hardware would be too expensive in comparison to the other two programs, about $28,000. With the rest of the existing bluetooth hardware still yet to be deployed, three devices, we recommend they use those devices along the rest of Cerrillos road to determine how many cars are traveling the entire Cerrillos corridor. Having this information can help prove how many people can benefit from knowing the travel times through Santa Fe. Overall, we recommend INRIX, but believe that Google Maps is also a great option if the NMDOT can incorporate it into their NMRoads app.

5.3 Recommendations Regarding Implementation of an Integrated Corridor in Santa Fe

Based on our findings and calculations we can make the following recommendations on implementing and integrated corridor in Santa Fe:

- Use the adaptive signal timing system cameras' to enhance system functions
- Plan to update all communications between traffic intersections during project
- Install an adaptive signal timing system over adding lanes to achieve a reduction in travel times.
- Install adaptive signal timing system on Cerrillos first because it saw the greatest reduction in travel times thus seeing the greatest benefit.

- Plan to install adaptive signal timing system on both arterial roadways because it saw the greatest benefit cost ratio.

Appendix 1 Integrated Corridor Implementation Guide

The Integrated Corridor Management: Implementation Guide and Lessons Learned produced by the FHWA in 2012 can be found online at the following link:

https://drive.google.com/file/d/0B2qF3IWx_vL6cU01dFBxZ3FheEk/edit?usp=sharing

Appendix 2 NMDOT ITS Inventorying Data Sheet

NMDOT ITS Inventorying Data Sheets

ITS DMS Inventory Sheet

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Project CN	Lat	Lon	Direction	Manufacturer	Mount	COMM_1	COMM_2	Control_Type	Control_Loc	Remote_Power	Meter Number	Meter Address	Model_No	Serial_No	Data_Collection_Method
I-25 NB @ 599	35.57189	-106.08994	North	ADAPTIVE	Roadside	CELL_CDMA		SKYLINE	SIGN_ASMBLY	UNKNOWN	59 403 398	Behind DMS to left	8700		GPS_Mtr
I-25 SB @ 599	35.59859	-106.04986	South	ADAPTIVE	Roadside	CELL_CDMA		SKYLINE	SIGN_ASMBLY	UNKNOWN	64 294 051	Behind DMS	8700		GPS_Mtr
I-25 NB @ Old Pecos Trail	35.63701	-105.94131	North	ADAPTIVE	Roadside	DSL		SKYLINE	SIGN_ASMBLY	UNKNOWN	63 627 310	Behind DMS	8700		GPS_Mtr
I-25 SB @ Old Pecos Trail	35.63762	-105.94129	South	ADAPTIVE	Roadside			SKYLINE	SIGN_ASMBLY	UNKNOWN			8700		GPS_Mtr
US 84/285 NB @ NM 599	35.71414	-105.9376	North	ADAPTIVE	Roadside	CELL_CDMA		SKYLINE	SIGN_ASMBLY	UNKNOWN	65 243 656	in front of DMS	8600	29290-003	GPS_Mtr
US 84/285 SB @ 502 Pojoaque	35.88376	-106.01581	South	ADAPTIVE	Roadside	CELL_CDMA		SKYLINE	SIGN_ASMBLY	UNKNOWN	840 956 71	Front of Gas Station	8600		GPS_Mtr

ITS CCTV Inventory Sheet

1	17	2	3	5	6	18	7	19	20	11	12	13	14	15	16
Project CN	**Location**	Lat	Lon	Manufacturer	Mount	CCTV_TYP	COMM	Control_Features	Protocol	Remote_Power	**Meter Number**	**Meter Address**	Model_No	Serial_No	Data_Collection_Method
I-25 @ Cerillos Road		35.60454	-106.03525	COHU	CONC_POLE	DOME	CELL_CDMA	PAN_TLT_ZM	AXIS	OTHER	UNKNOWN		91422	902101842	GPS_Mtr
I-25 @ St. Francis Dr.		35.63527	-105.95573	COHU	CONC_POLE	I_View	CELL_CDMA	PAN_TLT_ZM	AXIS	OTHER	636 27 310	By DMS on Old Pecos Trail NB	91422	902101825	GPS_Mtr
US 84/285 @ Pojoaque		35.89078	-106.02325	COHU	CONC_POLE	DOME	CELL_CDMA	PAN_TLT_ZM	AXIS	OTHER	103 740 342	Across street	91422	902101843	GPS_Mtr
I-25 @ Upper La Bajada		35.52099	-106.168	COHU	OTHER	I_View	CELL_CDMA	PAN_TLT_ZM	AXIS	UNKNOWN	UNREACHABLE	With meter cluster in property	UNREACHABLE	UNREACHABLE	GPS_Mtr
I-25 @ Lower La Bajada		35.50599	-106.244	COHU	SGN_STRUCT	I_View	CELL_CDMA	PAN_TLT_ZM	AXIS	UNKNOWN	28 211 208	Across street	UNREACHABLE	UNREACHABLE	GPS_Mtr
I-25 @ Glorieta		35.5913	-105.77639	COHU	CONC_POLE	I_View	CELL_CDMA	PAN_TLT_ZM	AXIS	UNKNOWN	76 023 197	Behind camera on pole	91422	906005887	GPS_Mtr
US 84/285 @ Espanola	Fairview Drive	36.00799	-106.06519	COHU	STL_POLE	DOME	CELL_CDMA	PAN_TLT_ZM	AXIS	OTHER	Illegible	Opposite side of street, next to box	UNKNOWN	UNKNOWN	GPS_Mtr
US 84/285 @ Espanola	NM 76	35.99788	-106.06418	COHU	STL_POLE	DOME	CELL_CDMA	PAN_TLT_ZM	AXIS	OTHER	116 242 542	Oppodite side of street, left of Long John Silver's	UNKNOWN	UNKNOWN	GPS_Mtr
US 84/285 @ Espanola	Stanley Griegos Bridge	35.98862	-106.06568	COHU	STL_POLE	DOME	CELL_CDMA	PAN_TLT_ZM	OTHER	OTHER	113 493 680	Opposite side of street , in front of Dandy's Char-Broiled Burgers	UNKNOWN	UNKNOWN	GPS_Mtr
TOTALS:															
Mount		**CCTV Type**													
Concrete Pole	4	Dome	5												
Steel Pole	3	I-View	4												
Sign Structure	1														
Other	1														

ITS CCTV Poles Inventory Sheet

1	2	3	4	21	22	23	24	16
Project CN	**Location**	Lat	Lon	Pole_Type	Material	Height_ft	Video_Type	DataCollectionMethod
I-25 @ Cerillos Road		35.60454	-106.03525	ITS_POLE	CONCRETE	50FT	CCTV	GPS_Mtr
I-25 @ St. Francis Dr.		35.63527	-105.95573	ITS_POLE	CONCRETE	50FT	CCTV	GPS_Mtr
US 285 @ Pojoaque		35.89078	-106.02325	ITS_POLE	CONCRETE	50FT	CCTV	GPS_Mtr
I-25 @ Upper La Bajada		35.52099	-106.168	OTHER	OTHER	45FT	CCTV	GPS_Mtr
I-25 @ Lower La Bajada		35.50599	-106.244	OTHER	STEEL	30FT	CCTV	GPS_Mtr
I-25 @ Glorieta		35.5913	-105.77639	ITS_POLE	CONCRETE	50FT	CCTV	GPS_Mtr
US 84/285 @ Espanola NB	Fairview Drive	36.00799	-106.06519	TYPE_II	STEEL	30FT	CCTV	GPS_Mtr
US 84/285 @ Espanola SB	NM 76	35.99788	-106.06418	TYPE_III	STEEL	30FT	CCTV	GPS_Mtr
US 84/285 @ Espanola	Stanley Griegos Bridge	35.98862	-106.06568	TYPE_III	STEEL	30FT	CCTV	GPS_Mtr
TOTALS:								
Pole Type		**Height**		**Material**				
ITS Pole	4	30FT	4	Concrete	4			
Type II	1	45FT	1	Steel	4			
Type III	2	50FT	4	Other	1			

Explanation of Titles

1. **Project CN:** ITS title of equipment
2. **Lat:** Latitude
3. **Long:** Longitude
4. **Direction:** Direction in which the Dynamic Message sign in facing with regards to the flow of traffic
5. **Manufacturer:** Manufacturing company
6. **Mount:** Structure that the equipment in resting on
7. **COMM_1/COMM:** Communication method
8. **COMM_2:** Secondary communication method
9. **Control_Type:** Software brand that relays data from DMS to technician
10. **Control_Loc:** Location of control software
11. **Remote_Power:** Type of and if remote power is used
12. **Meter Number:** Serial number of meter corresponding to equipment
13. **Meter Address:** Location of meter relative to corresponding equipment
14. **Model_No:** Model number of equipment
15. **Serial_No:** Serial number of equipment
16. **Data_Collection_Method:** Method in which the lat and long data is collected (GPS_Mtr = GPS with meter or more accuracy)
17. **Location:** Location clarification of equipment if multiple pieces of equipment are in same area and have similar Project CNs
18. **CCTV_Type:** Type of CCTV camera used
19. **Control_Features:** Amount of camera control (PAN_TLT_ZM = Pan, Tilt, Zoom)
20. **Protocol:** Type of software protocol used to communicate with CCTV cameras
21. **Pole_Type:** Identification of physical pole type. (ITS Pole = owned by ITS, TYPE_II = Street pole with one arm, TYPE_III = Street pole with one arm partway up pole)
22. **Material:** Physical material of which the pole is made
23. **Height_ft:** Height in feet of the pole
24. **Video_Type:** Type of video feed used

