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7. Author(s)
Daniel B. Fambro, Srinivas M. Sangineni, Carlos A. Lopez, Srinivasa R. Sunkari, and Ronald T. Barnes

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16. Abstract

The Texas Department of Transportation (TxDOT) was the administering agency for the Traffic Light Synchronization (TLS) Program II which was funded with Oil Overcharge funds made available by the Governor's Energy Office. The TLS Program was approved by the United States Department of Energy as part of a package of transportation-related programs with the objective of reducing energy consumption. TLS II resulted in a total of $7.7 million of program funds and local matches being spent for the optimization of traffic signal timing plans and the replacement of outdated signal controller equipment across the state. As stated previously, the program's objective was to reduce traffic congestion and facilitate the flow of traffic, with the goal of achieving more efficient use of energy resources.

With 73 completed projects, the TLS II Program has resulted in benefits that will pay for the cost of the program many times over. These benefits were estimated from the required before and after studies that were submitted by the cities. These studies document the major goals of the TLS II Program -- reductions in fuel consumption and unnecessary delay and stops. All projects were evaluated using the same unit costs. The TLS II Program resulted in 1,348 intersections in 43 cities being improved; the expenditure of $7.7 million of program funds and local matches; and annual reductions in fuel consumption, delay, and stops of 13.5 percent (20.8 million gallons), 29.6 percent (22 million hours), and 11.5 percent (729 million stops), respectively. The total savings to the public in the form of reduced fuel, delay, and stops will be approximately $252 million in the next year alone. In regard to fuel savings, Texas motorists are realizing $2.68 in savings for every dollar spent, and if stops and delay are included, Texas motorists are realizing $32.30 in savings for every dollar spent. These savings will continue for the next few years without additional expenditures; therefore, the benefits to the public will be even greater.

This report is the first of two volumes. The other volume is:
Benefits of Texas Traffic Light Synchronization (TLS) Grant Program II: Volume II. Appendices D - F

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BENEFITS OF THE TEXAS TRAFFIC LIGHT SYNCHRONIZATION (TLS) GRANT PROGRAM II

VOLUME I. EXECUTIVE SUMMARY AND APPENDICES A - C

by

Daniel B. Fambro, P.E.
Associate Research Engineer, Texas Transportation Institute
Associate Professor, Civil Engineering Department

Srinivas M. Sangineni
Assistant Research Scientist
Texas Transportation Institute

Carlos A. Lopez, P.E.
Engineer of Traffic
Texas Department of Transportation

Srinivasa R. Sunkari
Assistant Research Scientist
Texas Transportation Institute

and

Ronald T. Barnes
Assistant Program Manager
Texas Department of Transportation

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Sponsored by
The Texas Department of Transportation
and
The Texas Governor's Energy Office

February 1995

TEXAS TRANSPORTATION INSTITUTE
The Texas A&M University System
College Station, Texas 77843-3135

IMPLEMENTATION STATEMENT

This report documents results of a special grant program, "Traffic Light Synchronization Grant Program II" rather than the results of a research study. Thus, there are no findings, recommended procedures for implementation, or additional work needed to achieve implementation.

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DISCLAIMER

The contents of this report reflect the views of the authors who are responsible for the opinions, findings, and conclusions presented herein. The contents do not necessarily reflect the official views or policies of the Texas Department of Transportation, Governor's Energy Office, or U.S. Department of Energy. This report does not constitute a standard, specification, or regulation and is NOT INTENDED FOR CONSTRUCTION, BIDDING, OR PERMIT PURPOSES. The engineer in charge of preparing this report was Daniel B. Fambro, P.E. No. 47535 (Texas).

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The Texas Department of Transportation secured the funding, prepared the grant manual, and was responsible for all contractual and administrative matters. TxDOT staff members making significant contributions to the TLS II Program include:

Byron C. Blaschke	Anna M. Isbell	Henry A. Thomason
Connie Bohuslav	Ernest W. Kanak	Gary K. Trietsch
Phil Fredricks	Michael J. McAndrew	Roger G. Welsch
Bob G. Hodge	Wilbur Mehaffey	Brenda Nilsson
Victor J. Holubec	Cindy Nelson	

The training manuals, related materials, and documentation of benefits were prepared by the Texas Transportation Institute and Texas Engineering Extension Service at Texas A&M University, and the McTrans Center at the University of Florida. Staff members from these organizations that made significant contributions to the TLS II Program include:

James A. Bonneson	A. Nelson Evans	Dana S. Mixson
Victor Bhagat	Christopher M. Hoff	Sreelata Nanduri
Edmond C.P. Chang	Sarah M. Hubbard	Brian Schamburger
John F. Cordary	Manjunath Kalsanka	Steven P. Venglar
Kenneth G. Courage	Carroll J. Messer	Charles E. Wallace

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SUMMARY

The Texas Department of Transportation (TxDOT) was the administering agency for the Traffic Light Synchronization II (TLS II) Program, which was funded with Oil Overcharge funds made available through the Governor's Energy Office. The TLS II Program was approved by the United States Department of Energy as part of a package of transportation-related programs with the objective of reducing energy consumption. TLS II resulted in a total of $7.7 million of program funds and local matches being spent for the optimization of traffic signal timing plans and the replacement of outdated signal controller equipment across the state. As stated previously, the program's objective was to reduce traffic congestion and facilitate the flow of traffic, with the goal of achieving more efficient use of energy resources.

With 73 completed projects, the TLS II Program has resulted in benefits that will pay for the cost of the program many times over. These benefits were estimated from the required before and after studies that were submitted by the cities. These studies document the major goals of the TLS II Program -- reductions in fuel consumption and unnecessary delay and stops. All projects were evaluated using the same unit costs. The TLS II Program resulted in 1,348 intersections in 43 cities being improved; the expenditure of $7.7 million of program funds and local matches; and annual reductions in fuel consumption, delay, and stops of 13.5 percent (20.8 million gallons), 29.6 percent (22 million hours), and 11.5 percent (729 million stops), respectively. The total savings to the public in the form of reduced fuel, delay, and stops will be approximately $252 million in the next year alone. In regard to fuel savings, Texas motorists are realizing $2.68 in savings for every dollar spent, and if stops and delay are included, Texas motorists are realizing $32.30 in savings for every dollar spent. These savings will continue for the next few years without additional expenditures; therefore, the benefits to the public will be even greater.

Besides the intuitive benefits of reducing unnecessary vehicle stops, delays, fuel consumption and emissions, the TLS II Program brought together the diverse transportation community of city staffs, consultants, TxDOT personnel and researchers to improve traffic operations at the state's signalized intersections. The program also has increased the expertise of transportation professionals in Texas and created a traffic data base that can be used for additional transportation projects. Most importantly, perhaps, the TLS II Program has enhanced the image of the transportation profession by improving the quality of traffic flow on arterial streets in Texas, and helping to change the driver's perspective of always stopping at a "red" light to not stopping at a "green" light.

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CHAPTER ONE

INTRODUCTION

It has been estimated that motor vehicles use approximately one-fifth of the total daily U.S. oil consumption while traveling through signalized intersections in urban areas. A significant portion of this fuel consumption is wasted due to poor signal timing. In street networks with poorly timed traffic signals, the fuel consumed by vehicles stopping and idling at traffic signals accounts for approximately 40 percent of network-wide vehicular fuel consumption. Improving traffic signal timing improves the quality of traffic flow 24 hours per day, 7 days per week with no sacrifice required on the part of the individual driver. Driving is made faster and easier for all cars, trucks, and buses using the street system (1).

It also has been estimated that of the approximately 240,000 urban signalized intersections in the United States, 30,000 are in need of signal timing optimization, while another 148,000 need signal timing optimization and upgrading outdated equipment. These types of projects generally provide noticeable improvements in traffic flow on arterial streets for relatively small costs (2). For example, past retiming projects have generally reported benefit/cost ratios between 20 to 1 and 30 to 1 (1). More significantly, however, an average of 10 gallons of fuel was saved for each dollar that was spent on signal retiming projects, i.e., about 10 cents in project costs for each gallon saved (3). Signal timing optimization projects are extraordinarily cost effective - providing an estimated 20 to 30 dollars in benefits for each project dollar invested.

In recognition of these potential savings, and as a result of the Oil Overcharge Restitutionary Act, the Texas Department of Transportation (TxDOT) in conjunction with the Governor's Energy Office secured funding and developed the Texas Traffic Light Synchronization (TLS) Program for retiming traffic signals and replacing outdated equipment on city streets. The objective of this program was to reduce traffic congestion and facilitate the flow of traffic, with the goal of achieving more efficient use of energy resources. This objective was accomplished by:

1. Selecting projects and administering grants;
2. Training local staff/consultants in the use of computer technology for timing traffic signals;
3. Providing technical assistance in the use of computer models;
4. Providing technical assistance in collecting data and retiming signals; and
5. Providing for the replacement of outdated equipment.

This report documents the benefits resulting from the second phase of this program, TLS II. The following sections describe the Texas TLS Program in greater detail.

Program Description

The Texas Department of Transportation (TxDOT) was the administering agency for the Traffic Light Synchronization (TLS) Program, which was funded with Oil Overcharge funds made available by the Governor's Energy Office. The United States Department of Energy (DOE) approved the TLS Program as part of a package of transportation-related programs with the objective of reducing energy consumption. TLS II resulted in a total of $7.7 million of program funds and local matches being spent for the optimization of traffic signal timing plans and the replacement of outdated signal controller equipment across the state. As stated previously, the program's objective was to reduce traffic congestion and facilitate the flow of traffic, with the goal of achieving more efficient use of energy resources.

Besides the intuitive benefits of reducing unnecessary vehicle stops, delays, fuel consumption and emissions, the TLS program brought together the diverse transportation community of city staffs, consultants, TxDOT personnel and researchers to improve traffic operations at the state's signalized intersections. The program also has increased the signal timing expertise of transportation professionals in Texas and created a traffic data base that can be used for additional transportation projects. Most importantly, perhaps, the TLS Program has enhanced the image of the transportation profession by improving the quality of traffic flow, and helping to change the driver's perspective of always stopping at a "red" light to not stopping at a "green" light.

Funding Distribution

TLS funds were expended through contracts administered by TxDOT on signal retiming projects proposed by local city governments. There were three major funding categories: large cities (cities with populations over 200,000), medium-sized cities (cities with populations ranging between 50,000 and 200,000), and small cities (cities with populations under 50,000). The approved program of work is shown in Table 1, totaling 43 cities, 73 arterial and network signal system projects, and 1,348 of the state's approximately 13,000 traffic signals.

Fifty percent of available funds were expended in large cities, with each of the eight Texas cities presently over 200,000 population assigned an allotment proportional to its population; 16 medium and 19 small cities received 35 percent and 15 percent, respectively, of available funds. This distribution of funds helped to achieve one of the goals of the TLS program -- a widespread, geographic distribution of funds which allowed indirect restitution to a large segment of the population that was overcharged by the oil companies.

Table 1. Traffic Light Synchronization (TLS II) Program of Work

Funding Category	Cities	Systems	Signals
Large Cities	8	22	802
Medium Cities	16	23	339
Small Cities	19	28	207
Totals	43	73	1,348

Selection Criteria

Projects were recommended for funding using the following criteria developed by an advisory panel composed of local government officials and TxDOT personnel:

1. **Operational Characteristics of the Traffic Signal System** - operational characteristics such as delay, average travel speed, average daily traffic, etc., were used to estimate the benefits improved signal timing could produce. This criteria was used to identify projects with the greatest needs and maximum potential benefits.

