Project Evaluation

Iowa Motor Vehicle Fuel Reduction Program

DNR

Iowa Department of Transportation

June, 1989

JBM CONSULTING ENGINEERS
Johnson, Brickell, Mulcahy & Associates, Inc.

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TABLE OF CONTENTS

Introduction

The results of a study which evaluates the Iowa Motor Vehicle Fuel Reduction Program have been summarized and described in this report. The Iowa Motor Vehicle Fuel Reduction Program was designed to demonstrate fuel savings through traffic signal modernization projects and provide direct benefits to motorists in Iowa.

The program was funded by Exxon oil overcharge funds ($3 million) through the Iowa Department of Natural Resources. The Iowa Department of Transportation (DOT) developed the plan for disbursement of the funds and administered the Iowa Motor Vehicle Fuel Reduction Program

PURPOSE

The program had two basic objectives. The first, to demonstrate ways to reduce fuel consumption, vehicle stops, and delays through modernization of traffic control facilities at selected field demonstrations throughout the State of Iowa; while the second objective was to provide immediate restitution to Iowa motor vehicle fuel users for previous oil overcharges by Exxon.

PROJECT SELECTION

The demonstration projects for the Iowa Motor Vehicle Fuel Reduction Program were selected based on three criteria: city size, geographic location, and type of project. Project selection based on city size was evenly divided between small cities (population less than 10,000); medium cities (population 10,000 - 50,000); and large cities (population over 50,000). The project sites were also distributed evenly geographically throughout the State of Iowa.

Twenty-one demonstration projects were selected. Three projects were located in each of the DOT's six districts - one in each population grouping. Three "at large" projects were also selected. The demonstration projects have been summarized in Table 1, by IDOT District, and are graphically depicted on Figure 1. Two (2) project sites initially selected (Harlan and Knoxville) were dropped because the sites failed to meet the signal warrant criteria of the Manual On Uniform Traffic Control Devices.

TABLE 1

FINAL DEMONSTRATION PROJECTS
IOWA MOTOR VEHICLE FUEL REDUCTION PROGRAM

LOCATION	CITY SIZE	PROJECT TYPE
District 1		
Des Moines/Urbandale/DOT	Large	Closed Loop System
Ames	Medium	Closed Loop System
Webster City	Small	Time-Based Coordination
District 2		
Waterloo	Large	Closed Loop System
Mason City	Medium	Closed Loop System
Algona	Small	Actuated Intersection
District 3		
Sioux City	Large	Computer Control
Spencer	Medium	Closed Loop System
Storm Lake	Small	Time-Based Coordination
District 4		
Council Bluffs	Large	Closed Loop System
Atlantic	Medium	Closed Loop System
District 5		
Muscatine	Large	Time-Based Coordination
Indianola	Medium	Time-Based Coordination
District 6		
Iowa City	Large	Closed Loop System
Bettendorf	Medium	Vehicle Detectors
Monticello	Small	Actuated Intersections
AT LARGE		
Des Moines	Large	Various Improvements/ Retiming
West Des Moines	Medium	Closed Loop System
Decorah	Small	Closed Loop System