Appendix 3 City of Santa Fe Inventorying Data Sheets

Cerrillos Road System Cabinets Inventory Sheet

1	2	3	4	5	6		7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Intersection ID Road	**Intersection ID Connector**	**Street 1**	**Street 2**	Lat	Lon	Cabinet_Type	Cabinet_Size	Manufacturer	System Type	Controller	Controller ID	Inductance Detection	Video Detection	PreEmp	Other Detection	Splice Config	Data Collection Method	Interior Photo Link	Meter Number	Meter Address Lat	Meter Address Long
100	30	Cerillos Road	St. Francis Drive	36	-106		P	ECONOLITE	AIRES	OTHER	11470	NO	YES	NO		Cop_Cop	GPS_Mtr	100-30 Box 1 System Cabinet Inside	89 217 298	35.67769408	-105.953393
							P	EAGLE	OTHER	OTHER	UNKNOWN	NO		NO		Fib_Fib	GPS_Mtr	100-30 Box 2 System Cabinet Inside	89 217 298	35.67769408	-105.953393
				36	-106		P	ECONOLITE	AIRES	ASC 2S / 2100	7491	YES		NO		Cop_Cop	GPS_Mtr	100-30 Box 3 System Cabinet Inside	89 217 298	35.67769408	-105.953393
100	40	Cerillos Road	Cordova Road	36	-106		P	ECONOLITE	AIRES	ASC 8000	9561	YES	NO	NO		Cop_Cop	GPS_Mtr	100-40 System Cabinet Inside	86 405 204	35.67479666	-105.95801
100	50	Cerillos Road	Baca Street/Monterey Drive	36	-106		P	ECONOLITE	AIRES	ASC 2S / 1000	731	YES	YES	911		Cop_Cop	GPS_Mtr	100-50 System Cabinet Inside	16 455 980	35.67201656	-105.962338
100	60	Cerillos Road	Second Street	36	-106		P	ECONOLITE	AIRES	ASC 2-2100	1984	YES	NO	NO		Cop_Cop	GPS_Mtr	100-60 System Cabinet Inside	94 462 246	35.66682126	-105.969628
100	70	Cerillos Road	Fire Station #3 - Ashbaugh Park	36	-106		P	ECONOLITE	AIRES	ASC 8000	1492	YES	NO	NO		Cop_Cop	GPS_Mtr	100-70 System Cabinet Inside	87 744 482	35.66603084	-105.971227
100	80	Cerillos Road	St. Michael's Drive/Osage Avenue	36	-106		P	ECONOLITE	AIRES	ASC 2S / 1000	9494	YES	NO	NO		Cop_Cop	GPS_Mtr	100-80 System Cabinet Inside	89 680 475	35.66273247	-105.977377
100	90	Cerillos Road	Lujan Street	36	-106		P	ECONOLITE	AIRES	ASC/3-2100	7272	YES	NO	NO		Cop_Cop	GPS_Mtr	100-90 System Cabinet Inside	33 760 688	35.6609529	-105.980903
100	100	Cerillos Road	Camino Carlos Rey	36	-106		P	ECONOLITE	AIRES	ASC/3-2100	21346	YES	NO	911	Pucks	Fib_Fib	GPS_Mtr	100-100 System Cabinet Inside	88 957 705	35.65813028	-105.98658
100	110	Cerillos Road	Siler Road	36	-106		P	ECONOLITE	AIRES	ASC/3-2100	21345	YES	NO	911	Pucks	Fib_Fib	GPS_Mtr	100-110 System Cabinet Inside	88 957 704	35.65594082	-105.990866
100	120	Cerillos Road	Calle de Cielo	36	-106		P	ECONOLITE	AIRES	ASC/3-2100	9999	YES	NO	911	Pucks	Fib_Fib	GPS_Mtr	100-120 System Cabinet Inside	30 026 676	35.65337207	-105.995238
100	125	Cerillos Road	Wal-Mart/Camino Consuelo	36	-106		P	ECONOLITE	AIRES	ASC/3-2100	5099	YES	YES	911	Pucks	Fib_Fib	GPS_Mtr	100-125 System Cabinet Inside	28 024 086	35.65207429	-105.997384
100	130	Cerillos Road	Richards Avenue	36	-106		P	EAGLE	OTHER	OTHER	80639	NO	YES	NO	Radar (Wa	Fib_Fib	GPS_Mtr	100-130 System Cabinet Inside	62 255 29	35.6496079	-106.001365
100	133	Cerillos Road	Avenida de las Americas	36	-106		P	EAGLE	OTHER	OTHER	75197	NO	YES	911		Fib_Fib	GPS_Mtr	100-133 System Cabinet Inside	24 527 162	35.64825149	-106.002851
100	135	Cerillos Road	Vegas Verdes Drive	36	-106		P	EAGLE	OTHER	OTHER	75196	NO	YES	911	IR (FLIR)	Fib_Fib	GPS_Mtr	100-135 System Cabinet Inside	16 814 327		
100	137	Cerillos Road	Zafarano Drive	36	-106		P	EAGLE	OTHER	OTHER	75195	YES	YES	NO	Radar (Wa	Fib_Fib	GPS_Mtr	100-137 System Cabinet Inside	24 527 ???	35.64228768	-106.012339
100	140	Cerillos Road	Airport Road/Rodeo Road	36	-106		P	ECONOLITE	AIRES	ASC 2S / 1000	9496	NO	YES	911		Cop_Cop	GPS_Mtr	100-140 System Cabinet Inside	62 09 28	35.63892531	-106.017933
100	160	Cerillos Road	Wagon Road/Camino Entrada	36	-106		P	ECONOLITE	AIRES	ASC 2S / 1000	2903	YES	YES	911		Cop_Cop	GPS_Mtr	100-160 System Cabinet Inside	36 96 81	35.63535792	-106.020056
100	165	Cerillos Road	Christo's	36	-106		P	ECONOLITE	AIRES	ASC 2S / 2100	2312	YES	NO	911		Cop_Cop	GPS_Mtr	100-165 System Cabinet Inside	72 12 22	35.63016641	-106.023144
100	170	Cerillos Road	Jaguar Drive	36	-106		P	ECONOLITE	AIRES	ASC 2S / 1000	7489	YES	YES	911		Cop_Cop	GPS_Mtr	100-170 System Cabinet Inside	62 08 97	35.62778087	-106.024627
100	174	Cerillos Road	Las Soleras Drive	36	-106		P	ECONOLITE	AIRES	ASC/3-2100	18349	YES	NO	911	SENSYS	Cop_Cop	GPS_Mtr	100-174 System Cabinet Inside	87 947 492	35.62068422	-106.028912
100	176	Cerillos Road	Herrera Drive	36	-106		P	ECONOLITE	AIRES	ASC/3-2100	18348	YES	NO	911		Cop_Cop	GPS_Mtr	100-176 System Cabinet Inside	UNREADIBLE	35.61760275	-106.030818
100	180	Cerillos Road	Beckner Road	36	-106		P	ECONOLITE	AIRES	ASC 2-2100	1486	YES	YES	911		Cop_Cop	GPS_Mtr	100-180 System Cabinet Inside	23 032 432?	35.61329434	-106.032784
TOTALS:																					
Cabinets	24																				
Econolite	19																				
Eagle	5																				
Meters	24																				
Have Preemp	14																				
Have Pucks	4																				
Have Radar	2																				
Have IR	1																				
Copper	15																				
Fiber	9																				

St. Francis Drive System Cabinets Inventory Sheet

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	5	6
Intersection ID Road	**Intersection ID Connector**	**Street 1**	**Street 2**	Lat	Lon	Cabinet Size	Manufacturer	System Type	Controller	Controller ID	Inductance Detection	Video Detection	PreEmp	Other Detection	Splice Config	Data Collection Method	Interior Photo Link	METER NUMER	METER LOCATION LAT	METER LOCATION LON
200	10	St. Francis Drive	Alamo Drive	35.7	-105.95	P	ECONOLITE	AIRES	ASC/3-2100	2657	YES	NO	911		Cop_Cop	GPS_Mtr	200-10 System Cabinet Inside	33 298 939	35.7	-105.95
200	20	St. Francis Drive	Paseo de Peralta/Camino de Crucitas (north)	35.69	-105.95	P	ECONOLITE	AIRES	ASC 2S / 1000	1008	YES	NO	NO		Cop_Cop	GPS_Mtr	200-20 System Cabinet Inside	33 297 608	35.69	-105.95
200	30	St. Francis Drive	Alameda Street	35.69	-105.95	P	ECONOLITE	AIRES	ASC 2S / 2100	7485	YES	NO	NO		Cop_Cop	GPS_Mtr	200-30 System Cabinet Inside	64 294 084	35.69	-105.95
200	40	St. Francis Drive	Agua Fria Street	35.68	-105.96	P	ECONOLITE	AIRES	ASC 2S / 2100	9849	YES	NO	NO		Cop_Cop	GPS_Mtr	200-40 System Cabinet Inside	UNREADABLE	35.68	-105.96
200	50	St. Francis Drive	Paseo de Peralta/Hickox Street (south)	35.68	-105.95	P	ECONOLITE	AIRES	ASC 2S / 1000	7490	YES	NO	NO		Cop_Cop	GPS_Mtr	200-50 System Cabinet Inside	97 684 481	35.68	-105.95
200	60	St. Francis Drive	Cordova Road	35.67	-105.95	P	ECONOLITE	AIRES	ASC 2S / 1000	9497	NO	YES	911		Cop_Cop	GPS_Mtr	200-60 System Cabinet Inside	29 836 111	35.67	-105.95
200	70	St. Francis Drive	Alta Vista Street	35.67	-105.95	P	ECONOLITE	AIRES	ASC 2S / 1000	5263	NO	YES	911		Cop_Cop	GPS_Mtr	200-70 System Cabinet Inside	33 299 087	35.67	-105.95
200	80	St. Francis Drive	San Mateo Road	35.66	-105.96	P	ECONOLITE	AIRES	ASC 2S / 1000	9493	NO	YES	911		Cop_Cop	GPS_Mtr	200-80 System Cabinet Inside	10 229 297	35.66	-105.96
200	90	St. Francis Drive	Siringo Road	35.65	-105.96	P	ECONOLITE	AIRES	ASC 2S / 1000	Blury Image	NO	YES	911		Cop_Cop	GPS_Mtr	200-90 System Cabinet Inside	65 539 734	35.65	-105.96
200	100	St. Francis Drive	Zia Road	35.65	-105.96	P	ECONOLITE	AIRES	ASC 2S / 1000	1883	NO	YES	NO		Cop_Cop	GPS_Mtr	200-100 System Cabinet Inside	22 583 111	35.65	-105.96
200	110	St. Francis Drive	Saw Mill Road	35.54	-105.96	P	ECONOLITE	AIRES	ASC 2S / 1000	9495	NO	YES	911		Cop_Cop	GPS_Mtr	200-110 System Cabinet Inside	UNREADABLE	35.64	-105.96
TOTALS:																				
Cabinets	11																			
Econolite	11																			
Eagle	0																			
Meters	11																			
Have Preemp	6																			
Have Pucks	0																			
Have Radar	0																			
Have IR	0																			
Copper	11																			
Fiber	0																			

Cerrillos Road Intersection Inventory Sheet (page 1 of 3)

1	2	3	4	22	23	24	25	25	25	25	26	27	28	29	30	31	32	33
Intersection ID Road	Intersection ID Connector	Street 1	Street 2	Traffic Light Dir	Pole Type	Leftmost	Next	Next	Next	Next	Rightmost	Pedestrian Xing?	Streetlamps?	Cameras?	Radar?	Pucks?	Loops Visible?	Other?
100	30	Cerillos Road	St. Francis Drive	NE	3	3H	3V					NO	NO	YES	NO	NO	NO	
				NW	3	3H	3V	3V				NO	YES	YES	NO	NO	NO	
				NW 2	3	3H	3H	3V				NO	NO	YES	NO	NO	NO	
				N MEDIAN	1	3V						NO	NO	NO	NO	NO	NO	
				N MEDIAN 2	3	3H	3H	3V	3V			NO	NO	YES	NO	NO	NO	
				SW	3	3V	3V					YES	NO	YES	NO	NO	NO	
				SE	3	3H	3V	3V				NO	NO	YES	NO	NO	NO	
				SE MEDIAN	1	3V						NO	NO	NO	NO	NO	NO	
				S MEDIAN	1	3V						NO	NO	NO	NO	NO	NO	
				S MEDIAN 2	1	3V						NO	NO	NO	NO	NO	NO	
100	40	Cerillos Road	Cordova Road	NE	3	3H	3V					NO	NO	NO	NO	NO	YES	
				SE	1	5V						NO	NO	NO	NO	NO	YES	
				SW	3	3V	3V	3V	3V			NO	NO	NO	NO	NO	NO	
				S MEDIAN	1	5V						NO	NO	NO	NO	NO	NO	
100	50	Cerillos Road	Baca Street/Monterey Drive	NE	3	5H	3H	3V	3V			YES	NO	YES	NO	NO	NO	
				NW	3	5H						NO	NO	NO	NO	NO	YES	
				NW 2	1	5V	3V					YES	NO	NO	NO	NO	NO	
				SE	3	3H	3V					NO	YES	YES	NO	NO	YES	
				SE 2	1	5V						YES	NO	NO	NO	NO	NO	
				SW	3	5H	3H	5V	3V			YES	YES	YES	NO	NO	NO	
100	60	Cerillos Road	Second Street	NE	3	5H	3V	3V				YES	NO	NO	NO	NO	NO	
				NW	3	3H	5V	3V				YES	NO	NO	NO	NO	YES	
				SE	3	3H	5V	3V				YES	NO	NO	NO	NO	YES	
				SW	3	5H	3V	3V				YES	NO	NO	NO	NO	YES	
100	70	Cerillos Road	Fire Station #3 - Ashbaugh Park	W	1	3V						NO	NO	NO	NO	NO	NO	BLUETOOTH
				N	3	3H	3H	3V				NO	NO	NO	NO	NO	NO	
				S MEDIAN	3	3H	3H	3V				NO	NO	NO	NO	NO	NO	
100	80	Cerillos Road	St. Michael's Drive/Osage Avenue	NE	3	5H	5V	3V				YES	YES	NO	NO	NO	NO	
				NW	2	3H	3H	5V	3V			YES	NO	NO	NO	NO	YES	
				SE	3	5H	5V	3V				YES	YES	NO	YES	NO	YES	
				SW	3	5H	3H	3V	3V			YES	NO	NO	NO	NO	NO	
100	90	Cerillos Road	Lujan Street	NE	3	3V	3V	5H	3H			YES	NO	NO	NO	NO	NO	
				NW	3	3H	3H	4V	3V			YES	NO	NO	NO	NO	YES	
				N MEDIAN	1	4V						YES	NO	NO	NO	NO	NO	
				SE	3	5H	4V	3V				YES	NO	NO	NO	NO	NO	
				SW	3	3H	3H	3V	3V			YES	NO	NO	NO	NO	NO	
				S MEDIAN	1	4V						YES	NO	NO	NO	NO	NO	
100	100	Cerillos Road	Camino Carlos Rey	NE	3	3H	3H	3H	5V			YES	NO	NO	NO	NO	NO	
				NE 2	1	5V						YES	NO	NO	NO	NO	NO	
				N MEDIAN	1	4V						YES	NO	NO	NO	NO	NO	
				NW	3	5H	3H	3V				YES	NO	NO	NO	NO	NO	
				NW 2	1	4V						YES	NO	NO	NO	NO	NO	
				SE	1	4V						YES	NO	NO	NO	NO	NO	
				SE 2	3	5H	3V					YES	NO	NO	NO	NO	NO	
				SW	3	3H	3H	3H	5V			YES	YES	NO	YES	NO	NO	
				SW 2	1	5V						YES	NO	NO	NO	NO	NO	
				S MEDIAN	1	4V						YES	NO	NO	NO	NO	NO	

Cerrillos

Road Intersection Inventory Sheet (page 2 of 3)