2. **Availability of Local Staff to Implement Timing Plans** - having local staff available allows the knowledge gained through the required technical training to be retained and facilitates future retiming efforts by local city governments.

3. **Average Signal Spacing** - the greater the concentration of signals, the more important synchronization and optimal signal timing become. A signal must have been no further than one mile from an adjacent signal for it to be considered part of a signal system.

4. **Other Criteria such as Recent Growth in the Project Area, Date of Last Retiming Effort, Level of Expansion Over Current Effort, and Certification that TLS Funds will supplement and not Supplant Existing Funds** - this criteria aided in determining where the need for TLS funds was greatest and where maximum benefit could be achieved.

Reimbursement Guidelines and Eligibility

Up to 75 percent of project costs were eligible for reimbursement. If a project was funded, the local government or TxDOT paid a minimum of 25 percent of the total direct costs of the project in matching funds and/or in-kind services. TxDOT provided a local match when a project contained traffic signals that were maintained and operated by TxDOT, unless the local government and TxDOT agreed otherwise.

Costs eligible for reimbursement under the program included training local staff and/or consultants in the use of computer technology for retiming traffic signals; providing technical assistance in the use of the computer models; providing technical assistance in collecting data and retiming signals; and replacing outdated signal controller equipment. TLS Program funds could not be used to supplant or replace existing funds earmarked for specific signal retiming projects. That is, if existing funds were authorized for signal retiming expenditures, those funds could not be released and then replaced by TLS funds.

The TLS Program targeted traffic control systems (four signals minimum) currently coordinated and/or controlled in a manner that permitted implementation of multiple coordinated timing plans, i.e., timing plans that match traffic needs at different times of day. By focusing on traffic signal systems that currently have coordination capabilities, maximum energy savings could be realized with the available funds.

Signal systems included in the program ranged from those with sophisticated computer-controlled units to fixed-time electromechanical dial units. Many projects coordinated signals that were not presently a part of a coordinated system. Coordination is being supplied to previously isolated intersections by time-based (as opposed to hard-wire interconnect) methods. Signal controller equipment being purchased through a TLS project was, in general, either providing for coordination of a previously uncoordinated group of signals, adding signals to a currently coordinated system, or providing optimum signal timing capabilities.

Training and Technical Assistance

One of the program's major objectives was to train local staff in the use of the PASSER II, PASSER III, and TRANSYT-7F signal timing models to facilitate ongoing maintenance of efficient timing plans. Local governments awarded a grant were required to have local project staff and/or their consultant attend specialized training workshops that were offered at the onset of the program. TxDOT secured the services of the Texas Transportation Institute (TTI) to provide signal timing training and technical assistance to the cities during project development. The McTrans Center at the University of Florida and the Texas Engineering Extension Service (TEEX) at Texas A&M University assisted TTI in the training phase of the program. TTI also provided in-depth analysis of before and after studies submitted by cities and prepared the Final Report documenting reductions in fuel consumption, stops, and delay as a result of the TLS II Program for submission to the Governor's Energy Office.

Four training courses (2 PASSER, 2 TRANSYT) were offered through the TLS II Program. Through these courses, 60 transportation professionals were trained (listing shown in Appendix A). Also, each of the participating cities was furnished copies of the PASSER and TRANSYT computer software. This training of city, consultant, and TxDOT personnel helped achieve another TLS goal - providing statewide expertise in signal retiming techniques so that these efforts can continue long after the last TLS dollar is spent.

TLS II General Facts

The following general facts relate to the TLS Program:

- Program Cost: $7,747,532
- Date Started: April, 1991 - Request for Proposals (RFPs) issued.
- Number of Cities Participating: 43 (8 large, 16 medium, 19 small - listing and funding amounts shown in Appendix B)
- Number of Signal Systems: 73
- Number of Signals Retimed: 1,348; this total represents approximately 1/10 of all the signals in the state.
- Date Completed: February 1995 - Final Report submitted to TxDOT and the Governor's Office.

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CHAPTER TWO

RESULTS

As mentioned in Chapter One, previous traffic signal retiming projects have reported benefit/cost ratios of 20 to 1 to 30 to 1 and an average fuel savings of approximately 10 gallons per dollar spent (1). It should be noted that ultraconservative values for time were used in computing these benefits, and if more realistic values had been used, the resultant benefit/cost ratios would have been much greater. The two signal retiming programs cited most often in the literature are the Federal Highway Administration's (FHWA's) National Signal Timing Optimization Project (1) and California's FETSIM (Fuel Efficient Traffic Signal Management) Program (3). In both programs, TRANSYT-7F was used to estimate motorist benefits as the hourly difference in fuel consumption and delay between the before and after retiming conditions. These differences were converted to annual differences and then multiplied by unit costs for fuel consumption and vehicular delay to obtain an estimate of annual benefits. The estimated improvements were validated with arterial travel time data from field studies during the before and after conditions. The TLS Program followed the same procedure for estimating benefits.

The benefits from the FETSIM Program (3) through 1988 were substantial - with an average first year reduction of 14 percent in stops and delay, 7.5 percent in travel time, and 8.1 percent in fuel use. Reductions in fuel usage in the first year were four times the program cost, and the first year benefit to cost ratio was 16 to 1. The state cost per signal, including retiming, training, and technical assistance was approximately $1,500 per intersection. Similar to the TLS Program, expenditures were allowed for all aspects of signal timing: data collection, data processing, timing plan development, implementation, and field evaluation. Unlike the TLS Program, however, expenditures were not allowed for replacing outdated equipment. Thus, the state cost per signal in the TLS Program will probably be slightly higher than in the FETSIM Program.

The preceding discussion demonstrates the range of benefits that have been obtained from other signal retiming projects, and can serve as a basis for comparison of the TLS Program. The following sections describe the results of the TLS Program in more detail and compare those results to other signal retiming programs.

Program Results

With 73 projects completed, the TLS II Program has seen results that will pay for the cost of the program many times over. These results were estimated from the required before and after studies that were submitted by the cities. These studies document the major goal of the TLS program - reductions in fuel consumption and unnecessary delay and stops. All projects were evaluated using the same unit costs. The cost for fuel was based on current prices ($1.00

per gallon), and costs for delay and stops were based on values suggested by AASHTO ($10 per vehicle-hour of delay and 1.4 cents per stop). A summary of the results follows:

- 73 projects completed;
- 1,348 signals in 43 cities have been retimed;
- Approximately $7.7 million of program funds and local matches have been expended (several cities expended more than the required local match);
- 20.8 million gallons of fuel will be saved within the next year alone;
- Texas motorists are realizing $2.68 in fuel savings for every program dollar spent;
- Reductions in fuel consumption, delay, and stops were 13.5, 29.6, and 11.5 percent, respectively;
- The total savings to the public in the form of reduced fuel, delay, and stops will be approximately $252 million within the next year alone; and
- The TLS II Program benefit to cost (b/c) ratio is 32 to 1; in other words, Texas motorists are realizing $32 in savings for every program dollar spent.

The expected benefits during the first year after the signal timing improvements are implemented are summarized in Table 2. As expected, the majority of the benefits occurred in the large cities where population and traffic volumes are highest. Note, however, that substantial benefits also occurred in the medium and small cities, and that the average benefit to cost ratio for projects in small cities was 22 to 1 (47.5/2.1).

Table 2. Traffic Light Synchronization (TLS II) Program Annual Benefits

	Stops	Delay	Fuel	Savings	Cost
Large Cities	487,504,050	13,125,028	13,338,461	151,413,795	4,008,866
Medium Cities	171,169,284	4,664,466	3,661,809	52,702,835	1,605,481
Small Cities	70,628,388	4,271,465	3,797,688	47,501,734	2,133,185
Total	729,301,722	22,060,958	20,797,958	251,617,763	7,747,532

Annual Benefits

The annual benefits estimated for each project were calculated on the basis of a 300-day year and a 10 to 15-hour day, depending on local traffic conditions. These conservative hour per day values were used in order **not** to claim benefits when traffic volumes were low; i.e, retiming probably will not benefit weekend or late night traffic. In other words, an intentional effort was made to **not** overestimate benefits. Furthermore, field data from the required before and after arterial travel time runs were used to verify the benefits that were being estimated. These travel time improvements were comparable to the percentage reductions in fuel, delay, and stops.

Annual benefits and changes in measures of effectiveness for each of the 43 cities in the program are illustrated in Tables 3 and 4. Note that the majority of the benefits were in the large city category; however, significant benefits also occurred in the medium and small city categories. Given that higher traffic volumes are generally found in the larger cities, this result was expected. When interpreting this table, one should not try to compare between cities, as the number of retimed signals and the types of projects varied greatly between the cities. Generally, the more intersections that were retimed, the larger the improvements. For example, Austin retimed 240 intersections whereas Corpus Christi only retimed 9 intersections. As expected, the savings in Austin were greater than the savings in Corpus Christi; however, the percentage improvement in stops, delay, and fuel consumption was comparable.

Type of signal retiming project also had an impact on the estimated benefits. Generally, coordinating a previously uncoordinated system resulted in large improvements. Also, projects that involved the purchase of new hardware or arterial streets with relatively low traffic volumes resulted in low benefit to cost ratios. Finally, note that there were four cities with projects that resulted in increases in fuel consumption. These increases were a result of increases in side street delay in order to provide better flow along the arterial. The increase in fuel consumption was offset by decreases in stops and delay on the arterial streets, with the net effect being positive benefit to cost ratios.

The cost side of the benefit to cost (b/c) ratios reflect not only the time spent by local staff in developing and implementing timing plans but also the total equipment costs. Even though the equipment installed under a TLS project will likely last several years, the total equipment costs (not an amortized value) was used in the calculation of the b/c ratios. Furthermore, the benefits were assumed to last only one year, when in reality some measure of the benefits will be realized over several years. Thus, the true benefits to Texas drivers are probably two to three times greater than the values reported in this report.