1	2	3	4	22	23	24	25	25	25	25	26	27	28	29	30	31	32	33
Intersection ID Road	Intersection ID Connector	Street 1	Street 2	Traffic Light Dir	Pole Type	Leftmost	Next	Next	Next	Next	Rightmost	Pedestrian Xing?	Streetlamps?	Cameras?	Radar?	Pucks?	Loops Visible?	Other?
100	110	Cerillos Road	Siler Road	NE	3	3H	3H	3H	3V	3V		YES	NO	NO	NO	NO	NO	
				NW	1	4V						YES	NO	NO	NO	NO	NO	
				N MEDIAN	1	4V						YES	NO	NO	NO	NO	NO	
				SE	2	3H	3H	5V				YES	NO	NO	NO	NO	NO	
				SE	1	4V						YES	YES	NO	NO	NO	NO	
				S MEDIAN	1	4V						YES	NO	NO	NO	NO	NO	
				SW	3	3H	3H	3H	5V			YES	YES	NO	NO	YES	NO	
100	120	Cerillos Road	Calle de Cielo	NE	3	3H	3H	5V	5V			YES	YES	NO	NO	NO	NO	
				NW	3	5H	3H	4V	3V			YES	YES	NO	NO	NO	NO	
				N MEDIAN	1	4V						YES	YES	NO	NO	NO	NO	
				SE	3	5H	3H	4V	3V			YES	YES	NO	NO	NO	NO	
				SW	3	3H	3H	5V	5V			YES	YES	NO	YES	NO	NO	
				S MEDIAN	1	4V						YES	YES	NO	NO	NO	NO	
100	125	Cerillos Road	Wal-Mart/Camino Consuelo	NE	3	3H	3H	3V	3V			YES	YES	NO	NO	NO	YES	
				N MEDIAN	1	3V						YES	YES	NO	NO	NO	NO	
				SE	3	3H	3H	4V	3V			YES	YES	NO	NO	NO	NO	
				SW	3	3H	3H	5V	5V			YES	YES	NO	NO	NO	NO	
				S MEDIAN	1	4V						YES	YES	NO	NO	NO	NO	
100	130	Cerillos Road	Richards Avenue	NE	3	3H	3H	3H	5V	3V		YES	YES	YES	YES	NO	NO	
				NW	3	3H	3H	3V	3V			YES	YES	YES	NO	NO	NO	
				SE	3	5H	3V	3V				YES	YES	YES	NO	NO	NO	
				SW	3	3H	3H	3H	3V	5V		YES	YES	YES	YES	NO	NO	DOME TRAFFIC CAMERA
100	133	Cerillos Road	Avenida de las Americas	NE	3	5H	3H	3H	3V	3V		YES	YES	YES	NO	NO	NO	
				NW	3	3H	3H	5V	3V			YES	YES	YES	NO	NO	NO	
				SE	3	3H	5V	3V				YES	YES	YES	NO	NO	NO	
				SW	3	5H	3H	3H	3V	3V		YES	YES	YES	NO	NO	NO	
100	135	Cerillos Road	Vegas Verdes Drive	NE	3	3H	3H	3H	3V	3V	3V	YES	YES	YES	NO	NO	NO	
				NW	3	3H	3H	3V	3V			YES	YES	YES	NO	NO	NO	
				SE	3	3H	3H	3V	3V			YES	YES	YES	NO	NO	NO	
				SW	3	3H	3H	3H	3V	3V		YES	YES	YES	NO	NO	NO	
				SW 2	1	3V						YES	YES	YES	NO	NO	NO	
100	137	Cerillos Road	Zafarano Drive	NE	3	3H	3H	3H	3V	5V		YES	YES	YES	YES	UNK	NO	
				NW	3	3H	3H					YES	YES	YES	NO	UNK	NO	
				SE	3	3H	3H	3H	3V	3V		YES	YES	YES	NO	UNK	NO	
				SW	3	3H	3H	3H	5V			YES	YES	YES	YES	UNK	NO	
				NW 2	1	3V	5V					YES	YES	YES	NO	UNK	NO	
				SW2	1	3V						YES	YES	YES	NO	UNK	NO	
100	140	Cerillos Road	Airport Road/Rodeo Road	NE	3	3H	3H	3H	3V	3V		YES	YES	YES	NO	NO	NO	
				NW	3	3H	3H	3H	3V	3V		YES	YES	YES	NO	NO	NO	CCTV
				SE	3	3H	3H	3H	3V	3V		YES	YES	YES	NO	NO	NO	
				SW	3	3H	3H	3H	3V	3V		YES	YES	YES	NO	NO	NO	BLUETOOTH
				W	1	3V						YES	NO	NO	NO	NO	NO	
				W 2	1	3V						YES	NO	NO	NO	NO	NO	

Cerrillos Road Intersection Inventory Sheet (page 3 of 3)

1	2	3	4	22	23	24	25	25	25	25	26	27	28	29	30	31	32	33
Intersection ID Road	Intersection ID Connector	Street 1	Street 2	Traffic Light Dir	Pole Type	Leftmost	Next	Next	Next	Next	Rightmost	Pedestrian Xing?	Streetlamps?	Cameras?	Radar?	Pucks?	Loops Visible?	Other?
100	160	Cerillos Road	Wagon Road/Camino Entrada	NE	3	3H	3H	3H	5V			YES	YES	YES	NO	NO	NO	
				NW	3	5H	5V	3V				YES	YES	YES	NO	NO	NO	
				SW	3	3H	3H	3H	5V	3V	3V	YES	YES	YES	NO	NO	NO	
				SE	3	3H	5V	3V				YES	YES	YES	NO	NO	NO	
				N	1	5V						NO	NO	NO	NO	NO	NO	
				S	1	5V						NO	NO	NO	NO	NO	NO	
				E	1	3V	3V					YES	NO	NO	NO	NO	NO	
100	165	Cerillos Road	Christo's	NE	3	3H	3H	3V	3V			YES	YES	NO	NO	NO	YES	
				NW	3	3H	5V	3V				YES	YES	NO	NO	NO	YES	
				SE	3	3H	5V	3V				YES	YES	NO	NO	NO	YES	
				SW	3	3H	3H	3V	3V			YES	YES	NO	NO	NO	YES	
				N	1	5V						NO	NO	NO	NO	NO	YES	
				S	1	5V						NO	NO	NO	NO	NO	YES	
100	170	Cerillos Road	Jaguar Drive	NE	3	5H	3H	3H	5V	3V		YES	YES	YES	NO	NO	YES	
				NW	3	5H	5V	3V				YES	YES	YES	NO	NO	NO	
				SE	3	5H	5V	3V				YES	YES	YES	NO	NO	YES	
				SW	3	5H	3H	3H	5V	3V		YES	YES	YES	NO	NO	NO	
100	174	Cerillos Road	Las Soleras Drive	NE	3	3H	3H	3H	3V	3V		YES	YES	NO	YES	YES	NO	
				NW	3	3H	5V	5V				YES	YES	NO	NO	YES	NO	
				SE	3	3H	3H	5V	5V			YES	YES	NO	NO	YES	NO	
				SW	3	3H	3H	3H	3H			YES	YES	NO	NO	YES	NO	
				N	1	5V						NO	NO	NO	NO	YES	NO	
				S	1	5V						NO	NO	NO	NO	YES	NO	
				E	1	3V						NO	NO	NO	NO	YES	YES	
				W	1	3V						NO	NO	NO	NO	YES	YES	
100	176	Cerillos Road	Herrera Drive	NE	3	3H	3H	3V	3V			YES	YES	NO	YES	NO	NO	
				NW	3	3H	3H	5V	5V			YES	YES	NO	NO	NO	NO	
				SE	3	3H	3H	5V	5V			YES	YES	NO	NO	NO	NO	
				SW	3	3H	3H	5V	3V			YES	YES	NO	NO	NO	NO	
				N	1	5V						YES	NO	NO	NO	YES	NO	
				S	1	5V						YES	NO	NO	NO	YES	NO	
				E	1	3V						NO	NO	NO	NO	NO	YES	
				W	1	3V						NO	NO	NO	NO	NO	YES	
100	180	Cerillos Road	Beckner Road	NE	3	5H	3H	3H	5V	5V		NO	YES	YES	NO	NO	NO	
				NW	3	5H	3H	5V	3V			NO	YES	YES	NO	NO	NO	
				SE	3	5H	3H	5V	3V			NO	YES	YES	NO	NO	NO	
				SW	3	5H	3H	5V	3V			NO	YES	YES	NO	NO	NO	
TOTALS:																		
Traffic Lights	127																	
Pole Type 1:	43																	
Pole Type 2:	2																	
Pole Type 3:	82																	
Ped. Xing:	95																	
Streetlamps:	66																	
Cameras:	45																	
Radar:	9																	
Pucks:	11																	
Visible Loops	23																	

St. Francis Drive Intersection Inventory Sheet (page 1 of 2)

1	2	3	4	22	23	24	25	25	25	25	26	27	28	29	30	31	32	33
Intersection ID Road	Intersection ID Connector	Street 1	Street 2	Traffic Light Dir	Pole Type	Leftmost	Next	Next	Next	Next	Rightmost	Pedestrian Xing?	Streetlamps?	Cameras?	Radar?	Pucks?	Loops Visible?	Other?
200	10	St. Francis Drive	Alamo Drive	NE	2	3H	3V	3V				YES	NO	NO	NO	NO	YES	
				NW	2	3H	4V	3V				YES	NO	NO	NO	NO	NO	
				N MEDIAN	1	4V						YES	NO	NO	NO	NO	NO	911
				SE	2	3H	3V					YES	NO	NO	NO	NO	YES	
				SW	2	3H	3H	3V	3V			YES	NO	NO	NO	NO	YES	
200	20	St. Francis Drive	Paseo de Peralta/Camino de Crucitas (north)	NE	2	5H	3H	4V	3V			YES	NO	NO	NO	NO	NO	
				NW	2	3H	3H	5V	3V			YES	NO	NO	NO	NO	YES	
				SE	2	4H	5V	3V				YES	NO	NO	NO	NO	NO	911
				SW	2	5H	3H	3V	3V	3V		YES	NO	NO	NO	NO	YES	
200	30	St. Francis Drive	Alameda Street	NE	2	5H	3H	3V				YES	NO	YES	NO	NO	YES	
				NW	2	5H	3V					YES	NO	NO	NO	NO	NO	
				SE	2	3H	3V					YES	NO	NO	NO	NO	NO	
				SW	2	5H	3H	3V				YES	NO	NO	NO	NO	YES	
200	40	St. Francis Drive	Agua Fria Street	NE	2	5H	3H	5V	3V			YES	NO	NO	NO	NO	YES	
				NW	2	5H	5V	3V				YES	NO	NO	NO	NO	NO	
				SE	2	5H	5V	3V				YES	NO	NO	NO	NO	YES	
				SW	2	5H	3H	5V	3V			YES	NO	NO	NO	NO	YES	
200	50	St. Francis Drive	Paseo de Peralta/Hickox Street (south)	NE	2	5H	3H	5V	3V			YES	YES	NO	NO	NO	YES	
				NW	2	5H	5V	3V				YES	NO	NO	NO	NO	NO	
				SE	2	5H	5V	3V				YES	NO	NO	NO	NO	YES	
				SW	2	5H	3H	5V	3V			YES	NO	NO	NO	NO	YES	
200	60	St. Francis Drive	Cordova Road	NE	2	5H	3H	5V	3V			YES	NO	YES	NO	NO	NO	911
				NW	2	5H	3H	5V	3V			YES	NO	YES	NO	NO	NO	911
				SE	2	5H	3H	5V	3V			YES	NO	YES	NO	NO	NO	911
				SW	2	5H	3H	5V	3V			YES	NO	YES	NO	NO	NO	911
200	70	St. Francis Drive	Alta Vista Street	NE	2	5H	3H	5V	3V			YES	NO	YES	NO	NO	NO	911
				NW	2	5H	5V	3V				YES	NO	YES	NO	NO	NO	911
				SE	2	5H	5V	3V				YES	NO	YES	NO	NO	NO	911
				SW	2	5H	3H	5V	3V			YES	NO	YES	NO	NO	NO	911
200	80	St. Francis Drive	San Mateo Road	NE	2	5H	3H	3V	5V			YES	NO	YES	NO	NO	NO	911
				NW	2	5H	5V	3V				YES	NO	YES	NO	NO	NO	911
				SE	2	5H	5V	3V				YES	NO	YES	NO	NO	NO	911
				SW	2	5H	3H	5V	3V			YES	NO	YES	NO	NO	NO	911

St. Francis Drive Intersection Inventory Sheet (page 2 of 2)

1	2	3	4	22	23	24	25	25	25	25	26	27	28	29	30	31	32	33
Intersection ID Road	**Intersection ID Connector**	**Street 1**	**Street 2**	**Traffic Light Dir**	**Pole Type**	**Leftmost**	**Next**	**Next**	**Next**	**Next**	**Rightmost**	**Pedestrian Xing?**	**Streetlamps?**	**Cameras?**	**Radar?**	**Pucks?**	**Loops Visible?**	**Other?**
200	90	St. Francis Drive	Siringo Road	NE	3	3H	3H	5V	3V			YES	NO	YES	NO	NO	NO	911
				NW	3	5H	5V	3V				YES	YES	NO	NO	NO	NO	
				N	2	5H	5V	3V	5V			YES	NO	YES	NO	NO	NO	
				SE	3	5H	5V	3V				YES	YES	NO	NO	NO	NO	
				SW	3	3H	3H	3V				YES	NO	YES	NO	NO	NO	911, RADIO
				SW 2	1	5V						YES	NO	NO	NO	NO	NO	
				S	2	5H	5V	3V	5V			YES	NO	YES	NO	NO	NO	911
200	100	St. Francis Drive	Zia Road	NE	3	3H	3H	3V				NO	YES	YES	NO	NO	NO	RADIO
				NE 2	1	3V						YES	NO	NO	NO	NO	NO	
				NW	3	3H	3V	3V	3V			YES	YES	NO	NO	NO	NO	
				N	3	3H	3H	3V	3V	3V		YES	YES	YES	NO	NO	NO	911
				SE	3	3H	3V	3V				YES	YES	NO	NO	NO	NO	
				SW	3	3H	3H	3V	3V			YES	YES	YES	NO	NO	NO	
				S	3	3H	3H	3V	3V			YES	YES	YES	NO	NO	NO	911
200	110	St. Francis Drive	Saw Mill Road	NE	3	3H	3H	3V	3V			YES	YES	YES	NO	NO	NO	911
				NW	3	5H	5V	3V				YES	YES	NO	NO	NO	NO	
				N	3	5H	5V	3V	5V			YES	NO	YES	NO	NO	NO	911
				SE	3	3H	5V	3V				YES	YES	NO	NO	NO	NO	
				SW	3	3H	3H	5V	3V			YES	YES	YES	NO	NO	NO	911, RADIO
				S	3	3H	3H	5V	3V	5V		YES	NO	YES	NO	NO	NO	911
TOTALS:																		
Traffic Lights:	53																	
Pole Type 1:	3																	
Pole Type 2:	34																	
Pole Type 3:	16																	
Ped. Xing:	52																	
Streetlamps:	13																	
Cameras:	31																	
Radar:	0																	
Pucks:	0																	
Visible Loops:	13																	

Explanation of Titles

1. **Intersection ID Road:** Main Road's unique intersection ID as prescribed by the Santa Fe Traffic Office
2. **Intersection ID Connector:** Intersecting Road's intersection ID as prescribed by the Santa Fe Traffic Office
3. **Street 1:** Main Road
4. **Street 2:** Intersecting Road
5. **Lat:** Latitude
6. **Long:** Longitude
7. **Cabinet Size:** Size of cabinet as designated by a letter
8. **Manufacturer:** Manufacturing company
9. **System Type:** Type of software used
10. **Controller:** Model type of controller used
11. **Controller ID:** Unique identification number of controller
12. **Inductance Detection:** Whether or not there is inductance detection installed
13. **Video Detection:** Whether or not there is CCTV detection installed
14. **PreEmp:** Whether or not there is preemption detection capabilities installed
15. **Other Detection:** Any other detection capabilities
16. **Splice Config:** Physical type of wires used to transmit and receive information.
17. **Data Collection Method:** Method in which the lat and long data is collected (GPS_Mtr = GPS with meter or more accuracy)
18. **Interior Photo Link:** Hyperlink to corresponding online photo of the interior of the cabinet
19. **Meter Number:** Serial number of meter corresponding to equipment
20. **Meter Address Lat:** Latitude coordinate of meter location
21. **Meter Address Long:** Longitude coordinate of meter location
22. **Traffic Light Dir:** Direction in which the traffic light structure is facing in relation to traffic flow
23. **Pole Type:** Identification of physical pole type. (1 = Street pole with no arms, 2 = Street pole with one arm, 3 = Street pole with one arm partway up pole)
24. **Leftmost:** Leftmost traffic light on the pole
25. **Next:** Going from left to right, the next traffic light in
26. **Rightmost:** Rightmost traffic light on the pole
27. **Pedestrian Xing?:** Whether or not there is pedestrian crossing on the traffic pole
28. **Streetlamps?:** Whether or not there are streetlamps on the traffic pole
29. **Cameras?:** Whether or not there are CCTV cameras on the traffic pole
30. **Radar?:** Whether or not there is a radar device on the traffic pole
31. **Pucks?:** Whether or not there are known pucks in the direction of the nearest traffic pole
32. **Loops Visible?:** Whether or not there are inductance loops visible in the pavement of the nearest traffic pole
33. **Other?:** Space to mark if there is anything else of note on the traffic pole

Appendix 4 Cost of Roadway Construction per Mile

To view the complete cost break down of roadway construction per mile determined by the Florida DOT, view the following link:

https://drive.google.com/file/d/0B2qF3IWx_vL6eTZMNnBIQmhWWHc/edit?usp=sharing

Roadway Cost Per Centerline Mile
Revised June 2012

	Construction Cost From LRE	MOT *	Mobilization *	Subtotal	Scope Contingency (25%)	Total Construction Cost	PE Design (15%)	CEI (15%)	Total Project Cost **
Rural Arterial									
New Construction (2-Lane Roadway) with 5' Paved Shoulders	$2,997,141	$299,714	$329,686	$3,626,541	$906,635	$4,533,176	$679,976	$679,976	$5,893,129
New Construction (4-Lane Roadway) with 5' Paved Shoulders	$4,783,393	$478,339	$526,173	$5,787,905	$1,446,976	$7,234,881	$1,085,232	$1,085,232	$9,405,346
New Construction (6-Lane Roadway) with 5' Paved Shoulders	$6,097,845	$609,785	$670,763	$7,378,393	$1,844,598	$9,222,991	$1,383,449	$1,383,449	$11,989,888
Milling and Resurfacing (4-Lane Roadway) with 5' Paved Shoulders	$1,031,387	$103,139	$113,453	$1,247,979	$311,995	$1,559,973	$233,996	$233,996	$2,027,965
Milling and Resurfacing (6-Lane Roadway) with 5' Paved Shoulders	$1,509,273	$150,927	$166,020	$1,826,220	$456,555	$2,282,775	$342,416	$342,416	$2,967,607
Add Lanes (2 to 4 Lanes) with 5' Paved Shoulders (Includes milling and resurfacing of existing pavement)	$3,764,991	$376,499	$414,149	$4,555,640	$1,138,910	$5,694,550	$854,182	$854,182	$7,402,914
Add Lanes (4 to 6 Lanes) with 5' Paved Shoulders (Includes milling and resurfacing of existing pavement)	$4,147,292	$414,729	$456,202	$5,018,223	$1,254,556	$6,272,779	$940,917	$940,917	$8,154,613
Add Lanes (4 to 8 Lanes) with 5' Paved Shoulders (Includes milling and resurfacing of existing pavement)	$5,567,988	$556,799	$612,479	$6,737,266	$1,684,317	$8,421,583	$1,263,237	$1,263,237	$10,948,057
Add Lanes (6 to 8 Lanes) with 5' Paved Shoulders (Includes milling and resurfacing of existing pavement)	$5,224,825	$522,483	$574,731	$6,322,039	$1,580,510	$7,902,548	$1,185,382	$1,185,382	$10,273,313
Add 1 Through Lane on Inside (To Existing) with 5' Paved Shoulders	$871,292	$87,129	$95,842	$1,054,263	$263,566	$1,317,829	$197,674	$197,674	$1,713,177
Add 1 Through Lane on Outside (To Existing) with 5' Paved Shoulders	$1,423,981	$142,398	$156,638	$1,723,017	$430,754	$2,153,771	$323,066	$323,066	$2,799,903
Add 300' Exclusive Left Turn Lane	$44,214	$6,632	$7,627	$58,473	$14,618	$73,091	$10,964	$10,964	$95,018
Add 300' Exclusive Right Turn Lane	$107,770	$16,165	$18,590	$142,526	$35,631	$178,157	$26,724	$26,724	$231,604
Urban Arterial									
New Construction (2-Lane Roadway) with 5' Sidewalk, and Curb & Gutter	$4,279,236	$427,924	$470,716	$5,177,876	$1,294,469	$6,472,344	$970,852	$970,852	$8,414,048
New Construction (4-Lane Roadway) with 5' Sidewalk, and Curb & Gutter	$6,040,559	$604,056	$664,462	$7,309,077	$1,827,269	$9,136,346	$1,370,452	$1,370,452	$11,877,250
New Construction (6-Lane Roadway) with 5' Sidewalk, and Curb & Gutter	$7,396,260	$739,626	$813,589	$8,949,474	$2,237,369	$11,186,843	$1,678,026	$1,678,026	$14,542,896
Milling and Resurfacing (4-Lane Roadway) with 5' Sidewalk, and Curb & Gutter	$1,108,757	$110,876	$121,963	$1,341,595	$335,399	$1,676,994	$251,549	$251,549	$2,180,093
Milling and Resurfacing (6-Lane Roadway) with 5' Sidewalk, and Curb & Gutter	$1,573,097	$157,310	$173,041	$1,903,447	$475,862	$2,379,309	$356,896	$356,896	$3,093,102
Add Lanes (2 to 4 Lanes) with 5' Sidewalk, and Curb & Gutter (Includes milling and resurfacing existing pavement)	$4,686,892	$468,689	$515,558	$5,671,140	$1,417,785	$7,088,925	$1,063,339	$1,063,339	$9,215,602
Add Lanes (4 to 6 Lanes) with 5' Sidewalk, and Curb & Gutter (Includes milling and resurfacing existing pavement)	$5,179,396	$517,940	$569,734	$6,267,070	$1,566,767	$7,833,837	$1,175,076	$1,175,076	$10,183,988
Add Lanes (4 to 8 Lanes) with 5' Sidewalk, and Curb & Gutter (Includes milling and resurfacing existing pavement)	$6,977,100	$697,710	$767,481	$8,442,291	$2,110,573	$10,552,863	$1,582,930	$1,582,930	$13,718,722
Add Lanes (6 to 8 Lanes) with 5' Sidewalk, and Curb & Gutter (Includes milling and resurfacing existing pavement)	$6,115,218	$611,522	$672,674	$7,399,413	$1,849,853	$9,249,267	$1,387,390	$1,387,390	$12,024,047
Add 1 Through Lane on Inside (To Existing) with 5' Sidewalk, and Curb & Gutter	$840,549	$84,055	$92,460	$1,017,064	$254,266	$1,271,330	$190,699	$190,699	$1,652,729
Add 1 Through Lane on Outside (To Existing) with 5' Sidewalk, and Curb & Gutter	$2,331,279	$233,128	$256,441	$2,820,847	$705,212	$3,526,059	$528,909	$528,909	$4,583,877
Add 300' Exclusive Left Turn Lane	$57,270	$8,591	$9,879	$75,740	$18,935	$94,675	$14,201	$14,201	$123,077
Add 300' Exclusive Right Turn Lane	$126,412	$18,962	$21,806	$167,179	$41,795	$208,974	$31,346	$31,346	$271,666

* A 15% MOT and Mobilization factor was used for exclusive left and right turn lanes. A 10% factor was used for all other figures.
** Total cost shown is derived from a standard typical section. Costs will need to be adjusted to account for signals, bridges, or any additional item not deemed typical.

Note:
1. Estimates were derived from FDOT LRE system
2. These figures exclude costs for intersections/interchanges, improvements to cross streets, bridges over 20', right-of-way, landscaping, ITS, and traffic signals.
3. The figures are based on market costs for Hillsborough County.
4. Costs shown are present day costs.
5. The costs developed for this report are not project-specific and should be used for preliminary estimating purposes only.

Appendix 5 Equipment Costs for Roadside Detection

USDOT prices for replacing inductance loops taken from the Equipment Costs for Roadside Detection table. The full table can be found at the following link:

http://www.itscosts.its.dot.gov/ITS/benecost.nsf/SubsystemCostsAdjusted?ReadForm&Subsystem=Roadside+Detection+(RS-D)

Unit Cost Element	IDAS #	Life *Years*	Capital Cost *$K, 2009 Dollars (Source Year)*	O&M Cost *$K/year, Dollars (Source Year)*	Description
Inductive Loop Surveillance on Corridor ***Index: 2***		5	2 - 6 *(2001)*	0.3 - 0.5 *(2005)*	Double set (four loops) with controller, power, etc.
Inductive Loop Surveillance at Intersection ***Index: 2***		5	7.5 - 13.3 *(2005)*	0.8 - 1.2 *(2005)*	Four legs, two lanes per approach.
Machine Vision Sensor on Corridor ***Index: 2***		10	18.0 - 24 *(2003)*	0.2 - 0.3 *(2003)*	One sensor both directions of travel. Does not include installation.