Table 3. Annual Benefits By City

Cities	Number of Intersections	Stops	Percent	Delay (hrs)	Percent	Fuel Cons. (gal)	Percent	Range of B/C Ratio(s)
Large Cities								
Arlington	9	3,582,000	6.5	204,300	17.3	180,000	11.7	44.0
Austin	240	245,359,350	9.4	10,609,107	30.3	9,057,294	14.4	9.3 to 1,334
Corpus Christi	9	9,387,750	10.9	358,304	55.9	261,300	15.6	3.6
Dallas	168	(1,839,600)	-0.6	110,898	5.3	47,640	0.8	1.9
El Paso	16	10,433,250	12.6	470,651	15.0	724,793	19.5	23.7
Fort Worth	15	3,018,900	4.4	143,994	20.7	126,990	5.8	16.9
Houston	50	25,334,400	9.9	620,274	22.6	638,544	12.7	6.4
San Antonio	295	192,228,000	18.8	607,500	10.0	2,301,900	9.4	29.4
Total	802	487,504,050	10.8	13,125,028	25.5	13,338,461	12.4	1.9 to 1,334
Medium Cities								
Baytown	11	21,576,300	39.3	135,210	39.3	(317,400)	-64.2	35.1
Brownsville	50	25,230,000	33.6	76,200	19.8	138,000	14.5	12.5
Bryan	27	12,799,734	9.5	230,967	21.7	268,285	9.7	23.6
Carrollton	15	10,125,300	9.8	714,603	29.6	825,549	18.7	143.7
College Station	37	625,800	0.5	12,450	1.1	12,423	0.3	1.9
Denton	17	19,784,400	23.7	35,700	8.1	207,240	14.1	6.1 to 22.2
Grand Prairie	8	6,525,000	18.9	1,288,200	73.9	958,800	55.4	933.6
Laredo	25	8,760,600	10.6	80,355	14.2	98,988	6.2	6.6 to 10
Longview	12	14,168,700	24.5	98,490	22.0	(519,150)	-83.5	2.2 to 4.5
McAllen	29	21,853,800	13.6	114,000	7.4	233,400	6.0	13.2
Midland	9	(14,489,400)	-23.8	927,359	65.1	169,025	10.0	171.1
Odessa	13	13,356,300	12.8	175,500	17.2	240,900	11.6	13.8
Port Arthur	12	3,487,200	4.8	242,790	34.6	613,080	27.0	47.2
San Angelo	31	14,693,100	25.5	132,516	33.5	233,232	17.8	1.3 to 8.4
Waco	36	11,412,450	19.3	388,125	56.0	474,675	32.0	36.4 to 264.6
Wichita Falls	7	1,260,000	4.8	12,000	5.9	24,762	2.7	2.5
Total	339	171,169,284	13.3	4,664,466	32.2	3,661,809	11.4	1.3 to 933.6
Small Cities								
Brownwood	7	(93,300)	-1.4	6,675	24.0	4,548	8.3	1.4
Colleyville	9	522,000	2.9	34,200	9.1	25,920	5.9	24.2
Coppell	9	1,744,800	5.9	117,492	23.1	123,984	9.2	20.1
Diboll	3	144,300	6.9	19,830	60.2	17,139	24.3	8.9
Edinburg	18	10,455,900	14.5	330,000	35.0	427,500	19.8	2.7 to 23.7
Forest Hill	3	(887,100)	-10.8	444,258	64.1	320,361	55.1	101.8
Georgetown	10	4,474,800	12.1	70,125	30.1	285,731	38.2	31.5
Harlingen	17	7,433,400	10.8	90,600	15.4	130,200	8.4	20.7
Huntsville	10	4,924,200	9.7	88,320	25.6	(209,280)	-34.8	15.0
Hurst	18	1,670,100	3.3	165,339	21.2	139,463	9.5	2.4 to 54.8
Lampasas	5	2,025,150	26.2	31,260	36.5	35,858	30.3	3.9
Lufkin	17	4,847,700	42.7	119,985	77.7	215,400	68.5	0.2 to7.1
Mineral Wells	8	(24,600)	-1.7	516	7.2	288	1.0	0.4
Nacogdoches	23	1,935,300	9.7	144,060	49.6	156,042	23.2	2.5 to 3.5
New Braunfels	4	319,800	3.5	1,860	6.0	3,720	4.2	0.4
North Richland Hills	12	4,309,200	11.1	214,149	41.5	179,010	17.6	9.5 to 11.2
Sonora	3	432,138	8.8	4,316	18.3	5,366	4.5	2.2
Texas City	5	3,506,400	21.5	19,380	23.3	(51,960)	-38.1	3.1
Tyler City	26	22,888,200	27.1	2,369,100	85.2	1,988,400	54.7	45.2 to 225.9
Total	207	70,628,388	13.1	4,271,465	50.3	3,797,688	25.1	0.2 to 225.9
Grand Total	1,348	729,301,722	11.5	22,060,958	29.6	20,797,958	13.5	0.2 to 1,334

Table 4. Annual Changes in Measures of Effectiveness

Cities	Number of Intersections	Overall Stops Before	Overall Stops After	Overall Delay (hrs) Before	Overall Delay (hrs) After	Overall Fuel Consumption (gal) Before	Overall Fuel Consumption (gal) After	Range of B/C Ratio
Large Cities								
Arlington	9	54,975,000	51,393,000	1,178,400	974,100	1,537,500	1,357,500	44.0
Austin	240	2,614,794,525	2,369,435,175	34,966,992	24,357,885	63,088,172	54,030,878	9.3 to 1,334
Corpus Christi	9	86,025,150	76,637,400	640,529	282,225	1,676,625	1,415,325	3.6
Dallas	168	329,537,400	331,377,000	2,107,278	1,996,380	5,639,280	5,591,640	1.9
El Paso	16	82,791,900	72,358,650	3,132,770	2,662,119	3,724,560	2,999,768	23.7
Fort Worth	15	68,529,000	65,510,100	694,218	550,224	2,173,350	2,046,360	16.9
Houston	50	255,897,000	230,562,600	2,743,851	2,123,577	5,042,583	4,404,039	6.4
San Antonio	295	1,025,193,900	832,965,900	6,063,900	5,456,400	24,388,500	22,086,600	29.4
Total	802	4,517,743,875	4,030,239,825	51,527,938	38,402,910	107,270,570	93,932,110	1.9 to 1,334
Medium Cities								
Baytown	11	54,890,400	33,314,100	344,400	209,190	494,400	811,800	35.1
Brownsville	50	75,118,800	49,888,800	384,600	308,400	952,800	814,800	12.5
Bryan	27	134,737,305	121,937,571	1,066,199	835,231	2,761,634	2,493,350	23.6
Carrollton	15	103,124,700	92,999,400	2,415,999	1,701,396	4,406,055	3,580,506	143.7
College Station	37	122,486,100	121,860,300	1,084,143	1,071,693	4,416,777	4,404,354	1.9
Denton	17	83,361,600	63,577,200	442,080	406,380	1,471,320	1,264,080	6.1 to 22.2
Grand Prairie	8	34,518,000	27,993,000	1,744,200	456,000	1,729,200	770,400	933.6
Laredo	25	82,329,300	73,568,700	564,555	484,200	1,603,236	1,504,248	6.6 to 10
Longview	12	57,777,000	43,608,300	447,900	349,410	621,870	1,141,020	2.2 to 4.5
McAllen	29	160,369,800	138,516,000	1,531,200	1,417,200	3,878,400	3,645,000	13.2
Midland	9	60,988,350	75,477,750	1,423,732	496,373	1,686,680	1,517,655	171.1
Odessa	13	104,302,950	90,946,650	1,021,800	846,300	2,077,650	1,836,750	13.8
Port Arthur	12	72,503,100	69,015,900	701,640	458,850	2,273,160	1,660,080	47.2
San Angelo	31	57,646,200	42,953,100	395,685	263,169	1,307,991	1,074,759	1.3 to 8.4
Waco	36	59,061,750	47,649,300	693,555	305,430	1,483,740	1,009,065	36.4 to 264.6
Wichita Falls	7	26,303,100	25,043,100	203,127	191,127	911,535	886,773	2.5
Total	339	1,289,518,455	1,118,349,171	14,464,814	9,800,349	32,076,449	28,414,640	1.3 to 933.6
Small Cities								
Brownwood	7	6,598,200	6,691,500	27,765	21,090	54,629	50,081	1.4
Colleyville	9	17,726,400	17,204,400	375,120	340,920	442,200	416,280	24.2
Coppell	9	29,497,800	27,753,000	509,574	392,082	1,349,592	1,225,608	20.1
Diboll	3	2,091,450	1,947,150	32,955	13,125	70,578	53,439	8.9
Edinburg	18	72,130,500	61,674,600	941,700	611,700	2,163,000	1,735,500	2.7 to 23.7
Forest Hill	3	8,247,900	9,135,000	692,601	248,343	581,856	261,495	101.8
Georgetown	10	36,901,200	32,426,400	233,280	163,155	747,777	462,047	31.5
Harlingen	17	68,925,600	61,492,200	586,800	496,200	1,545,600	1,415,400	20.7
Huntsville	10	51,012,600	46,088,400	345,480	257,160	601,140	810,420	15.0
Hurst	18	50,290,950	48,620,850	781,193	615,853	1,469,219	1,329,756	2.4 to 54.8
Lampasas	5	7,737,150	5,712,000	85,560	54,300	118,523	82,665	3.9
Lufkin	17	11,353,200	6,505,500	154,365	34,380	314,475	99,075	0.2 to7.1
Mineral Wells	8	1,449,300	1,473,900	7,128	6,612	29,385	29,097	0.4
Nacogdoches	23	19,934,250	17,998,950	290,490	146,430	672,595	516,554	2.5 to 3.5
New Braunfels	4	9,012,000	8,692,200	31,260	29,400	87,840	84,120	0.4
North Richland Hills	12	38,895,600	34,586,400	516,525	302,376	1,014,540	835,530	9.5 to 11.2
Sonora	3	4,920,000	4,487,862	23,520	19,204	119,070	113,704	2.2
Texas City	5	16,279,200	12,772,800	83,100	63,720	136,260	188,220	3.1
Tyler City	26	84,337,500	61,449,300	2,780,400	411,300	3,634,500	1,646,100	45.2 to 225.9
Total	207	537,340,800	466,712,412	8,498,816	4,227,351	15,152,778	11,355,090	0.2 to 225.9
Grand Total	1,348	6,344,603,130	5,615,301,408	74,491,568	52,430,609	154,499,797	133,701,839	0.2 to 1,334

Benefits Per Intersection

Annual benefits and changes in measures of effectiveness per intersection for each of the 43 cities in the program are illustrated in Tables 5 and 6. Note that on the average, more than 15,429 gallons of gasoline (13.5 percent), 16,366 hours of delay (29.6 percent), and 541,025 stops (11.5 percent) per intersection were saved as a result of this program. The values reported in these tables are somewhat easier to compare between cities and could be used to estimate a range of potential benefits from retiming a certain number of signalized intersections; however, the discrepancy between different traffic volumes and types of projects in each of the participating cities still exists.

Note that the average benefits per intersection are similar for the large, medium, and small city categories. The range of benefits per intersection within each city size category and, in some cases an overlap between categories is primarily the result of different types of projects. For example, coordinating a series of isolated intersections generally produced greater benefits than retiming an existing system. In other words, how bad or good the before condition was had a great deal to do with the benefits that could be obtained. Appendix C presents benefits for nine different types of signal retiming projects.

Comparison With Other Programs

The estimated benefits from the Texas TLS II Program are consistent with those reported by other statewide signal retiming programs. TLS II reduced fuel, delay, and stops by 13.5, 29.6, and 11.5 percent, respectively. California's FETSIM Program reduced fuel consumption by 8.1 percent and stops and delay by 14 percent. Texas motorists realized $2.68 in fuel savings for every program dollar spent, whereas California motorists realized $4.00 in fuel savings for every program dollar spent. It should be noted, however, that FETSIM used a slightly higher cost per gallon for fuel in their analysis. In terms of average annual fuel savings per intersection, TLS II and North Carolina's Traffic Signal Timing Optimization Program (4) estimated savings per intersection of 15,429 gallons and 13,900 gallons, respectively.

First year benefit to cost ratios were 32 to 1 for TLS II and 16 to 1 for FETSIM; however, different delay costs were used by the two programs. Thus, the reported benefit to cost ratios are not easily comparable. Because the benefits of the two programs in terms of percent reductions in fuel, delay, and stops were essentially the same and the costs were higher for TLS because of equipment purchases ($5,700 per intersection in TLS II and $1,500 per intersection in FETSIM), the comparable benefit to cost ratios for TLS II were probably slightly lower than they were for FETSIM.

Table 5. Annual Benefits Per Intersection By City

Cities	Number of Intersections	Stops	Percent	Delay (hrs)	Percent	Fuel Cons. (gal)	Percent	Range of B/C Ratio(s)
Large Cities								
Arlington	9	398,000	6.5	22,700	17.3	20,000	11.7	44.0
Austin	240	1,022,331	9.4	44,205	30.3	37,739	14.4	9.3 to 1,334
Corpus Christi	9	1,043,083	10.9	39,812	55.9	29,033	15.6	3.6
Dallas	168	(10,950)	-0.6	660	5.3	284	0.8	1.9
El Paso	16	652,078	12.6	29,416	15.0	45,300	19.5	23.7
Fort Worth	15	201,260	4.4	9,600	20.7	8,466	5.8	16.9
Houston	50	506,688	9.9	12,405	22.6	12,771	12.7	6.4
San Antonio	295	651,620	18.8	2,059	10.0	7,803	9.4	29.4
Average		607,860	10.8	16,365	25.5	16,631	12.4	
Medium Cities								
Baytown	11	1,961,482	39.3	12,292	39.3	(28,855)	-64.2	35.1
Brownsville	50	504,600	33.6	1,524	19.8	2,760	14.5	12.5
Bryan	27	474,064	9.5	8,554	21.7	9,936	9.7	23.6
Carrollton	15	675,020	9.8	47,640	29.6	55,037	18.7	143.7
College Station	37	16,914	0.5	336	1.1	336	0.3	1.9
Denton	17	1,163,788	23.7	2,100	8.1	12,191	14.1	6.1 to 22.2
Grand Prairie	8	815,625	18.9	161,025	73.9	119,850	55.4	933.6
Laredo	25	350,424	10.6	3,214	14.2	3,960	6.2	6.6 to 10
Longview	12	1,180,725	24.5	8,208	22.0	(43,263)	-83.5	2.2 to 4.5
McAllen	29	753,579	13.6	3,931	7.4	8,048	6.0	13.2
Midland	9	(1,609,933)	-23.8	103,040	65.1	18,781	10.0	171.1
Odessa	13	1,027,408	12.8	13,500	17.2	18,531	11.6	13.8
Port Arthur	12	290,600	4.8	20,233	34.6	51,090	27.0	47.2
San Angelo	31	473,971	25.5	4,275	33.5	7,524	17.8	1.3 to 8.4
Waco	36	317,013	19.3	10,781	56.0	13,185	32.0	36.4 to 264.6
Wichita Falls	7	180,000	4.8	1,714	5.9	3,537	2.7	2.5
Average		504,924	13.3	13,759	32.2	10,802	11.4	
Small Cities								
Brownwood	7	(13,329)	-1.4	954	24.0	650	8.3	1.4
Colleyville	9	58,000	2.9	3,800	9.1	2,880	5.9	24.2
Coppell	9	193,867	5.9	13,055	23.1	13,776	9.2	20.1
Diboll	3	48,100	6.9	6,610	60.2	5,713	24.3	8.9
Edinburg	18	580,883	14.5	18,333	35.0	23,750	19.8	2.7 to 23.7
Forest Hill	3	(295,700)	-10.8	148,086	64.1	106,787	55.1	101.8
Georgetown	10	447,480	12.1	7,013	30.1	28,573	38.2	31.5
Harlingen	17	437,259	10.8	5,329	15.4	7,659	8.4	20.7
Huntsville	10	492,420	9.7	8,832	25.6	(20,928)	-34.8	15.0
Hurst	18	92,783	3.3	9,186	21.2	7,748	9.5	2.4 to 54.8
Lampasas	5	405,030	26.2	6,252	36.5	7,172	30.3	3.9
Lufkin	17	285,159	42.7	7,058	77.7	12,671	68.5	0.2 to7.1
Mineral Wells	8	(3,075)	-1.7	64	7.2	36	1.0	0.4
Nacogdoches	23	84,143	9.7	6,263	49.6	6,784	23.2	2.5 to 3.5
New Braunfels	4	79,950	3.5	465	6.0	930	4.2	0.4
North Richland Hills	12	359,100	11.1	17,846	41.5	14,918	17.6	9.5 to 11.2
Sonora	3	144,046	8.8	1,439	18.3	1,789	4.5	2.2
Texas City	5	701,280	21.5	3,876	23.3	(10,392)	-38.1	3.1
Tyler City	26	880,315	27.1	91,119	85.2	76,477	54.7	45.2 to 225.9
Average		341,200	13.1	20,635	50.3	18,346	25.1	
Overall Mean		541,025	11.5	16,366	29.6	15,429	13.5	

Table 6. Annual Changes in Measures of Effectiveness Per Intersection By City

Cities	Number of Intersections	Overall Stops Before	Overall Stops After	Overall Delay (hrs) Before	Overall Delay (hrs) After	Overall Fuel Consumption (gal) Before	Overall Fuel Consumption (gal) After	Range of B/C Ratio
Large Cities								
Arlington	9	6,108,333	5,710,333	130,933	108,233	170,833	150,833	44.0
Austin	240	10,894,977	9,872,647	145,696	101,491	262,867	225,129	9.3 to 1,334
Corpus Christi	9	9,558,350	8,515,267	71,170	31,358	186,292	157,258	3.6
Dallas	168	1,961,532	1,972,482	12,543	11,883	33,567	33,284	1.9
El Paso	16	5,174,494	4,522,416	195,798	166,382	232,785	187,485	23.7
Fort Worth	15	4,568,600	4,367,340	46,281	36,682	144,890	136,424	16.9
Houston	50	5,117,940	4,611,252	54,877	42,472	100,852	88,081	6.4
San Antonio	295	3,475,234	2,823,613	20,556	18,496	82,673	74,870	29.4
Average		5,633,097	5,025,237	64,249	47,884	133,754	117,122	
Medium Cities								
Baytown	11	4,990,036	3,028,555	31,309	19,017	44,945	73,800	35.1
Brownsville	50	1,502,376	997,776	7,692	6,168	19,056	16,296	12.5
Bryan	27	4,990,271	4,516,206	39,489	30,934	102,283	92,346	23.6
Carrollton	15	6,874,980	6,199,960	161,067	113,426	293,737	238,700	143.7
College Station	37	3,310,435	3,293,522	29,301	28,965	119,372	119,037	1.9
Denton	17	4,903,624	3,739,835	26,005	23,905	86,548	74,358	6.1 to 22.2
Grand Prairie	8	4,314,750	3,499,125	218,025	57,000	216,150	96,300	933.6
Laredo	25	3,293,172	2,942,748	22,582	19,368	64,129	60,170	6.6 to 10
Longview	12	4,814,750	3,634,025	37,325	29,118	51,823	95,085	2.2 to 4.5
McAllen	29	5,529,993	4,776,414	52,800	48,869	133,738	125,690	13.2
Midland	9	6,776,483	8,386,417	158,192	55,153	187,409	168,628	171.1
Odessa	13	8,023,304	6,995,896	78,600	65,100	159,819	141,288	13.8
Port Arthur	12	6,041,925	5,751,325	58,470	38,238	189,430	138,340	47.2
San Angelo	31	1,859,555	1,385,584	12,764	8,489	42,193	34,670	1.3 to 8.4
Waco	36	1,640,604	1,323,592	19,265	8,484	41,215	28,030	36.4 to 264.6
Wichita Falls	7	3,757,586	3,577,586	29,018	27,304	130,219	126,682	2.5
Average		3,803,889	3,298,965	42,669	28,910	94,621	83,819	
Small Cities								
Brownwood	7	942,600	955,929	3,966	3,013	7,804	7,154	1.4
Colleyville	9	1,969,600	1,911,600	41,680	37,880	49,133	46,253	24.2
Coppell	9	3,277,533	3,083,667	56,619	43,565	149,955	136,179	20.1
Diboll	3	697,150	649,050	10,985	4,375	23,526	17,813	8.9
Edinburg	18	4,007,250	3,426,367	52,317	33,983	120,167	96,417	2.7 to 23.7
Forest Hill	3	2,749,300	3,045,000	230,867	82,781	193,952	87,165	101.8
Georgetown	10	3,690,120	3,242,640	23,328	16,316	74,778	46,205	31.5
Harlingen	17	4,054,447	3,617,188	34,518	29,188	90,918	83,259	20.7
Huntsville	10	5,101,260	4,608,840	34,548	25,716	60,114	81,042	15.0
Hurst	18	2,793,942	2,701,158	43,400	34,214	81,623	73,875	2.4 to 54.8
Lampasas	5	1,547,430	1,142,400	17,112	10,860	23,705	16,533	3.9
Lufkin	17	667,835	382,676	9,080	2,022	18,499	5,828	0.2 to7.1
Mineral Wells	8	181,163	184,238	891	827	3,673	3,637	0.4
Nacogdoches	23	866,707	782,563	12,630	6,367	29,243	22,459	2.5 to 3.5
New Braunfels	4	2,253,000	2,173,050	7,815	7,350	21,960	21,030	0.4
North Richland Hills	12	3,241,300	2,882,200	43,044	25,198	84,545	69,628	9.5 to 11.2
Sonora	3	1,640,000	1,495,954	7,840	6,401	39,690	37,901	2.2
Texas City	5	3,255,840	2,554,560	16,620	12,744	27,252	37,644	3.1
Tyler City	26	3,243,750	2,363,435	106,938	15,819	139,788	63,312	45.2 to 225.9
Average		2,595,849	2,254,649	41,057	20,422	73,202	54,856	
Overall Mean		4,706,679	4,165,654	55,261	38,895	114,614	99,185	

CHAPTER THREE

CONCLUSIONS

The TxDOT experience in administering the TLS Program has been very positive. The working relationship between TxDOT and city transportation professionals has been enhanced, and Texas motorists have benefited from improved operation on many arterials. These benefits will extend well beyond the life of the TLS Program. Several cities have received positive press coverage as a result of improvements made through the TLS Program. Partial program results of the TLS I Program were presented at meetings of the Texas Section of the Institute of Transportation Engineers. Final program results are being shared with all 43 of the participating cities.

With 73 projects completed, the TLS II Program has seen results that will pay for the cost of the program many times over. These results were estimated from the required before and after studies that were submitted by the cities. These studies document the major goal of the TLS Program -- reductions in fuel consumption and unnecessary delay and stops. All projects were evaluated using the same unit costs. The TLS Program resulted in 1,348 signals in 43 cities (73 separate projects) being retimed; the expenditure of $7.7 million of program funds and local matches; and annual reductions in fuel consumption, delay, and stops of 13.5 percent (20.8 million gallons), 29.6 percent (22 million hours), and 11.5 percent (729 million stops), respectively. Individual project summaries are presented in Appendices D, E, and F.