Appendix 6 Synchro Results for Current Traffic Programming

Cerrillos AM

Arterial Level of Service: NE CERRILLOS ROAD

Cross Street	Arterial Class	Flow Speed	Running Time	Signal Delay	Travel Time (s)	Dist (mi)	Arterial Speed	Arterial LOS
ZAFARANO	II	40	144.3	20.0	164.3	1.60	35.1	A
VEGAS VERDES	II	40	26.2	3.9	30.1	0.24	28.5	B
LAS AMERICAS	II	40	41.7	2.0	43.7	0.44	36.1	A
RICHARDS AVE	II	40	17.2	11.3	28.5	0.15	18.9	D
CAM. CONSUELO	II	40	28.5	4.1	32.6	0.28	30.9	B
CAM CIELO	II	40	17.4	9.9	27.3	0.15	19.9	D
SILER RD	II	35	33.2	6.7	39.9	0.30	27.2	C
CAM CARLOS REY	II	35	31.5	17.9	49.4	0.29	20.9	D
SMITHS	II	35	38.0	2.8	40.8	0.35	31.0	B
ST. MICHAELS	II	35	29.5	39.7	69.2	0.25	12.9	F
Total	II		407.5	118.3	525.8	4.05	27.7	C

Arterial Level of Service: SW CERRILLOS ROAD

Cross Street	Arterial Class	Flow Speed	Running Time	Signal Delay	Travel Time (s)	Dist (mi)	Arterial Speed	Arterial LOS
OSAGE	II	35	81.5	22.9	104.4	0.79	27.3	C
LUJAN	II	35	29.5	6.6	36.1	0.25	24.8	C
CAM CARLOS REY	II	35	38.0	8.1	46.1	0.35	27.5	C
SILER RD	II	35	31.5	15.8	47.3	0.29	21.8	D
	II	35	33.2	15.9	49.1	0.30	22.1	C
	II	40	17.4	4.8	22.2	0.15	24.5	C
Richards Ave	II	40	28.5	31.8	60.3	0.28	16.7	E
Las Americas	II	40	17.2	1.3	18.5	0.15	29.2	B
Vegas Verdes	II	40	41.7	4.4	46.1	0.44	34.3	B
ZAFARANO	II	40	26.2	5.9	32.1	0.24	26.7	C
Total	II		344.7	117.5	462.2	3.24	25.2	C

Cerrillos Noon

Arterial Level of Service: NE CERRILLOS ROAD

Cross Street	Arterial Class	Flow Speed	Running Time	Signal Delay	Travel Time (s)	Dist (mi)	Arterial Speed	Arterial LOS
ZAFARANO	II	40	144.3	39.0	183.3	1.60	31.5	B
VEGAS VERDES	II	40	26.2	4.6	30.8	0.24	27.8	C
LAS AMERICAS	II	40	41.7	1.8	43.5	0.44	36.3	A
RICHARDS AVE	II	40	17.2	18.3	35.5	0.15	15.2	E
CAM. CONSUELO	II	40	28.5	7.1	35.6	0.28	28.3	B
CAM CIELO	II	40	17.4	12.6	30.0	0.15	18.1	D
SILER RD	II	35	33.2	9.4	42.6	0.30	25.5	C
CAM CARLOS REY	II	35	31.5	29.3	60.8	0.29	17.0	E
SMITHS	II	35	38.0	22.0	60.0	0.35	21.1	D
ST. MICHAELS	II	35	29.5	30.1	59.6	0.25	15.0	E
Total	II		407.5	174.2	581.7	4.05	25.1	C

Arterial Level of Service: SW CERRILLOS ROAD

Cross Street	Arterial Class	Flow Speed	Running Time	Signal Delay	Travel Time (s)	Dist (mi)	Arterial Speed	Arterial LOS
OSAGE	II	35	81.5	32.1	113.6	0.79	25.1	C
LUJAN	II	35	29.5	12.6	42.1	0.25	21.2	D
CAM CARLOS REY	II	35	38.0	11.6	49.6	0.35	25.5	C
SILER RD	II	35	31.5	18.2	49.7	0.29	20.7	D
	II	35	33.2	10.5	43.7	0.30	24.8	C
	II	40	17.4	3.4	20.8	0.15	26.2	C
Richards Ave	II	40	28.5	15.9	44.4	0.28	22.7	C
Las Americas	II	40	17.2	4.5	21.7	0.15	24.9	C
Vegas Verdes	II	40	41.7	7.5	49.2	0.44	32.1	B
ZAFARANO	II	40	26.2	9.9	36.1	0.24	23.7	C
Total	II		344.7	126.2	470.9	3.24	24.8	C

Cerrillos PM

Arterial Level of Service: NE CERRILLOS ROAD

Cross Street	Arterial Class	Flow Speed	Running Time	Signal Delay	Travel Time (s)	Dist (mi)	Arterial Speed	Arterial LOS
ZAFARANO	II	40	144.3	36.1	180.4	1.60	32.0	B
VEGAS VERDES	II	40	26.2	8.0	34.2	0.24	25.0	C
LAS AMERICAS	II	40	41.7	7.0	48.7	0.44	32.4	B
RICHARDS AVE	II	40	17.2	15.0	32.2	0.15	16.7	E
CAM. CONSUELO	II	40	28.5	5.2	33.7	0.28	29.9	B
CAM CIELO	II	40	17.4	7.7	25.1	0.15	21.7	D
SILER RD	II	35	33.2	11.2	44.4	0.30	24.5	C
CAM CARLOS REY	II	35	31.5	8.6	40.1	0.29	25.7	C
SMITHS	II	35	38.0	4.8	42.8	0.35	29.6	B
ST. MICHAELS	II	35	29.6	33.4	63.0	0.25	14.2	E
Total	II		407.6	137.0	544.6	4.05	26.8	C

Arterial Level of Service: WB CERRILLOS ROAD

Cross Street	Arterial Class	Flow Speed	Running Time	Signal Delay	Travel Time (s)	Dist (mi)	Arterial Speed	Arterial LOS
OSAGE	II	35	81.5	37.9	119.4	0.79	23.9	C
LUJAN	II	35	29.6	14.1	43.7	0.25	20.5	D
CAM CARLOS REY	II	35	38.0	11.5	49.5	0.35	25.6	C
SILER RD	II	35	31.5	8.1	39.6	0.29	26.1	C
	II	35	33.2	9.5	42.7	0.30	25.5	C
	II	40	17.4	4.2	21.6	0.15	25.2	C
Richards Ave	II	40	28.5	26.3	54.8	0.28	18.4	D
Las Americas	II	40	17.2	2.7	19.9	0.15	27.1	C
Vegas Verdes	II	40	41.7	11.0	52.7	0.44	30.0	B
ZAFARANO	II	40	26.2	11.7	37.9	0.24	22.6	C
Total	II		344.6	137.0	481.6	3.24	24.2	C

St. Francis AM

Arterial Level of Service: NB St. Francis

Cross Street	Arterial Class	Flow Speed	Running Time	Signal Delay	Travel Time (s)	Dist (mi)	Arterial Speed	Arterial LOS
Sawmill Road	II	45	44.9	23.7	68.6	0.51	26.7	C
Zia Road	II	45	32.3	102.6	134.9	0.34	9.0	F
Siringo Rd	II	45	33.4	14.6	48.0	0.35	26.1	C
San Mateo	II	45	55.7	34.4	90.1	0.70	27.8	C
Alta Vist	II	35	63.5	3.0	66.5	0.62	33.4	B
Cordova	II	35	27.1	19.9	47.0	0.23	17.5	D
Cerrillos Road	II	35	28.9	21.4	50.3	0.24	17.4	D
Paseo de Peralta Sou	II	35	30.4	25.4	55.8	0.28	17.8	D
Agua Fria	II	35	23.6	28.3	51.9	0.19	13.1	E
Alameda	II	35	33.7	20.9	54.6	0.31	20.2	D
Paseo de Peralta Nor	II	35	17.5	43.6	61.1	0.14	8.2	F
Alamo	II	45	37.4	9.4	46.8	0.40	30.6	B
Total	II		428.4	347.2	775.6	4.29	19.9	D

Arterial Level of Service: SB St. Francis

Cross Street	Arterial Class	Flow Speed	Running Time	Signal Delay	Travel Time (s)	Dist (mi)	Arterial Speed	Arterial LOS
Alamo	II	45	28.4	15.7	44.1	0.27	22.3	C
IAS CRUCITA	II	35	41.8	25.1	66.9	0.40	21.4	D
Alameda	II	35	17.5	38.5	56.0	0.14	9.0	F
Agua Fria	II	35	33.7	36.8	70.5	0.31	15.6	E
Hickox	II	35	23.6	7.8	31.4	0.19	21.6	D
Cerrillos Road	II	35	30.4	32.4	62.8	0.28	15.8	E
Cordova	II	35	28.9	19.7	48.6	0.24	18.0	D
Alta Vist	II	35	27.1	13.0	40.1	0.23	20.5	D
San Mateo	II	45	49.4	6.5	55.9	0.62	39.8	A
Siringo Rd	II	45	55.7	8.4	64.1	0.70	39.1	A
Zia Road	II	45	33.4	18.7	52.1	0.35	24.0	C
Sawmill Road	II	45	32.3	34.3	66.6	0.34	18.2	D
Total	II		402.2	256.9	659.1	4.05	22.1	C

St. Francis Noon

Arterial Level of Service: NB St. Francis

Cross Street	Arterial Class	Flow Speed	Running Time	Signal Delay	Travel Time (s)	Dist (mi)	Arterial Speed	Arterial LOS
Sawmill Road	II	45	53.4	15.5	68.9	0.67	34.9	B
Zia Road	II	45	32.3	14.0	46.3	0.34	26.2	C
Siringo Rd	II	45	33.4	11.8	45.2	0.35	27.7	C
San Mateo	II	45	55.7	8.5	64.2	0.70	39.0	A
Alta Vist	II	35	63.5	15.2	78.7	0.62	28.3	B
Cordova	II	35	27.1	16.0	43.1	0.23	19.0	D
Cerrillos Road	II	35	28.9	17.7	46.6	0.24	18.8	D
Paseo de Peralta	II	35	30.4	11.6	42.0	0.28	23.7	C
Agua Fria	II	35	23.6	17.5	41.1	0.19	16.5	E
Alameda	II	35	33.7	10.9	44.6	0.31	24.7	C
Paseo de Peralta Nor	II	35	17.5	8.7	26.2	0.14	19.2	D
Alamo	II	45	37.4	2.0	39.4	0.40	36.4	A
Total	II		436.9	149.4	586.3	4.45	27.3	C

Arterial Level of Service: SB St. Francis

Cross Street	Arterial Class	Flow Speed	Running Time	Signal Delay	Travel Time (s)	Dist (mi)	Arterial Speed	Arterial LOS
Alamo Drive	II	45	28.4	9.9	38.3	0.27	25.7	C
Las Crucitas	II	35	41.8	12.8	54.6	0.40	26.2	C
Alameda	II	35	17.5	21.3	38.8	0.14	13.0	F
Agua Fria	II	35	33.7	9.1	42.8	0.31	25.8	C
Hickox	II	35	23.6	15.4	39.0	0.19	17.4	D
Cerrillos Road	II	35	30.4	13.4	43.8	0.28	22.7	C
Cordova	II	35	28.9	9.7	38.6	0.24	22.7	C
Alta Vist	II	35	27.1	18.7	45.8	0.23	17.9	D
San Mateo	II	45	49.4	9.4	58.8	0.62	37.8	A
Siringo Rd	II	45	55.7	9.1	64.8	0.70	38.7	A
Zia Road	II	45	33.4	7.9	41.3	0.35	30.3	B
Sawmill Road	II	45	32.3	7.9	40.2	0.34	30.2	B
Total	II		402.2	144.6	546.8	4.05	26.7	C

St. Francis PM

Arterial Level of Service: NB St. Francis

Cross Street	Arterial Class	Flow Speed	Running Time	Signal Delay	Travel Time (s)	Dist (mi)	Arterial Speed	Arterial LOS
Sawmill Road	II	45	53.4	16.5	69.9	0.67	34.4	B
Zia Road	II	45	32.3	20.5	52.8	0.34	23.0	C
Siringo Rd	II	45	33.4	21.5	54.9	0.35	22.8	C
San Mateo	II	45	55.7	4.6	60.3	0.70	41.6	A
Alta Vist	II	45	49.4	20.9	70.3	0.62	31.6	B
Cordova	II	35	27.1	26.5	53.6	0.23	15.3	E
Cerrillos Road	II	35	28.9	39.2	68.1	0.24	12.9	F
Paseo de Peralta	II	35	30.4	16.8	47.2	0.28	21.1	D
Agua Fria	II	35	23.6	15.9	39.5	0.19	17.2	D
Alameda	II	35	33.7	15.8	49.5	0.31	22.3	C
Paseo de Peralta Nor	II	45	15.2	13.8	29.0	0.14	17.4	D
Alamo	II	45	37.4	2.2	39.6	0.40	36.2	A
Total	II		420.5	214.2	634.7	4.45	25.2	C

Arterial Level of Service: SB St. Francis

Cross Street	Arterial Class	Flow Speed	Running Time	Signal Delay	Travel Time (s)	Dist (mi)	Arterial Speed	Arterial LOS
Alamo Drive	II	45	28.4	9.8	38.2	0.27	25.8	C
Las Crucitas	II	45	37.4	39.0	76.4	0.40	18.8	D
Alameda	II	35	17.5	32.7	50.2	0.14	10.0	F
Agua Fria	II	35	33.7	39.3	73.0	0.31	15.1	E
Hickox	II	35	23.6	29.3	52.9	0.19	12.8	F
Cerrillos Road	II	35	30.4	113.1	143.5	0.28	6.9	F
Cordova	II	35	28.9	9.9	38.8	0.24	22.6	C
Alta Vist	II	35	27.1	28.9	56.0	0.23	14.7	E
San Mateo	II	45	49.4	10.2	59.6	0.62	37.3	A
Siringo Rd	II	45	55.7	9.5	65.2	0.70	38.4	A
Zia Road	II	45	33.4	54.4	87.8	0.35	14.3	E
Sawmill Road	II	45	32.3	13.1	45.4	0.34	26.7	C
Total	II		397.8	389.2	787.0	4.05	18.5	D

Appendix 7 Synchro Results Optimized for InSync Modeling

Cerrillos AM NB:

Arterial Level of Service   Friday AM NO PEDS
4/30/2014

Arterial Level of Service: NE CERRILLOS ROAD

Cross Street	Arterial Class	Flow Speed	Running Time	Signal Delay	Travel Time (s)	Dist (mi)	Arterial Speed	Arterial LOS
ZAFARANO	II	40	144.3	19.7	164.0	1.60	35.2	A
VEGAS VERDES	II	40	26.2	2.6	28.8	0.24	29.7	B
LAS AMERICAS	II	40	41.7	1.8	43.5	0.44	36.3	A
RICHARDS AVE	II	40	17.2	3.4	20.6	0.15	26.2	C
CAM. CONSUELO	II	40	28.5	2.4	30.9	0.28	32.6	B
CAM CIELO	II	40	17.4	3.5	20.9	0.15	26.0	C
SILER RD	II	35	33.2	2.8	36.0	0.30	30.2	B
CAM CARLOS REY	II	35	31.5	5.3	36.8	0.29	28.0	C
SMITHS	II	35	38.0	2.4	40.4	0.35	31.3	B
ST. MICHAELS	II	35	29.5	6.7	36.2	0.25	24.7	C
Total	II		407.5	50.6	458.1	4.05	31.8	B

Arterial Level of Service: SW CERRILLOS ROAD

Cross Street	Arterial Class	Flow Speed	Running Time	Signal Delay	Travel Time (s)	Dist (mi)	Arterial Speed	Arterial LOS
OSAGE	II	35	81.5	10.5	92.0	0.79	31.0	B
LUJAN	II	35	29.5	2.5	32.0	0.25	27.9	C
CAM CARLOS REY	II	35	38.0	7.0	45.0	0.35	28.1	B
SILER RD	II	35	31.5	2.6	34.1	0.29	30.2	B
	II	35	33.2	5.1	38.3	0.30	28.3	B
	II	40	17.4	1.9	19.3	0.15	28.2	B
Richards Ave	II	40	28.5	11.9	40.4	0.28	24.9	C
Las Americas	II	40	17.2	2.5	19.7	0.15	27.4	C
Vegas Verdes	II	40	41.7	4.3	46.0	0.44	34.3	B
ZAFARANO	II	40	26.2	9.0	35.2	0.24	24.3	C
Total	II		344.7	57.3	402.0	3.24	29.0	B

Cerrillos AM SB:

Arterial Level of Service: NE CERRILLOS ROAD

Cross Street	Arterial Class	Flow Speed	Running Time	Signal Delay	Travel Time (s)	Dist (mi)	Arterial Speed	Arterial LOS
ZAFARANO	II	40	144.3	19.9	164.2	1.60	35.2	A
VEGAS VERDES	II	40	26.2	2.5	28.7	0.24	29.8	B
LAS AMERICAS	II	40	41.7	1.8	43.5	0.44	36.3	A
RICHARDS AVE	II	40	17.2	3.5	20.7	0.15	26.1	C
CAM. CONSUELO	II	40	28.5	2.5	31.0	0.28	32.5	B
CAM CIELO	II	40	17.4	3.7	21.1	0.15	25.8	C
SILER RD	II	35	33.2	3.2	36.4	0.30	29.8	B
CAM CARLOS REY	II	35	31.5	5.4	36.9	0.29	27.9	C
SMITHS	II	35	38.0	2.8	40.8	0.35	31.0	B
ST. MICHAELS	II	35	29.5	7.3	36.8	0.25	24.3	C
Total	II		407.5	52.6	460.1	4.05	31.7	B

Arterial Level of Service: SW CERRILLOS ROAD

Cross Street	Arterial Class	Flow Speed	Running Time	Signal Delay	Travel Time (s)	Dist (mi)	Arterial Speed	Arterial LOS
OSAGE	II	35	81.5	10.6	92.1	0.79	31.0	B
LUJAN	II	35	29.5	2.6	32.1	0.25	27.8	C
CAM CARLOS REY	II	35	38.0	7.0	45.0	0.35	28.1	B
SILER RD	II	35	31.5	2.6	34.1	0.29	30.2	B
	II	35	33.2	4.1	37.3	0.30	29.1	B
	II	40	17.4	1.9	19.3	0.15	28.2	B
Richards Ave	II	40	28.5	11.6	40.1	0.28	25.1	C
Las Americas	II	40	17.2	2.4	19.6	0.15	27.5	C
Vegas Verdes	II	40	41.7	4.1	45.8	0.44	34.5	B
ZAFARANO	II	40	26.2	9.0	35.2	0.24	24.3	C
Total	II		344.7	55.9	400.6	3.24	29.1	B

Cerrillos Noon NB:

Arterial Level of Service: NE CERRILLOS ROAD

Cross Street	Arterial Class	Flow Speed	Running Time	Signal Delay	Travel Time (s)	Dist (mi)	Arterial Speed	Arterial LOS
ZAFARANO	II	40	144.3	10.0	154.3	1.60	37.4	A
VEGAS VERDES	II	40	26.2	4.1	30.3	0.24	28.3	B
LAS AMERICAS	II	40	41.7	2.5	44.2	0.44	35.7	A
RICHARDS AVE	II	40	17.2	9.6	26.8	0.15	20.1	D
CAM. CONSUELO	II	40	28.5	4.7	33.2	0.28	30.3	B
CAM CIELO	II	40	17.4	3.5	20.9	0.15	26.0	C
SILER RD	II	35	33.2	2.1	35.3	0.30	30.7	B
CAM CARLOS REY	II	35	31.5	5.3	36.8	0.29	28.0	B
SMITHS	II	35	38.0	2.1	40.1	0.35	31.6	B
ST. MICHAELS	II	35	29.5	8.5	38.0	0.25	23.5	C
Total	II		407.5	52.4	459.9	4.05	31.7	B

Arterial Level of Service: SW CERRILLOS ROAD

Cross Street	Arterial Class	Flow Speed	Running Time	Signal Delay	Travel Time (s)	Dist (mi)	Arterial Speed	Arterial LOS
OSAGE	II	35	81.5	16.9	98.4	0.79	29.0	B
LUJAN	II	35	29.5	3.2	32.7	0.25	27.3	C
CAM CARLOS REY	II	35	38.0	4.2	42.2	0.35	30.0	B
SILER RD	II	35	31.5	3.3	34.8	0.29	29.6	B
	II	35	33.2	6.5	39.7	0.30	27.3	C
	II	40	17.4	6.2	23.6	0.15	23.1	C
Richards Ave	II	40	28.5	5.2	33.7	0.28	29.9	B
Las Americas	II	40	17.2	1.2	18.4	0.15	29.3	B
Vegas Verdes	II	40	41.7	3.2	44.9	0.44	35.2	A
ZAFARANO	II	40	26.2	4.5	30.7	0.24	27.9	C
Total	II		344.7	54.4	399.1	3.24	29.2	B

Cerrillos Noon SB

Arterial Level of Service: NE CERRILLOS ROAD

Cross Street	Arterial Class	Flow Speed	Running Time	Signal Delay	Travel Time (s)	Dist (mi)	Arterial Speed	Arterial LOS
ZAFARANO	II	40	144.3	10.0	154.3	1.60	37.4	A
VEGAS VERDES	II	40	26.2	4.1	30.3	0.24	28.3	B
LAS AMERICAS	II	40	41.7	2.2	43.9	0.44	36.0	A
RICHARDS AVE	II	40	17.2	10.1	27.3	0.15	19.8	D
CAM. CONSUELO	II	40	28.5	4.6	33.1	0.28	30.4	B
CAM CIELO	II	40	17.4	3.5	20.9	0.15	26.0	C
SILER RD	II	35	33.2	2.2	35.4	0.30	30.7	B
CAM CARLOS REY	II	35	31.5	5.3	36.8	0.29	28.0	B
SMITHS	II	35	38.0	2.7	40.7	0.35	31.1	B
ST. MICHAELS	II	35	29.5	8.2	37.7	0.25	23.7	C
Total	II		407.5	52.9	460.4	4.05	31.7	B

Arterial Level of Service: SW CERRILLOS ROAD

Cross Street	Arterial Class	Flow Speed	Running Time	Signal Delay	Travel Time (s)	Dist (mi)	Arterial Speed	Arterial LOS
OSAGE	II	35	81.5	16.9	98.4	0.79	29.0	B
LUJAN	II	35	29.5	3.3	32.8	0.25	27.3	C
CAM CARLOS REY	II	35	38.0	4.2	42.2	0.35	30.0	B
SILER RD	II	35	31.5	3.3	34.8	0.29	29.6	B
	II	35	33.2	6.6	39.8	0.30	27.3	C
	II	40	17.4	5.1	22.5	0.15	24.2	C
Richards Ave	II	40	28.5	5.2	33.7	0.28	29.9	B
Las Americas	II	40	17.2	1.2	18.4	0.15	29.3	B
Vegas Verdes	II	40	41.7	3.2	44.9	0.44	35.2	A
ZAFARANO	II	40	26.2	4.2	30.4	0.24	28.2	B
Total	II		344.7	53.2	397.9	3.24	29.3	B

Cerrillos PM NB

Arterial Level of Service: NE CERRILLOS ROAD

Cross Street	Arterial Class	Flow Speed	Running Time	Signal Delay	Travel Time (s)	Dist (mi)	Arterial Speed	Arterial LOS
ZAFARANO	II	40	144.3	10.9	155.2	1.60	37.2	A
VEGAS VERDES	II	40	26.2	4.6	30.8	0.24	27.8	C
LAS AMERICAS	II	40	41.7	3.3	45.0	0.44	35.1	A
RICHARDS AVE	II	40	17.2	5.9	23.1	0.15	23.3	C
CAM. CONSUELO	II	40	28.5	7.8	36.3	0.28	27.7	C
CAM CIELO	II	40	17.4	5.0	22.4	0.15	24.3	C
SILER RD	II	35	33.2	1.9	35.1	0.30	31.0	B
CAM CARLOS REY	II	35	31.5	5.0	36.5	0.29	28.3	B
SMITHS	II	35	38.0	1.7	39.7	0.35	31.9	B
ST. MICHAELS	II	35	29.6	54.8	84.4	0.25	10.6	F
Total	II		407.6	100.9	508.5	4.05	28.7	B

Arterial Level of Service: WB CERRILLOS ROAD

Cross Street	Arterial Class	Flow Speed	Running Time	Signal Delay	Travel Time (s)	Dist (mi)	Arterial Speed	Arterial LOS
OSAGE	II	35	81.5	29.4	110.9	0.79	25.7	C
LUJAN	II	35	29.6	8.6	38.2	0.25	23.4	C
CAM CARLOS REY	II	35	38.0	11.3	49.3	0.35	25.7	C
SILER RD	II	35	31.5	1.9	33.4	0.29	30.9	B
	II	35	33.2	2.8	36.0	0.30	30.2	B
	II	40	17.4	4.5	21.9	0.15	24.8	C
Richards Ave	II	40	28.5	12.2	40.7	0.28	24.7	C
Las Americas	II	40	17.2	1.9	19.1	0.15	28.2	B
Vegas Verdes	II	40	41.7	6.1	47.8	0.44	33.0	B
ZAFARANO	II	40	26.2	4.1	30.3	0.24	28.3	B
Total	II		344.8	82.8	427.6	3.24	27.3	C

Cerrillos PM SB

Arterial Level of Service: NE CERRILLOS ROAD

Cross Street	Arterial Class	Flow Speed	Running Time	Signal Delay	Travel Time (s)	Dist (mi)	Arterial Speed	Arterial LOS
ZAFARANO	II	40	144.3	10.9	155.2	1.60	37.2	A
VEGAS VERDES	II	40	26.2	4.6	30.8	0.24	27.8	C
LAS AMERICAS	II	40	41.7	3.1	44.8	0.44	35.2	A
RICHARDS AVE	II	40	17.2	6.1	23.3	0.15	23.1	C
CAM. CONSUELO	II	40	28.5	7.7	36.2	0.28	27.8	C
CAM CIELO	II	40	17.4	5.1	22.5	0.15	24.2	C
SILER RD	II	35	33.2	2.0	35.2	0.30	30.9	B
CAM CARLOS REY	II	35	31.5	5.3	36.8	0.29	28.0	B
SMITHS	II	35	38.0	1.7	39.7	0.35	31.9	B
ST. MICHAELS	II	35	29.6	57.4	87.0	0.25	10.3	F
Total	II		407.6	103.9	511.5	4.05	28.5	B

Arterial Level of Service: WB CERRILLOS ROAD

Cross Street	Arterial Class	Flow Speed	Running Time	Signal Delay	Travel Time (s)	Dist (mi)	Arterial Speed	Arterial LOS
OSAGE	II	35	81.5	29.4	110.9	0.79	25.7	C
LUJAN	II	35	29.6	7.6	37.2	0.25	24.0	C
CAM CARLOS REY	II	35	38.0	10.1	48.1	0.35	26.3	C
SILER RD	II	35	31.5	1.9	33.4	0.29	30.9	B
	II	35	33.2	2.6	35.8	0.30	30.4	B
	II	40	17.4	4.6	22.0	0.15	24.7	C
Richards Ave	II	40	28.5	11.5	40.0	0.28	25.2	C
Las Americas	II	40	17.2	2.0	19.2	0.15	28.1	B
Vegas Verdes	II	40	41.7	5.9	47.6	0.44	33.2	B
ZAFARANO	II	40	26.2	4.1	30.3	0.24	28.3	B
Total	II		344.8	79.7	424.5	3.24	27.5	C