The total savings to the public in the form of reduced fuel, delay, and stops will be approximately $252 million in the next year alone. In regard to fuel savings, Texas motorists are realizing $2.68 in savings for every dollar spent, and if stops and delay are included, Texas motorists are realizing $32.30 in savings for every dollar spent. These savings will continue for the next few years without additional expenditures; therefore, the benefits to the public will be even greater.

Benefits besides those that can be given a dollar value have been realized through the TLS Program. The bringing together of the entire transportation community (local, state, consultant, and academic) to try to reach a common goal has been rewarding. In the area of traffic signal retiming, the technical expertise of more than 60 transportation professionals has been enhanced. The driver perspective of the "stop" light or the "red" light is starting to change to that of the "green" light.

As a result of the success of the TLS I and TLS II programs, DOE and the Governor's Energy Office has provided additional resources in Oil Overcharge funds to TxDOT to undertake a third TLS Program. This third program, which will run from July 1994 until August 1995, should allow the benefits of improved signal timing to be realized in more areas of the state.

Overall, the TLS Program has been developed, funded, and implemented on a multi-jurisdictional basis (local city governments and state agencies). The program has had a significant visible and positive effect on actual operation on a large part of the transportation system, as well as on the citizens' perception of the system. The direct savings in fuel consumption and delay represents significant increased efficiency, resulting in a more economical transportation system.

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APPENDIX A

PROGRAM PARTICIPANTS

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TLS Participants Trained in PASSER and/or TRANSYT

- Abed Abukar
  Texas Dept. of Transportation
  P. O. Box 6868
  Fort Worth, Texas 76115

- Mark Barnes
  City of Midland
  P. O. Box 1152
  Midland, Texas 79702

- Imelda Barrett
  Texas Dept. of Transportation
  P. O. Drawer 15426
  Austin, Texas 78761-5426

- Mark Beauchamp
  City of Wichita Falls
  2100 Seymour Highway
  Wichita Falls, Texas 76301

- Richard Bentley
  Texas Dept. of Transportation
  P. O. Box 280
  Lufkin, Texas 75901

- Henry Beyer
  Naztec (City of Dallas)
  816 Park Two Drive
  Sugar Land, Texas 77478

- Herbert Bickley
  Texas Dept. of Transportation
  P. O. Box 280
  Lufkin, Texas 75901

- Victor Bolanos
  City of El Paso
  2 Civic Center Plaza
  El Paso, Texas 79999

- Janet Bostic
  City of Grand Prairie
  P. O. Box 530011
  Grand Prairie, Texas 75053-0011

- Charles Brewer
  City of Forest Hill
  6800 Forest Hill Drive
  Forest Hill, Texas 76140

- John Burrus
  City of Wichita Falls
  2100 Seymour Highway
  Wichita Falls, Texas 76301

- Donald Buskohl
  City of New Braunfels
  424 S. Castell Avenue
  New Braunfels, Texas 78130

- Douglas Byrne
  City of Huntsville
  349 Elkins Lake
  Huntsville, Texas 77340

- Pete Cavazos, Jr.
  City of Harlingen
  118 E. Tyler
  Harlingen, Texas 78550

- Alex Constancio, Jr.
  City of Bryan
  1111 Waco
  Bryan, Texas 77805

- Joe Cox
  City of Waco
  P. O. Box 2570
  Waco, Texas 76702-2570

- Terry Dearing
  City of Midland
  P. O. Box 1152
  Midland, Texas 79702

- S. Decker
  Texas Dept. of Transportation
  P. O. Drawer EE
  Pharr, Texas 78577

- William Dobrowlski
  City of New Braunfels
  424 S. Castell Avenue
  New Braunfels, Texas 78130

- J. Don Dolberry
  Texas Dept. of Transportation
  1601 S. W. Parkway
  Wichita Falls, Texas 76308

- Darin DuBose
  City of Waco
  P. O. Box 2570
  Waco, Texas 76702-2570

- Scott Dyer
  City of Colleyville
  P. O. Box 185
  Colleyville, Texas 76034

- Jaime Enriquez
  City of Edinburg
  P. O. Box 1079
  Edinburg, Texas 78540

- Russell Fox
  City of Grand Prairie
  105 SW 2nd
  Grand Prairie, Texas 75051

- Jeff Gann
  City of Denton
  215 E. McKinney
  Denton, Texas 76266

- Lucio Garcia
  City of Laredo
  2800 Saunders
  Laredo, Texas 78041

- Rene Garza
  City of Laredo
  2800 Saunders
  Laredo, Texas 78041

- Ali Gord
  City of San Antonio
  223 S. Cherry St.
  San Antonio, Texas 78203

- Richard Gurley
  City of Carrollton
  P. O. Box 110535
  Carrollton, Texas 75011-0535

- Gordon Harkey
  Texas Dept. of Transportation
  P. O. Box 1549
  Brownwood, Texas 76804

- Jimmy Hilliard
  City of Carrollton
  P. O. Box 110535
  Carrollton, Texas 75011-0535enue
  New Braunfels, Texas 78130

- Stanley Hobbs
  City of Longview
  P. O. Box 1952
  Longview, Texas 75601

- John Hudson
  Traffic Engineers, Inc.
  8323 Southwest Fwy., #200
  Houston, Texas 77074

- Richard Ivy
  Texas Dept. of Transportation
  P. O. Box 280
  Lufkin, Texas 75901

- Hildy Kingma
  City of Georgetown
  P. O. Box 409
  Georgetown, Texas 78627

- Emmanuel Koukatsikas
  City of Houston
  Houston, Texas

- Charles Kraus, Jr.
  Texas Dept. of Transportation
  P. O. Drawer EE
  Pharr, Texas 78577

- Buddy Lackey
  City of San Angelo
  P. O. Box 1751
  San Angelo, Texas 76902

- Ray Latham
  City of Corpus Christi
  1201 Leopard St.
  Corpus Christi, Texas 78401

- F. Taylor Lewis
  Naztec (City of Houston)
  816 Park Two Drive
  Sugar Land, Texas 77478

- J. Mark Mathis
  City of Grand Prairie
  P. O. Box 530011
  Grand Prairie, Texas 75053-0011

- Michael May
  City of Denton
  215 E. McKinney
  Denton, Texas 76201

- James McWhorter
  City of Texas City
  1801 9th Avenue N.
  Texas City, Texas 77590

- David Millar
  WHM Transportation Eng. Cons., Inc.
  2414 Exposition Blvd., Ste. BC 230
  Austin, Texas 78703

- George Mitchell
  City of Bryan
  P. O. Box 1000
  Bryan, Texas 77805

- Carl Mock
  City of San Angelo
  P. O. Box 1751
  San Angelo, Texas 76902

- Rohit Parikh
  Texas Dept. of Transportation
  P. O. Box 6868
  Fort Worth, Texas 76115

- R. Keith Pulaski
  City of Brownwood
  P. O. Box 1389
  Brownwood, Texas 76804

- Angel (Joe) Ramirez, Jr.
  City of El Paso
  2 Civic Center Plaza
  El Paso, Texas 79999

- Roberto Rodriguez, Jr.
  City of Laredo
  2800 Saunders
  Laredo, Texas 78041

- Allen Ross
  Johnson Brickell Mulcahy & Assoc.
  (JBM)
  17440 Dallas Pkwy., Suite 242
  Dallas, Texas 75287

- John Russell
  City of Longview
  P. O. Box 1952
  Longview, Texas 75606

- Jose Sanchez, Jr.
  City of Harlingen
  118 E. Tyler
  Harlingen, Texas 78550

- Ruben Sepulveda
  JBM & Associates
  17440 Dallas Parkway
  Dallas, Texas 75287

- Sam Swan
  Texas Dept. of Transportation
  P. O. Box 1549
  Brownwood, Texas 76801

- Mario Talamantez
  Texas Dept. of Transportation
  P. O. Box 61550
  San Angelo, Texas 76904

- Jeff Talebi
  City of Arlington
  West Main Street
  Arlington, Texas

- Robert Torres
  City of Corpus Christi
  1201 Leopard
  Corpus Christi, Texas 78404

- Daniel Vedral
  City of Arlington
  Arlington, Texas

- Bill Ward
  City of Tyler
  P. O. Box 2039
  Tyler, Texas 75710

APPENDIX B

PROGRAM OF WORK

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TRAFFIC LIGHT SYNCHRONIZATION II (TLS II) PROGRAM OF WORK

City	Project	City Match $	State Match $	Oil Overcharge Funds $	Total Project Cost $	Number of Signals Retimed
LARGE CITIES						
Arlington	Diamond Interchange	14,230.02	0.00	42,009.59	56,239.61	9
Arlington Totals		14,230.02	0.00	42,009.59	56,239.61	9
Austin	Airport Blvd.	24,077.22	0.00	37,994.78	62,072.00	19
	Burnet/Anderson	4,572.36	0.00	10,078.52	14,651.08	25
	Burnet/Braker/Kramer	3,597.36	0.00	10,792.09	14,389.45	15
	Central/Lamar/UT Area	4,920.50	0.00	14,761.48	19,681.98	58
	East First St.	1,805.48	0.00	5,416.42	7,221.90	7
	East 6th/7th St.	5,345.18	0.00	15,632.40	20,922.58	10
	East Riverside Dr.	5,513.75	0.00	16,541.25	22,055.00	6
	Enfield/15th	6,435.97	0.00	19,242.79	25,578.76	18
	Far South Austin Area	21,712.17	0.00	65,135.52	86,847.69	36
	Far West Blvd.	2,551.99	0.00	3,124.14	5,676.13	3
	I.H. 35/U.S. 290	3255.94	0.00	4,662.46	7,918.40	4
	Jollyville Road	3,207.55	0.00	8,777.72	22,985.27	3
	Northland Drive	3,639.61	0.00	10,918.82	14,558.43	6
	N. Lamar/Koenig Ln.	6,165.12	0.00	7,852.53	14,017.65	14
	N. Lamar/Rundberg/Rutlan	1,018.52	0.00	3,055.55	4,074.07	16
Austin Totals		94,562.78		233,986.47	342,650.39	240
Corpus Christi	Shoreline Blvd./Ocean Dr.	93,270.58	0.00	106,348.21	199,618.79	9
Corpus Christi Totals		93,270.58	0.00	106,348.21	199,618.79	9

TRAFFIC LIGHT SYNCHRONIZATION II (TLS II) PROGRAM OF WORK

City	Project	City Match $	State Match $	Oil Overcharge Funds $	Total Project Cost $	Number of Signals Retimed
LARGE CITIES						
Dallas	City of Dallas	179526.53	0.00	395777.28	576464.17	168
Dallas Totals		179526.53	0.00	395777.28	576464.17	168
El Paso	Various	58,936.84	0.00	176,810.54	235,747.38	16
El Paso Totals		58,936.84	0.00	176,810.54	235,747.38	16
Fort Worth	Jacksboro Highway	23,265.72	0.00	69,797.16	93,062.88	15
Fort Worth Totals		23,265.72	0.00	69,797.16	93,062.88	15
Houston	Various	394,557.12	0.00	725,000.00	1,119,557.12	50
Houston Totals		394,557.12	0.00	725,000.00	1,119,557.12	50
San Antonio	Various Intersections	93,957.79	0.00	281,873.38	375,831.17	295
San Antonio Totals		93,957.79	0.00	281,873.38	375,831.17	295
LARGE CITY TOTALS		**952,307.38**	**0.00**	**2,031,602.63**	**2,999,171.51**	**802**

TRAFFIC LIGHT SYNCHRONIZATION II (TLS II) PROGRAM OF WORK

City	Project	City Match $	State Match $	Oil Overcharge Funds $	Total Project Cost $	Number of Signals Retimed
MEDIUM CITIES						
Baytown	Alexander Drive	8,831.44	0.00	26,494.32	35,325.76	11
Baytown Totals		8,831.44	0.00	26,494.32	35,325.76	11
Brownsville	CBD & Ringgold System	25,059.58	0.00	73,763.29	98,822.87	50
Brownsville Totals		25,059.58	0.00	73,763.29	98,822.87	50
Bryan	City-Wide	29,051.52	0.00	71,691.90	100,743.42	27
Bryan Totals		29,051.52	0.00	71,691.90	100,743.42	27
Carrollton	Trinitiy	13,851.44	0.00	41,385.26	55,236.70	15
Carrollton Totals		13,851.44	0.00	41,385.26	55,236.70	15
College Station	City-Wide	19,510.67	0.00	58,373.22	77,886.89	37
College Station Totals		19,510.67	0.00	58,373.22	77,886.89	37
Denton	Carroll Blvd.	5,626.23	0.00	13,604.95	19,231.18	7
	CBD	16,880.82	0.00	37,042.64	53,923.46	10
Denton Totals		22,507.05	0.00	50,647.59	73,154.64	17
Grand Prairie	NE/SE 8th/9th/FM1382	2,952.31	0.00	6,911.47	9,863.78	8
Grand Prairie Totals		2,952.31	0.00	6,911.47	9,863.78	8
Laredo	San Bernardo Ave.	18,219.06	0.00	42,887.70	61,106.76	15
	Saunders St.	22,041.30	0.00	40,965.14	63,006.44	10
Laredo Totals		40,260.36	0.00	83,852.84	124,113.20	25
Longview	Cotton & South St.	24,464.42	0.00	36,200.00	60,664.42	7
	Gilmer Rd.	40,251.75	0.00	76,335.00	116,586.75	5
Longview Totals		64,716.17	0.00	112,535.00	177,251.17	12

TRAFFIC LIGHT SYNCHRONIZATION II (TLS II) PROGRAM OF WORK

City	Project	City Match $	State Match $	Oil Overcharge Funds $	Total Project Cost $	Number of Signals Retimed
MEDIUM CITIES						
McAllen	Pecan/10th	36,088.43	0.00	92,415.74	128,504.17	29
McAllen Totals		36,088.43	0.00	92,415.74	128,504.17	29
Midland	Midland/Wall	26,577.34	0.00	28,700.43	55,277.77	9
Midland Totals		26,577.34	0.00	28,700.43	55,277.77	9
Odessa	Dixie Blvd.	39,114.03	0.00	117,342.10	156,456.13	13
Odessa Totals		39,114.03	0.00	117,342.10	156,456.13	13
Port Arthur	Jeff Dr./Hwy. 347	26,109.31	5,395.00	48,854.28	80,358.59	12
Port Arthur Totals		26,109.31	5,395.00	48,854.28	80,358.59	12
San Angelo	Beauregard	30,025.05	0.00	64,104.75	94,129.80	15
	Chadbourne Avenue	14,151.82	0.00	24,847.51	38,999.33	3
	Sherwood Way	41,910.43	0.00	102,231.61	144,142.04	10
	19th Street	15,993.31	0.00	27,167.75	43,161.06	3
San Angelo Totals		102,080.61	0.00	218,351.62	320,432.23	31
Waco	CBD	5,770.27	0.00	17,310.79	23,081.06	32
	Franklin Avenue	7,991.99	0.00	5,900.75	13,892.74	4
Waco Totals		13,762.26	0.00	23,211.54	36,973.80	36
Wichita Falls	Southwest Pkwy.	3,501.13	22,934.06	39,245.77	65,680.96	7
Wichita Falls Totals		3,501.13	22,934.06	39,245.77	65,680.96	7
MEDIUM CITY TOTALS		**473,973.65**	**28,329.06**	**1,093,776.37**	**1,596,082.08**	**339**

TRAFFIC LIGHT SYNCHRONIZATION II (TLS II) PROGRAM OF WORK

City	Project	City Match $	State Match $	Oil Overcharge Funds $	Total Project Cost $	Number of Signals Retimed
SMALL CITIES						
Brownwood	Austin/Coggin	13,936.42	0.00	31,200.00	45,136.42	7
Brownwood Totals		13,936.42	0.00	31,200.00	45,136.42	7
Colleyville	Colleyville Blvd.	2,685.07	1,824.28	10,978.20	15,487.55	9
Colleyville Totals		2,685.07	1,824.28	10,978.20	15,487.55	9
Coppell	Denton Tap Road	18,746.70	0.00	46,099.00	64,845.70	9
Coppell Totals		18,746.70	0.00	46,099.00	64,845.70	9
Diboll	South Temple	0.00	7,729.86	16,996.15	24,726.01	3
Diboll Totals		0.00	7,729.86	16,996.15	24,726.01	3
Edinburg	Center Grid	19,651.30	15,738.41	106,169.11	141,558.82	6
	South Closner	15,589.44	13,450.42	87,119.57	116,159.43	8
	W. University Dr.	9,569.96	8,690.42	54,781.12	73,041.50	4
Edinburg Totals		44,810.70	37,879.25	248,069.80	330,759.75	18
Forest Hill	Forest Hill	18,446.83	0.00	27,939.47	46,386.30	3
Forest Hill Totals		18,446.83	0.00	27,939.47	46,386.30	3
Georgetown	LP418/RM2338	1,300.00	10,378.30	21,688.26	33,366.56	10
Georgetown Totals		1,300.00	10,378.30	21,688.26	33,366.56	10
Harlingen	Tyler/Harrison	18,755.15	0.00	37,030.08	55,785.23	17
Harlingen Totals		18,755.15	0.00	37,030.08	55,785.23	17
Huntsville	11th Street	12,383.21	0.00	37,149.65	49,532.86	10
Huntsville Totals		12,383.21	0.00	37,149.65	49,532.86	10

TRAFFIC LIGHT SYNCHRONIZATION II (TLS II) PROGRAM OF WORK

City	Project	City Match $	State Match $	Oil Overcharge Funds $	Total Project Cost $	Number of Signals Retimed
SMALL CITIES						
Hurst	Precinct Line	2,818.12	1,867.41	14,056.23	18,741.76	9
	SH 26	2,864.19	2,586.80	15,021.19	20,472.18	9
Hurst Totals		5,682.31	4,454.21	29,077.42	39,213.94	18
Lampasas	US 182	0.00	24,328.96	72,986.85	97,315.81	5
Lampasas Totals		0.00	24,328.96	72,986.85	97,315.81	5
Lufkin	LP 266	0.00	48,780.06	94,610.00	143,390.06	5
	SH 94	0.00	95,126.56	110,145.47	205,272.03	12
Lufkin Totals		0.00	143,906.62	204,755.47	348,662.09	17
Mineral Wells	US 281/US 180	2,921.97	2,859.33	6,570.41	12,351.71	8
Mineral Wells Totals		2,921.97	2,859.33	6,570.41	12,351.71	8
Nacogdoches	FM 1275	0.00	138,093.40	103,175.79	241,269.26	16
	North Street	0.00	207,557.60	104,926.13	312,483.80	7
Nacogdoches Totals		0.00	345,651.00	208,101.92	553,753.06	23
New Braunfels	Castell Ave./Union Ave	19,397.01	0.00	42,909.46	62,306.47	4
New Braunfels Totals		19,397.01	0.00	42,909.46	62,306.47	4
N. Richland Hill	Bedford/Euless	4,138.61	890.40	15,087.00	20,116.01	3
	Davis Boulevard System	4,429.93	820.36	15,750.86	21,001.15	5
	S.H. 26 South System	4,609.41	1,157.50	16,875.00	22,641.91	4
N. Richland Hills Totals		13,177.95	2,868.26	47,712.86	63,759.07	12

TRAFFIC LIGHT SYNCHRONIZATION II (TLS II) PROGRAM OF WORK

City	Project	City Match $	State Match $	Oil Overcharge Funds $	Total Project Cost $	Number of Signals Retimed
SMALL CITIES						
Sonora	LP 467	0.00	6,890.43	17,934.62	24,825.05	3
Sonora Totals		0.00	6,890.43	17,934.62	24,825.05	3
Texas City	Ninth Avenue	17,677.77	0.00	45,477.07	63,154.84	5
Texas City Totals		17,677.77	0.00	45,477.07	63,154.84	5
Tyler	Broadway Avenue	44,656.40	0.00	50,636.25	95,292.65	15
	Gentry Parkway	20,037.96	0.00	26,556.46	46,594.42	6
	Palace Avenue	17,654.06	0.00	29,643.37	47,297.43	5
Tyler Totals		82,348.42	0.00	106,836.08	189,184.50	26
SMALL CITY TOTALS		**272,269.51**	**588,770.50**	**1,259,512.77**	**2,120,552.92**	**207**
GRAND TOTAL		**1,698,550.54**	**617,099.56**	**4,384,891.77**	**6,715,806.51**	**1348**

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APPENDIX C

BENEFITS BY TYPE OF TRAFFIC SIGNAL TIMING IMPROVEMENT

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Table C-1. Annual Benefits when Optimizing Uncoordinated Arterial with Existing Equipment

Cities	Projects	Number of Intersections	Stops	Percent	Delay (hrs)	Percent	Fuel Cons. (gal)	Percent	B/C Ratio
Small Cities									
Diboll	US 59	3	144,300	6.9	19,830	60.2	17,139	24.3	8.9
Total		3	144,300	6.9	19,830	60.2	17,139	24.3	

Table C-2. Annual Change in MOEs when Optimizing Uncoordinated Arterial with Existing Equipment

Cities	Projects	Number of Intersections	Overall Stops Before	Overall Stops After	Overall Delays (hrs) Before	Overall Delays (hrs) After	Overall Fuel Consumption (gals) Before	Overall Fuel Consumption (gals) After	B/C Ratio
Small Cities									
Diboll	US 59	3	2,091,450	1,947,150	32,955	13,125	70,578	53,439	8.9
Total		3	2,091,450	1,947,150	32,955	13,125	70,578	53,439	

Table C-3. Annual Benefits when Optimizing Coordinated Arterial with Existing Equipment

Cities	Projects	Number of Intersections	Stops	Percent	Delay (hrs)	Percent	Fuel Cons. (gal)	Percent	B/C Ratio
Large Cities									
Austin	Far West Boulevard	3	3,049,950	13.2	(825)	-0.7	18,209	5.3	9.3
	Jollyville Road	3	3,809,100	23.7	160,620	60.1	110,490	27.2	113.6
Total		6	6,859,050	18.5	159,795	29.7	128,699	16.3	

Table C-4. Annual Change in MOEs when Optimizing Coordinated Arterial with Existing Equipment