St. Francis AM NB

Arterial Level of Service: NB St. Francis

Cross Street	Arterial Class	Flow Speed	Running Time	Signal Delay	Travel Time (s)	Dist (mi)	Arterial Speed	Arterial LOS
Sawmill Road	II	45	44.9	16.9	61.8	0.51	29.7	B
Zia Road	II	45	32.3	109.6	141.9	0.34	8.5	F
Siringo Rd	II	45	33.4	18.9	52.3	0.35	23.9	C
San Mateo	II	45	55.7	21.6	77.3	0.70	32.4	B
Alta Vist	II	35	63.5	9.7	73.2	0.62	30.4	B
Cordova	II	35	27.1	11.6	38.7	0.23	21.2	D
Cerrillos Road	II	35	28.9	21.4	50.3	0.24	17.4	D
Paseo de Peralta Sou	II	35	30.4	15.9	46.3	0.28	21.5	D
Agua Fria	II	35	23.6	20.9	44.5	0.19	15.2	E
Alameda	II	35	33.7	13.8	47.5	0.31	23.2	C
Paseo de Peralta Nor	II	35	17.5	36.8	54.3	0.14	9.3	F
Alamo	II	45	37.4	4.6	42.0	0.40	34.1	B
Total	II		428.4	301.7	730.1	4.29	21.1	D

Arterial Level of Service: SB St. Francis

Cross Street	Arterial Class	Flow Speed	Running Time	Signal Delay	Travel Time (s)	Dist (mi)	Arterial Speed	Arterial LOS
Alamo	II	45	28.4	6.2	34.6	0.27	28.5	B
IAS CRUCITA	II	35	41.8	19.5	61.3	0.40	23.4	C
Alameda	II	35	17.5	20.5	38.0	0.14	13.2	E
Agua Fria	II	35	33.7	56.9	90.6	0.31	12.2	F
Hickox	II	35	23.6	18.7	42.3	0.19	16.0	E
Cerrillos Road	II	35	30.4	32.4	62.8	0.28	15.8	E
Cordova	II	35	28.9	9.9	38.8	0.24	22.6	C
Alta Vist	II	35	27.1	8.4	35.5	0.23	23.1	C
San Mateo	II	45	49.4	9.9	59.3	0.62	37.5	A
Siringo Rd	II	45	55.7	8.4	64.1	0.70	39.1	A
Zia Road	II	45	33.4	11.2	44.6	0.35	28.1	B
Sawmill Road	II	45	32.3	12.5	44.8	0.34	27.1	C
Total	II		402.2	214.5	616.7	4.05	23.7	C

St. Francis AM SB

Arterial Level of Service: NB St. Francis

Cross Street	Arterial Class	Flow Speed	Running Time	Signal Delay	Travel Time (s)	Dist (mi)	Arterial Speed	Arterial LOS
Sawmill Road	II	45	44.9	18.3	63.2	0.51	29.0	B
Zia Road	II	45	32.3	109.6	141.9	0.34	8.5	F
Siringo Rd	II	45	33.4	18.9	52.3	0.35	23.9	C
San Mateo	II	45	55.7	21.6	77.3	0.70	32.4	B
Alta Vist	II	35	63.5	9.5	73.0	0.62	30.5	B
Cordova	II	35	27.1	11.6	38.7	0.23	21.2	D
Cerrillos Road	II	35	28.9	21.4	50.3	0.24	17.4	D
Paseo de Peralta Sou	II	35	30.4	15.8	46.2	0.28	21.5	D
Agua Fria	II	35	23.6	20.9	44.5	0.19	15.2	E
Alameda	II	35	33.7	13.8	47.5	0.31	23.2	C
Paseo de Peralta Nor	II	35	17.5	36.8	54.3	0.14	9.3	F
Alamo	II	45	37.4	5.6	43.0	0.40	33.3	B
Total	II		428.4	303.8	732.2	4.29	21.1	D

Arterial Level of Service: SB St. Francis

Cross Street	Arterial Class	Flow Speed	Running Time	Signal Delay	Travel Time (s)	Dist (mi)	Arterial Speed	Arterial LOS
Alamo	II	45	28.4	7.6	36.0	0.27	27.3	C
IAS CRUCITA	II	35	41.8	19.5	61.3	0.40	23.4	C
Alameda	II	35	17.5	21.3	38.8	0.14	13.0	F
Agua Fria	II	35	33.7	56.9	90.6	0.31	12.2	F
Hickox	II	35	23.6	18.6	42.2	0.19	16.1	E
Cerrillos Road	II	35	30.4	32.4	62.8	0.28	15.8	E
Cordova	II	35	28.9	9.9	38.8	0.24	22.6	C
Alta Vist	II	35	27.1	8.3	35.4	0.23	23.2	C
San Mateo	II	45	49.4	9.9	59.3	0.62	37.5	A
Siringo Rd	II	45	55.7	8.4	64.1	0.70	39.1	A
Zia Road	II	45	33.4	11.2	44.6	0.35	28.1	B
Sawmill Road	II	45	32.3	13.4	45.7	0.34	26.5	C
Total	II		402.2	217.4	619.6	4.05	23.5	C

St. Francis Noon NB

Arterial Level of Service: NB St. Francis

Cross Street	Arterial Class	Flow Speed	Running Time	Signal Delay	Travel Time (s)	Dist (mi)	Arterial Speed	Arterial LOS
Sawmill Road	II	45	53.4	8.3	61.7	0.67	39.0	A
Zia Road	II	45	32.3	11.8	44.1	0.34	27.5	C
Siringo Rd	II	45	33.4	6.2	39.6	0.35	31.6	B
San Mateo	II	45	55.7	5.2	60.9	0.70	41.2	A
Alta Vist	II	35	63.5	6.8	70.3	0.62	31.6	B
Cordova	II	35	27.1	4.7	31.8	0.23	25.8	C
Cerrillos Road	II	35	28.9	13.7	42.6	0.24	20.6	D
Paseo de Peralta	II	35	30.4	1.4	31.8	0.28	31.3	B
Agua Fria	II	35	23.6	4.1	27.7	0.19	24.5	C
Alameda	II	35	33.7	3.1	36.8	0.31	30.0	B
Paseo de Peralta Nor	II	35	17.5	15.3	32.8	0.14	15.3	E
Alamo	II	45	37.4	0.8	38.2	0.40	37.5	A
Total	II		436.9	81.4	518.3	4.45	30.9	B

Arterial Level of Service: SB St. Francis

Cross Street	Arterial Class	Flow Speed	Running Time	Signal Delay	Travel Time (s)	Dist (mi)	Arterial Speed	Arterial LOS
Alamo Drive	II	45	28.4	3.7	32.1	0.27	30.7	B
Las Crucitas	II	35	41.8	16.0	57.8	0.40	24.8	C
Alameda	II	35	17.5	3.5	21.0	0.14	24.0	C
Agua Fria	II	35	33.7	8.3	42.0	0.31	26.3	C
Hickox	II	35	23.6	7.4	31.0	0.19	21.9	D
Cerrillos Road	II	35	30.4	26.9	57.3	0.28	17.3	D
Cordova	II	35	28.9	6.2	35.1	0.24	24.9	C
Alta Vist	II	35	27.1	5.8	32.9	0.23	25.0	C
San Mateo	II	45	49.4	6.0	55.4	0.62	40.1	A
Siringo Rd	II	45	55.7	2.7	58.4	0.70	42.9	A
Zia Road	II	45	33.4	14.1	47.5	0.35	26.4	C
Sawmill Road	II	45	32.3	7.6	39.9	0.34	30.4	B
Total	II		402.2	108.2	510.4	4.05	28.6	B

St. Francis Noon SB

Arterial Level of Service: NB St. Francis

Cross Street	Arterial Class	Flow Speed	Running Time	Signal Delay	Travel Time (s)	Dist (mi)	Arterial Speed	Arterial LOS
Sawmill Road	II	45	53.4	8.3	61.7	0.67	39.0	A
Zia Road	II	45	32.3	11.1	43.4	0.34	27.9	C
Siringo Rd	II	45	33.4	6.5	39.9	0.35	31.4	B
San Mateo	II	45	55.7	5.7	61.4	0.70	40.8	A
Alta Vist	II	35	63.5	5.9	69.4	0.62	32.0	B
Cordova	II	35	27.1	5.1	32.2	0.23	25.5	C
Cerrillos Road	II	35	28.9	13.7	42.6	0.24	20.6	D
Paseo de Peralta	II	35	30.4	1.7	32.1	0.28	31.0	B
Agua Fria	II	35	23.6	3.7	27.3	0.19	24.9	C
Alameda	II	35	33.7	3.3	37.0	0.31	29.8	B
Paseo de Peralta Nor	II	35	17.5	15.5	33.0	0.14	15.2	E
Alamo	II	45	37.4	0.8	38.2	0.40	37.5	A
Total	II		436.9	81.3	518.2	4.45	30.9	B

Arterial Level of Service: SB St. Francis

Cross Street	Arterial Class	Flow Speed	Running Time	Signal Delay	Travel Time (s)	Dist (mi)	Arterial Speed	Arterial LOS
Alamo Drive	II	45	28.4	3.5	31.9	0.27	30.9	B
Las Crucitas	II	35	41.8	15.8	57.6	0.40	24.9	C
Alameda	II	35	17.5	3.6	21.1	0.14	23.8	C
Agua Fria	II	35	33.7	8.2	41.9	0.31	26.3	C
Hickox	II	35	23.6	7.7	31.3	0.19	21.7	D
Cerrillos Road	II	35	30.4	27.0	57.4	0.28	17.3	D
Cordova	II	35	28.9	6.0	34.9	0.24	25.1	C
Alta Vist	II	35	27.1	5.6	32.7	0.23	25.1	C
San Mateo	II	45	49.4	5.9	55.3	0.62	40.2	A
Siringo Rd	II	45	55.7	2.4	58.1	0.70	43.1	A
Zia Road	II	45	33.4	13.5	46.9	0.35	26.7	C
Sawmill Road	II	45	32.3	6.2	38.5	0.34	31.5	B
Total	II		402.2	105.4	507.6	4.05	28.7	B

St. Francis PM NB

Arterial Level of Service: NB St. Francis

Cross Street	Arterial Class	Flow Speed	Running Time	Signal Delay	Travel Time (s)	Dist (mi)	Arterial Speed	Arterial LOS
Sawmill Road	II	45	53.4	6.5	59.9	0.67	40.1	A
Zia Road	II	45	32.3	8.7	41.0	0.34	29.6	B
Siringo Rd	II	45	33.4	6.3	39.7	0.35	31.5	B
San Mateo	II	45	55.7	6.2	61.9	0.70	40.5	A
Alta Vist	II	45	49.4	4.9	54.3	0.62	40.9	A
Cordova	II	35	27.1	4.8	31.9	0.23	25.7	C
Cerrillos Road	II	35	28.9	27.7	56.6	0.24	15.5	E
Paseo de Peralta	II	35	30.4	0.6	31.0	0.28	32.1	B
Agua Fria	II	35	23.6	2.5	26.1	0.19	26.0	C
Alameda	II	35	33.7	5.8	39.5	0.31	27.9	C
Paseo de Peralta Nor	II	45	15.2	11.3	26.5	0.14	19.0	D
Alamo	II	45	37.4	3.0	40.4	0.40	35.5	A
Total	II		420.5	88.3	508.8	4.45	31.5	B

Arterial Level of Service: SB St. Francis

Cross Street	Arterial Class	Flow Speed	Running Time	Signal Delay	Travel Time (s)	Dist (mi)	Arterial Speed	Arterial LOS
Alamo Drive	II	45	28.4	4.7	33.1	0.27	29.7	B
Las Crucitas	II	45	37.4	14.7	52.1	0.40	27.5	C
Alameda	II	35	17.5	5.8	23.3	0.14	21.6	D
Aqua Fria	II	35	33.7	4.7	38.4	0.31	28.7	B
Hickox	II	35	23.6	8.3	31.9	0.19	21.3	D
Cerrillos Road	II	35	30.4	76.1	106.5	0.28	9.3	F
Cordova	II	35	28.9	7.7	36.6	0.24	23.9	C
Alta Vist	II	35	27.1	5.3	32.4	0.23	25.3	C
San Mateo	II	45	49.4	5.5	54.9	0.62	40.5	A
Siringo Rd	II	45	55.7	4.1	59.8	0.70	41.9	A
Zia Road	II	45	33.4	18.6	52.0	0.35	24.1	C
Sawmill Road	II	45	32.3	3.4	35.7	0.34	34.0	B
Total	II		397.8	158.9	556.7	4.05	26.2	C