Cities	Projects	Number of Intersections	Overall Stops Before	After	Overall Delays (hrs) Before	After	Overall Fuel Consumption (gals) Before	After	B/C Ratio
Large Cities									
Austin	Far West Boulevard	3	23,076,000	20,026,050	112,785	113,610	343,100	324,891	9.3
	Jollyville Road	3	16,078,800	12,269,700	267,330	106,710	406,143	295,653	113.6
Total		6	39,154,800	32,295,750	380,115	220,320	749,243	620,544	

Table C-5. Annual Benefits when Optimizing Uncoordinated Arterial with New Equipment

Cities	Projects	Number of Intersections	Stops	Percent	Delay (hrs)	Percent	Fuel Cons. (gal)	Percent	B/C Ratio
Medium Cities									
Longview	Gilmer Road	7	12,988,500	26.5	87,780	21.9	(531,150)	-102.0	4.5
San Angelo	19th Street	3	87,000	0.8	4,116	4.7	3,726	2.0	1.3
Colleyville	SH 26	9	522,000	2.9	34,200	9.1	25,920	5.9	24.2
Edinburg	South Closner	8	7,183,800	20.5	12,000	4.6	90,900	9.0	2.7
	West University Drive	4	1,503,000	7.7	150,600	38.4	200,400	25.1	23.7
Forest Hill	Forest Hill Drive	3	(887,100)	-10.8	444,258	64.1	320,361	55.1	101.8
Huntsville	11th Street	10	4,924,200	9.7	88,320	25.6	(209,280)	-34.8	15.0
Hurst	SH 26	9	190,800	3.8	4,140	6.6	5,400	5.4	2.4
Lufkin	Loop 266	5	93,600	3.7	2,745	17.4	2,430	7.7	0.2
	SH 94	12	4,754,100	53.7	117,240	84.6	212,970	75.3	7.1
Nacogdoches	FM 1275	7	25,800	0.4	48,855	52.6	36,144	16.4	2.2
	North Street	16	1,909,500	13.9	95,205	48.2	119,898	26.5	3.5
North Richland Hills	Davis Boulevard System	5	1,930,200	16.7	19,761	26.0	29,070	9.3	11.2
	SH 26/South System	4	167,700	1.4	21,984	15.2	9,150	2.7	9.5
Sonora	Loop 467	3	432,138	8.8	4,316	18.3	5,366	4.5	2.2
Total		105	35,825,238	14.4	1,135,520	32.7	321,305	8.9	

Table C-6. Annual Change in MOEs when Optimizing Uncoordinated Arterial with New Equipment

Cities	Projects	Number of Intersections	Overall Stops Before	After	Overall Delays (hrs) Before	After	Overall Fuel Consumption (gals) Before	After	B/C Ratio
Medium Cities									
Longview	Gilmer Road	7	49,088,400	36,099,900	401,340	313,560	520,770	1,051,920	4.5
San Angelo	19th Street	3	10,485,000	10,398,000	86,787	82,671	181,965	178,239	1.3
Colleyville	SH 26	9	17,726,400	17,204,400	375,120	340,920	442,200	416,280	24.2
Edinburg	South Closner	8	35,050,800	27,867,000	263,400	251,400	1,008,300	917,400	2.7
	West University Drive	4	19,578,900	18,075,900	392,100	241,500	798,900	598,500	23.7
Forest Hill	Forest Hill Drive	3	8,247,900	9,135,000	692,601	248,343	581,856	261,495	101.8
Huntsville	11th Street	10	51,012,600	46,088,400	345,480	257,160	601,140	810,420	15.0
Hurst	SH 26	9	4,960,800	4,770,000	62,460	58,320	99,540	94,140	2.4
Lufkin	Loop 266	5	2,502,150	2,408,550	15,750	13,005	31,620	29,190	0.2
	SH 94	12	8,851,050	4,096,950	138,615	21,375	282,855	69,885	7.1
Nacogdoches	FM 1275	7	6,231,150	6,205,350	92,910	44,055	220,094	183,950	2.2
	North Street	16	13,703,100	11,793,600	197,580	102,375	452,502	332,604	3.5
North Richland Hills	Davis Boulevard System	5	11,579,100	9,648,900	76,044	56,283	311,550	282,480	11.2
	SH 26/South System	4	12,143,100	11,975,400	144,162	122,178	342,840	333,690	9.5
Sonora	Loop 467	3	4,920,000	4,487,862	23,520	19,204	119,070	113,704	2.2
Total		105	256,080,450	220,255,212	3,307,869	2,172,349	5,995,202	5,673,897	

Table C-7. Annual Benefits when Optimizing Partially Coordinated Arterial with New Equipment

Cities	Projects	Number of Intersections	Stops	Percent	Delay (hrs)	Percent	Fuel Cons. (gal)	Percent	B/C Ratio
Large Cities									
Corpus Christi	Shoreline Boulevard/Ocean Drive	9	9,387,750	10.9	358,304	55.9	261,300	15.6	3.6
Medium Cities									
Laredo	Sauders Street	10	5,107,200	12.0	29,982	9.4	43,608	4.7	6.6
Port Arthur	Jefferson Drive/Highway 347	12	3,487,200	4.8	242,790	34.6	613,080	27.0	47.2
San Angelo	Sherwood Way	10	11,749,500	37.2	90,000	44.5	155,730	20.3	8.4
Small Cities									
Hurst	Precinct Line Road	9	1,479,300	3.3	161,199	22.4	134,063	9.8	54.8
Total		50	31,210,950	13.6	882,275	33.2	1,207,781	16.0	

Table C-8. Annual Change in MOEs when Optimizing Partially Coordinated Arterial with New Equipment

Cities	Projects	Number of Intersections	Overall Stops Before	After	Overall Delays (hrs) Before	After	Overall Fuel Consumption (gals) Before	After	B/C Ratio
Large Cities									
Corpus Christi	Shoreline Boulevard/Ocean Drive	9	86,025,150	76,637,400	640,529	282,225	1,676,625	1,415,325	3.6
Medium Cities									
Laredo	Sauders Street	10	42,388,800	37,281,600	318,126	288,144	927,855	884,247	6.6
Port Arthur	Jefferson Drive/Highway 347	12	72,503,100	69,015,900	701,640	458,850	2,273,160	1,660,080	47.2
San Angelo	Sherwood Way	10	31,568,100	19,818,600	202,440	112,440	765,600	609,870	8.4
Small Cities									
Hurst	Precinct Line Road	9	45,330,150	43,850,850	718,733	557,534	1,369,679	1,235,616	54.8
Total		50	277,815,300	246,604,350	2,581,468	1,699,193	7,012,919	5,805,138	

Table C-9. Annual Benefits when Optimizing Coordinated Arterial with New Equipment

Cities	Projects	Number of Intersections	Stops	Percent	Delay (hrs)	Percent	Fuel Cons. (gal)	Percent	B/C Ratio
Large Cities									
Austin	Airport Boulevard	19	40,698,600	16.8	196,110	10.4	1,021,395	16.8	45.2
	East First Street	7	347,100	1.2	78,615	41.8	58,932	10.7	87.5
	East Riverside Drive	6	1,819,050	6.8	19,962	15.0	35,625	5.6	9.6
	Enfield/15th	18	28,865,700	11.3	613,845	26.6	613,305	13.4	192.3
	North Land Drive	6	26,239,050	36.2	684,945	68.3	660,711	45.7	437.4
Medium Cities									
Baytown	Alexander Drive	11	21,576,300	39.3	135,210	39.3	(317,400)	-64.2	35.1
Denton	Carroll Boulevard	7	12,582,600	23.7	16,500	5.8	164,640	15.2	22.2
Odessa	Dixie Boulevard	13	13,356,300	12.8	175,500	17.2	240,900	11.6	13.8
San Angelo	Beauregard Avenue	15	2,697,000	29.1	26,970	43.0	63,540	25.6	3.9
Waco	Franklin Avenue	4	1,896,750	10.6	330,525	78.0	344,175	43.7	264.6
Small Cities									
Lampasas	Five Intersections	5	2,025,150	26.2	31,260	36.5	35,858	30.3	3.9
Tyler City	Gentry Parkway	6	9,215,100	44.3	212,400	73.4	301,500	41.5	55.8
Total		117	161,318,700	20.8	2,521,842	32.0	3,223,180	12.4	

Table C-10. Annual Change in MOEs when Optimizing Coordinated Arterial with New Equipment

Cities	Projects	Number of Intersections	Overall Stops Before	After	Overall Delays (hrs) Before	After	Overall Fuel Consumption (gals) Before	After	B/C Ratio
Large Cities									
Austin	Airport Boulevard	19	242,722,650	202,024,050	1,893,150	1,697,040	6,083,610	5,062,215	45.2
	East First Street	7	28,400,100	28,053,000	188,235	109,620	550,974	492,042	87.5
	East Riverside Drive	6	26,767,650	24,948,600	133,452	113,490	632,006	596,381	9.6
	Enfield/15th	18	254,337,750	225,472,050	2,303,910	1,690,065	4,559,895	3,946,590	192.3
	North Land Drive	6	72,582,900	46,343,850	1,003,290	318,345	1,446,387	785,676	437.4
Medium Cities									
Baytown	Alexander Drive	11	54,890,400	33,314,100	344,400	209,190	494,400	811,800	35.1
Denton	Carroll Boulevard	7	53,039,400	40,456,800	286,080	269,580	1,083,720	919,080	22.2
Odessa	Dixie Boulevard	13	104,302,950	90,946,650	1,021,800	846,300	2,077,650	1,836,750	13.8
San Angelo	Beauregard Avenue	15	9,281,100	6,584,100	62,670	35,700	248,640	185,100	3.9
Waco	Franklin Avenue	4	17,923,650	16,026,900	423,555	93,030	788,340	444,165	264.6
Small Cities									
Lampasas	Five Intersections	5	7,737,150	5,712,000	85,560	54,300	118,523	82,665	3.9
Tyler City	Gentry Parkway	6	20,807,100	11,592,000	289,200	76,800	727,200	425,700	55.8
Total		117	892,792,800	731,474,100	8,035,302	5,513,460	18,811,344	15,588,164	

Table C-11. Annual Benefits when Optimizing Coordinated Network with Existing Equipment

Cities	Projects	Number of Intersections	Stops	Percent	Delay (hrs)	Percent	Fuel Cons. (gal)	Percent	B/C Ratio
Large Cities									
Austin	Burnet/Braker/Kramer	15	18,263,700	10.4	988,860	38.6	839,648	17.8	763.3
Medium Cities									
Carrollton	Carrollton Signal System	15	10,125,300	9.8	714,603	29.6	825,549	18.7	143.7
Total		30	28,389,000	10.1	1,703,463	34.1	1,665,197	18.2	

Table C-12. Annual Change in MOEs when Optimizing Coordinated Network with Existing Equipment

		Number of	Overall Stops		Overall Delays (hrs)		Overall Fuel Consumption (gals)		
Cities	Projects	Intersections	Before	After	Before	After	Before	After	B/C Ratio
Large Cities									
Austin	Burnet/Braker/Kramer	15	174,850,275	156,586,575	2,564,160	1,575,300	4,729,688	3,890,040	763.3
Medium Cities									
Carrollton	Carrollton Signal System	15	103,124,700	92,999,400	2,415,999	1,701,396	4,406,055	3,580,506	143.7
Total		30	277,974,975	249,585,975	4,980,159	3,276,696	9,135,743	7,470,546	