St. Francis PM SB

Arterial Level of Service: NB St. Francis

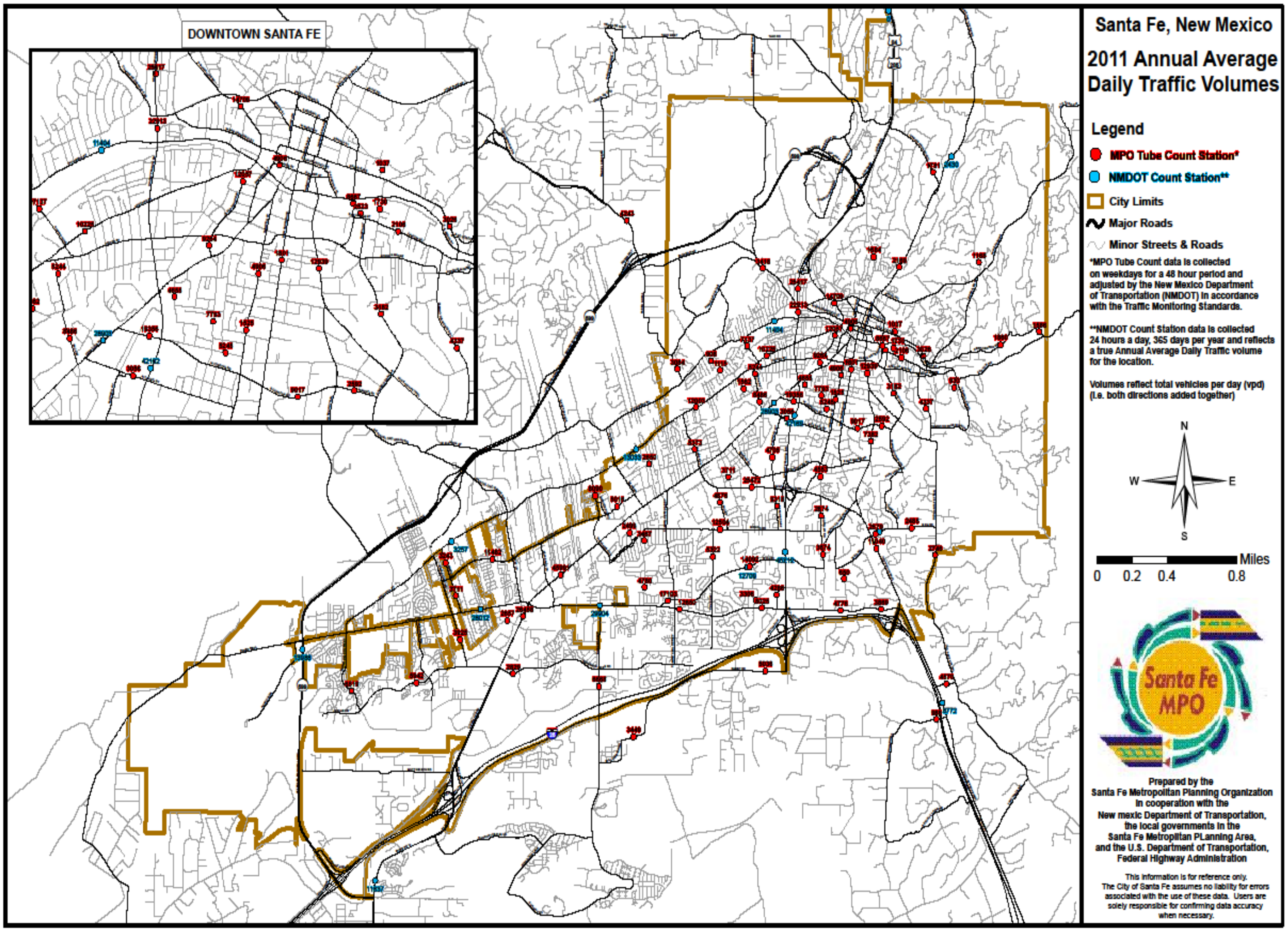
Cross Street	Arterial Class	Flow Speed	Running Time	Signal Delay	Travel Time (s)	Dist (mi)	Arterial Speed	Arterial LOS
Sawmill Road	II	45	53.4	6.7	60.1	0.67	40.0	A
Zia Road	II	45	32.3	8.7	41.0	0.34	29.6	B
Siringo Rd	II	45	33.4	7.4	40.8	0.35	30.7	B
San Mateo	II	45	55.7	4.6	60.3	0.70	41.6	A
Alta Vist	II	45	49.4	5.8	55.2	0.62	40.3	A
Cordova	II	35	27.1	7.3	34.4	0.23	23.9	C
Cerrillos Road	II	35	28.9	28.0	56.9	0.24	15.4	E
Paseo de Peralta	II	35	30.4	0.6	31.0	0.28	32.1	B
Agua Fria	II	35	23.6	2.6	26.2	0.19	25.9	C
Alameda	II	35	33.7	5.7	39.4	0.31	28.0	C
Paseo de Peralta Nor	II	45	15.2	11.3	26.5	0.14	19.0	D
Alamo	II	45	37.4	3.1	40.5	0.40	35.4	A
Total	II		420.5	91.8	512.3	4.45	31.2	B

Arterial Level of Service: SB St. Francis

Cross Street	Arterial Class	Flow Speed	Running Time	Signal Delay	Travel Time (s)	Dist (mi)	Arterial Speed	Arterial LOS
Alamo Drive	II	45	28.4	4.6	33.0	0.27	29.8	B
Las Crucitas	II	45	37.4	14.7	52.1	0.40	27.5	C
Alameda	II	35	17.5	6.3	23.8	0.14	21.1	D
Aqua Fria	II	35	33.7	4.1	37.8	0.31	29.2	B
Hickox	II	35	23.6	8.4	32.0	0.19	21.2	D
Cerrillos Road	II	35	30.4	76.3	106.7	0.28	9.3	F
Cordova	II	35	28.9	8.0	36.9	0.24	23.7	C
Alta Vist	II	35	27.1	5.2	32.3	0.23	25.4	C
San Mateo	II	45	49.4	5.0	54.4	0.62	40.9	A
Siringo Rd	II	45	55.7	4.6	60.3	0.70	41.6	A
Zia Road	II	45	33.4	18.5	51.9	0.35	24.1	C
Sawmill Road	II	45	32.3	4.0	36.3	0.34	33.4	B
Total	II		397.8	159.7	557.5	4.05	26.2	C

Appendix 8 Traffic Count SFMPO 2011

Traffic count volumes collected by the SFMPO in 2011 for the city of Santa Fe. A larger view of this figure can be found at the following link:
https://drive.google.com/file/d/0B2qF3IWx_vL6VW0wT3A0Ul9VbXc/edit?usp=sharing



Appendix 9 Features of Google Maps APIs for Business

Features	Maps API	Maps API for Business
Street View	✓	✓
Geocoding Web Service	2500 requests per 24 hour period	100 000 requests per 24 hour period
Directions Web Service	2500 requests per 24 hour period with 10 waypoints per request	100 000 requests per 24 hour period with 23 waypoints per request
Distance Matrix Web Service	100 elements per query 100 elements per 10 seconds 2500 elements per 24 hour period	625 elements per query 1000 elements per 10 seconds 100 000 elements per 24 hour period
Elevation Web Service	2500 requests per 24 hour period with 25 000 samples per 24 hour period	100 000 requests per 24 hour period with 1 000 000 samples per 24 hour period
Static Maps API maximum resolution	640 x 640	2048 x 2048
Static Maps API maximum scale	2X	4X
Street View Image API maximum resolution	640 x 640	2048 x 2048
Analytics		✓

Support	Maps API	Maps API for Business
Google Maps API Developer resources	✓	✓
Service Level Agreement		✓
Technical Support		✓
Support portal & usage reporting		✓

Use cases	Maps API	Maps API for Business
Free & publicly available	✓	✓
Internal deployments		✓
Embedding in software and applications for fee		✓
Reselling services with Google Maps		✓
Control of advertising		✓
Private asset tracking		✓

Appendix 10 InSync Interview Questions

- *How feasible is it to implement InSync with an existing system?* Depends on assumptions...corridor assumptions, preemption detection, pedestrian crossing, the demand to serve all movements of cars, if you care about serving pedestrians over serving cars. (usually takes 150 seconds to drive a critical intersection, for example). After choosing those assumptions, you can then create an independent progression scenario after which you can coordinate the rest of the intersections and corridors
- *What hardware will be needed to install the adaptive system? Santa Fe has two different controllers in use, is this alright?* In-Sync uses modular equipment, so it works with anything. It requires a processor, remote power relay, “black box”..thing with transformer and has Ethernet connection, cabling - InSync -> Tetra Calls -> InSync BUS. InSync works with existing controllers.
- *What type of communication is needed to install InSync? Currently Santa Fe has a mixture of communication lines.* Yes and no…..In-Sync needs communication between intersections, then one intersection needs to communicate with a TMC. All data crunching is done within the box. It is a distributed network (good!), not a centralized network (bad!) The only communication connection needed is Ethernet for TCP/IP @ 2-5Mbps minimum between each signal/intersection, then one drop to a PC (i.e. - laptop, desktop, iPad, etc. NOT a server) or TMC.
- *Will you be able to use the existing detection (radar, inductance loops, cameras, etc.) already in use in Santa Fe*? In-Sync runs on its own native video detection, and will provide its own adaptive detection equipment. In-Sync can use all other single point detection (radar, cameras, loops, etc.) to validate their calculations.
- *Is InSync a ring based system?* InSync is a non-ring system. No sequencing progression, no need to base the rest of the corridor on that one intersection. No limiting parameters = no preconceived notions on traffic management.
- *How difficult it is to implement an adaptive system when one or more coordinated corridors intersect the one using an adaptive system?* Yes! Columbia County Georgia, Grapevine, Texas both do that already.
- *One of the intersections intersects with a train, will this affect the progression of the adaptive system?* Want to begin progression/serving the secondary movement immediately after the train ends. In-Sync doesn’t need a reference point to match up with after the train ends. The train is considered a preemption, and preempts all other signals and services, leading to a preemption cycle to serve the train. After the train ends, the signals go through an ending cycle, then go right back to normal, thanks to the Adaptive signal processing. In a ring-based system, the train would end, then the intersection would go through the exit phasing, then have to match back up to the intersection correctly, then go back to its traditional traffic plan. This would take a couple of light cycles to go through.
- How quickly does InSync update its timing patterns?
- *Can you do vehicle classification with InSync cameras/equipment?* No.
- What is the cost to implement and install InSync?
  Equipment
  35K/intersection for In-Sync Fusion: In-Sync video and some physics-based detection.
  30K/intersection for In-Sync Fusion: In-Sync video OR some physics-based detection.
  Installation
  12-15K/intersection - a conservative number, assume you have nothing at all (must hire contractor to pull cable, install cameras, etc.)
  TOTAL:
  38-42K/intersection usually
  Project-Based Overhead
  5K/corridor
  Other
  Taxes and shipping

  Traditional Video costs ~ 13K-30K/intersection
- *Where any safety studies conducted after implementing InSync?* Yes. InSync saw 17-30% reduction in accidents (usually rear-ending and lane change). These studies can be found by contacting the police and counties that use this. See appendix XE for safety study conducted by Rhythm Engineering.
- *What improvements have been seen in the performance and wait time after implementing InSync?* Based on many other corridors that use InSync, they on average have seen a 24% reduction in travel time, but this is not a promised time. This can be estimated for a given corridor by using the “floating car method” in the program Synchro.

Appendix 11 Alameda Boulevard Synchro Results

Results from the Bernalillo County of New Mexico implementation of Synchro on Alameda Boulevard. The key findings and summary can be found here:

Key Findings: https://drive.google.com/file/d/0B2qF3IWx_vL6RTdTazYxRHBuM2s/edit?usp=sharing

Summary: https://drive.google.com/file/d/0B2qF3IWx_vL6ZGoybDdWWXBtdHM/edit?usp=sharing

Eastbound:

Period	Week 1 Seconds	Week 2 Seconds	Week 1 MPH	Week 2 MPH	Time Savings (sec./vehicle)	Average Volume	Total Time Savings (Hours)
AM Peak	402.4	299.9	17.1	22.9	102.5	1785	50.8
Noon	192.0	198.3	35.8	34.7	-6.3	956	-1.7
PM Peak	210.6	211.1	32.6	32.6	-0.5	997	-0.1

Westbound:

Period	Week 1 Seconds	Week 2 Seconds	Week 1 MPH	Week 2 MPH	Time Savings (sec./vehicle)	Average Volume	Total Time Savings (Hours)
AM Peak	216.5	198.6	31.8	34.6	17.9	670	3.3
Noon	211.1	209.3	32.6	32.9	1.9	956	0.5
PM Peak	274.0	218.3	25.1	31.5	55.8	1543	23.9

Westbound Annotated Comparison of InSync vs. Original:

No Adaptive ctrl

With Adaptive ctrl

Period	Week 1 Seconds	Week 2 Seconds	Week 1 MPH	Week 2 MPH	Time Savings (sec./vehicle)	Average Volume	Total Time Savings (Hours)
AM Peak	216.5	198.6	31.8	34.6	17.9	670	3.3
Noon	211.1	209.3	32.6	32.9	1.9	956	0.5
PM Peak	274.0	218.3	25.1	31.5	55.8	1543	23.9

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