Table C-13. Annual Benefits when Optimizing Uncoordinated Network with New Equipment

Cities	Projects	Number of Intersections	Stops	Percent	Delay (hrs)	Percent	Fuel Cons. (gal)	Percent	B/C Ratio
Medium Cities									
Longview	South Street/Cotton Street	5	1,180,200	13.6	10,710	23.0	12,000	11.9	2.2
Midland	Midland Drive/Wall Street	9	(14,489,400)	-23.8	927,359	65.1	169,025	10.0	171.1
Small Cities									
Brownwood	Various Intersections	7	(93,300)	-1.4	6,675	24.0	4,548	8.3	1.4
Coppell	Belt Line/Denton/MacArthur	9	1,744,800	5.9	117,492	23.1	123,984	9.2	20.1
Edinburg	Center Grid	6	1,769,100	10.1	167,400	58.5	136,200	38.3	13.0
New Braunfels	Union Avenue/Castell Avenue	4	319,800	3.5	1,860	6.0	3,720	4.2	0.4
North Richland Hills	SH 26 North System	3	2,211,300	14.6	172,404	58.2	140,790	39.1	90.1
Total		43	(7,357,500)	0.4	1,403,900	37.8	590,267	15.2	

Table C-14. Annual Change in MOEs when Optimizing Uncoordinated Network with New Equipment

Cities	Projects	Number of Intersections	Overall Stops Before	After	Overall Delays (hrs) Before	After	Overall Fuel Consumption (gals) Before	After	B/C Ratio
Medium Cities									
Longview	South Street/Cotton Street	5	8,688,600	7,508,400	46,560	35,850	101,100	89,100	2.2
Midland	Midland Drive/Wall Street	9	60,988,350	75,477,750	1,423,732	496,373	1,686,680	1,517,655	171.1
Small Cities									
Brownwood	Various Intersections	7	6,598,200	6,691,500	27,765	21,090	54,629	50,081	1.4
Coppell	Belt Line/Denton/MacArthur	9	29,497,800	27,753,000	509,574	392,082	1,349,592	1,225,608	20.1
Edinburg	Center Grid	6	17,500,800	15,731,700	286,200	118,800	355,800	219,600	13.0
New Braunfels	Union Avenue/Castell Avenue	4	9,012,000	8,692,200	31,260	29,400	87,840	84,120	0.4
North Richland Hills	SH 26 North System	3	15,173,400	12,962,100	296,319	123,915	360,150	219,360	90.1
Total		43	147,459,150	154,816,650	2,621,410	1,217,510	3,995,791	3,405,524	

Table C-15. Annual Benefits when Optimizing Partially Coordinated Network with New Equipment

Cities	Projects	Number of Intersections	Stops	Percent	Delay (hrs)	Percent	Fuel Cons. (gal)	Percent	B/C Ratio
Large Cities									
El Paso	City of El Paso	16	10,433,250	12.6	470,651	15.0	724,793	19.5	23.7
Fort Worth	Jacksboro Highway	15	3,018,900	4.4	143,994	20.7	126,990	5.8	16.9
Houston	Various Arterials	50	25,334,400	9.9	620,274	22.6	638,544	12.7	6.4
San Antonio	Various Intersections	295	192,228,000	18.8	607,500	10.0	2,301,900	9.4	29.4
Medium Cities									
Brownsville	CBD/Ringgold System	50	25,230,000	33.6	76,200	19.8	138,000	14.5	12.5
Bryan	City Wide	27	12,799,734	9.5	230,967	21.7	268,285	9.7	23.6
College Station	City Wide	37	625,800	0.5	12,450	1.1	12,423	0.3	1.9
Denton	Downtown CBD System	10	7,201,800	23.8	19,200	12.3	42,600	11.0	6.1
Grand Prairie	NE/SE 8th/9th Street	8	6,525,000	18.9	1,288,200	73.9	958,800	55.4	933.6
Laredo	San Bernardo Avenue	15	3,653,400	9.1	50,373	20.4	55,380	8.2	10.0
McAllen	10th Street/Pecan Boulevard	29	21,853,800	13.6	114,000	7.4	233,400	6.0	13.2
Wichita Falls	Southwest Parkway	7	1,260,000	4.8	12,000	5.9	24,762	2.7	2.5
Small Cities									
Georgetown	RM 2338/IH 35	10	4,474,800	12.1	70,125	30.1	285,731	38.2	31.5
Harlingen	City Wide	17	7,433,400	10.8	90,600	15.4	130,200	8.4	20.7
Mineral Wells	CBD	8	(24,600)	-1.7	516	7.2	288	1.0	0.4
Total		594	322,047,684	16.0	3,807,050	13.7	5,942,095	10.5	

Table C-16. Annual Change in MOEs when Optimizing Partially Coordinated Network with New Equipment

Cities	Projects	Number of Intersections	Overall Stops Before	Overall Stops After	Overall Delays (hrs) Before	Overall Delays (hrs) After	Overall Fuel Consumption (gals) Before	Overall Fuel Consumption (gals) After	B/C Ratio
Large Cities									
El Paso	City of El Paso	16	82,791,900	72,358,650	3,132,770	2,662,119	3,724,560	2,999,768	23.7
Fort Worth	Jacksboro Highway	15	68,529,000	65,510,100	694,218	550,224	2,173,350	2,046,360	16.9
Houston	Various Arterials	50	255,897,000	230,562,600	2,743,851	2,123,577	5,042,583	4,404,039	6.4
San Antonio	Various Intersections	295	1,025,193,900	832,965,900	6,063,900	5,456,400	24,388,500	22,086,600	29.4
Medium Cities									
Brownsville	CBD/Ringgold System	50	75,118,800	49,888,800	384,600	308,400	952,800	814,800	12.5
Bryan	City Wide	27	134,737,305	121,937,571	1,066,199	835,231	2,761,634	2,493,350	23.6
College Station	City Wide	37	122,486,100	121,860,300	1,084,143	1,071,693	4,416,777	4,404,354	1.9
Denton	Downtown CBD System	10	30,322,200	23,120,400	156,000	136,800	387,600	345,000	6.1
Grand Prairie	NE/SE 8th/9th Street	8	34,518,000	27,993,000	1,744,200	456,000	1,729,200	770,400	933.6
Laredo	San Bernardo Avenue	15	39,940,500	36,287,100	246,429	196,056	675,381	620,001	10.0
McAllen	10th Street/Pecan Boulevard	29	160,369,800	138,516,000	1,531,200	1,417,200	3,878,400	3,645,000	13.2
Wichita Falls	Southwest Parkway	7	26,303,100	25,043,100	203,127	191,127	911,535	886,773	2.5
Small Cities									
Georgetown	RM 2338/IH 35	10	36,901,200	32,426,400	233,280	163,155	747,777	462,047	31.5
Harlingen	City Wide	17	68,925,600	61,492,200	586,800	496,200	1,545,600	1,415,400	20.7
Mineral Wells	CBD	8	1,449,300	1,473,900	7,128	6,612	29,385	29,097	0.4
Total		594	2,163,483,705	1,841,436,021	19,877,844	16,070,794	53,365,082	47,422,988	

Table C-17. Annual Benefits when Optimizing Coordinated Network with New Equipment

Cities	Projects	Number of Intersections	Stops	Percent	Delay (hrs)	Percent	Fuel Cons. (gal)	Percent	B/C Ratio
Large Cities									
Arlington	Diamond Interchange	9	3,582,000	6.5	204,300	17.3	180,000	11.7	44.0
Austin	Burnet/Anderson	25	(6,685,500)	-2.8	81,345	4.2	36,386	0.7	45.0
	Central/Lamar/UT Area	58	39,982,200	6.2	183,105	2.3	1,173,432	8.4	100.7
	East Sixth/Seventh Street	10	1,955,400	5.9	17,895	13.8	44,055	6.0	9.7
	Far South Austin	36	67,608,150	13.5	6,915,195	54.7	3,793,770	23.7	704.3
	IH 35/US 290	4	5,333,850	20.1	65,475	36.6	191,220	35.7	116.3
	North Lamar/Koenig Lane	14	5,493,600	4.1	32,430	2.6	69,255	2.3	23.0
	North Lamar/Rundberg/Rutland	16	8,579,400	4.4	571,530	25.5	390,863	8.3	1,334.0
Dallas	City of Dallas	168	(1,839,600)	-0.6	110,898	5.3	47,640	0.8	1.9
Medium Cities									
San Angelo	Chadbourne Triangle	3	159,600	2.5	11,430	26.1	10,236	9.2	3.5
Waco	CBD	32	9,515,700	23.1	57,600	21.3	130,500	18.8	36.4
Small Cities									
Texas City	9th Avenue	5	3,506,400	21.5	19,380	23.3	(51,960)	-38.1	3.1
Tyler City	Broadway Avenue	15	11,301,600	23.7	1,962,900	88.4	1,519,800	62.2	225.9
	Palace Avenue	5	2,371,500	15.1	193,800	71.6	167,100	36.1	45.2
Total		400	150,864,300	5.7	10,427,283	16.3	7,702,296	8.8	

Table C-18. Annual Change in MOEs when Optimizing Coordinated Network with New Equipment

Cities	Projects	Number of Intersections	Overall Stops Before	After	Overall Delays (hrs) Before	After	Overall Fuel Consumption (gals) Before	After	B/C Ratio
Large Cities									
Arlington	Diamond Interchange	9	54,975,000	51,393,000	1,178,400	974,100	1,537,500	1,357,500	44.0
Austin	Burnet/Anderson	25	240,994,500	247,680,000	1,942,650	1,861,305	5,353,950	5,317,565	45.0
	Central/Lamar/UT Area	58	644,645,400	604,663,200	8,130,420	7,947,315	13,943,748	12,770,316	100.7
	East Sixth/Seventh Street	10	33,305,100	31,349,700	130,080	112,185	732,675	688,620	9.7
	Far South Austin	36	501,256,875	433,648,725	12,634,440	5,719,245	16,016,700	12,222,930	704.3
	IH 35/US 290	4	26,584,275	21,250,425	178,905	113,430	536,355	345,135	116.3
	North Lamar/Koenig Lane	14	134,049,150	128,555,550	1,240,965	1,208,535	3,029,130	2,959,875	23.0
	North Lamar/Rundberg/Rutland	16	195,143,100	186,563,700	2,243,220	1,671,690	4,723,813	4,332,950	1,334.0
Dallas	City of Dallas	168	329,537,400	331,377,000	2,107,278	1,996,380	5,639,280	5,591,640	1.9
Medium Cities									
San Angelo	Chadbourne Triangle	3	6,312,000	6,152,400	43,788	32,358	111,786	101,550	3.5
Waco	CBD	32	41,138,100	31,622,400	270,000	212,400	695,400	564,900	36.4
Small Cities									
Texas City	9th Avenue	5	16,279,200	12,772,800	83,100	63,720	136,260	188,220	3.1
Tyler City	Broadway Avenue	15	47,775,000	36,473,400	2,220,600	257,700	2,445,000	925,200	225.9
	Palace Avenue	5	15,755,400	13,383,900	270,600	76,800	462,300	295,200	45.2
Total		400	2,287,750,500	2,136,886,200	32,674,446	22,247,163	55,363,897	47,661,601	