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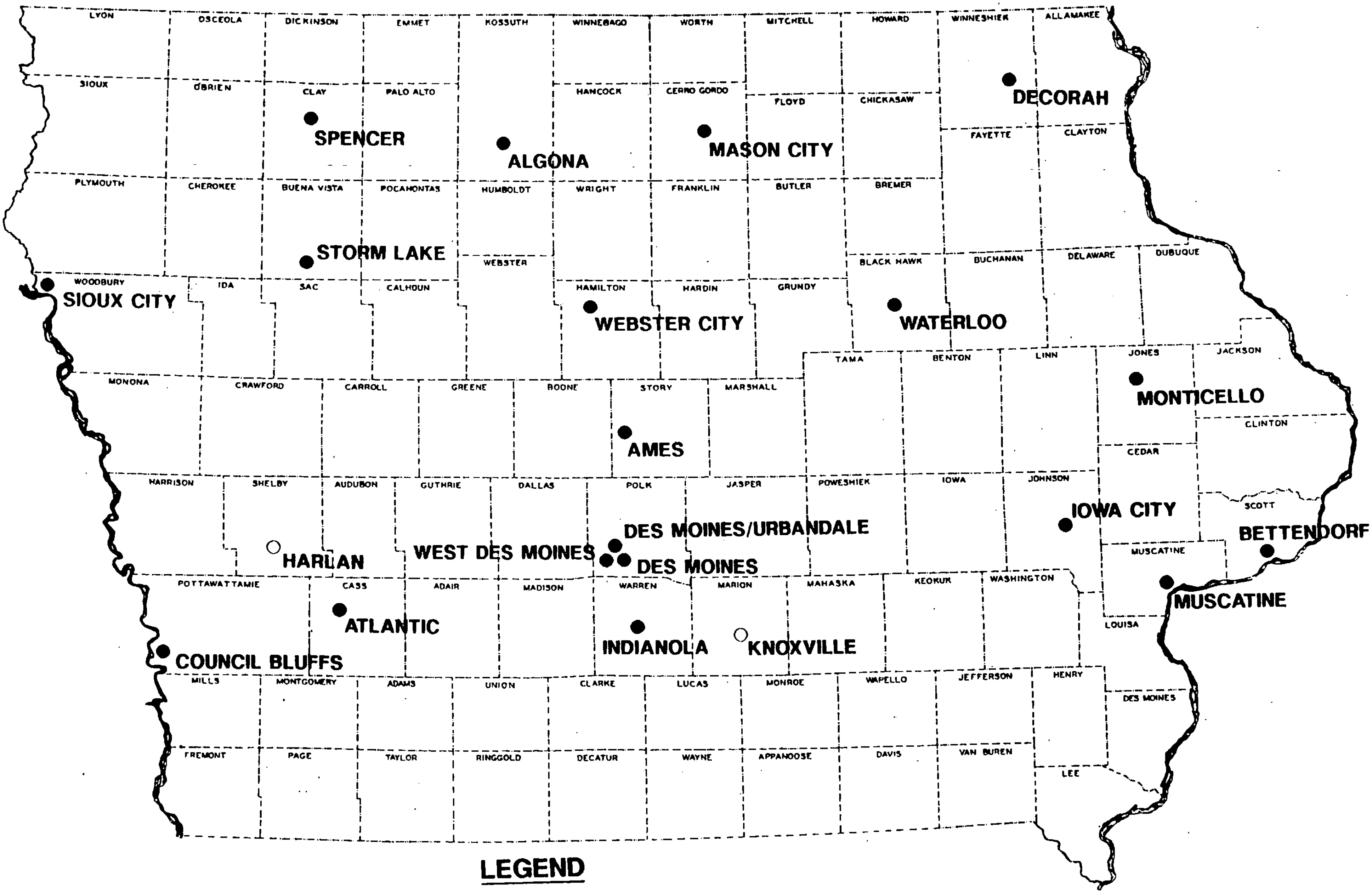
IOWA FUEL REDUCTION PROGRAM
DEMONSTRATION PROJECTS



LEGEND

● PROJECT SITE

○ PROJECT DROPPED

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FIGURE 1

PROJECT EVALUATION

The individual demonstration projects were evaluated utilizing benefit-cost analysis techniques. Road user benefits were determined by performing traffic studies before and after improvements were implemented at each demonstration project site. The studies completed for each project provided an estimation of vehicle stops, traffic delay, and fuel consumption.

Projects involving isolated intersections were evaluated utilizing an intersection delay study technique developed by the Federal Highway Administration. Projects involving arterials using time-based coordination or closed loop system technology were evaluated using travel time studies conducted along the route with an instrumented vehicle.

The route travel time study data and intersection delay study data was analyzed to determine estimated daily and annualized vehicle stops, traffic delay, and fuel consumption. The studies completed before the individual demonstration projects were implemented provided the base condition against which to measure traffic operations improvements realized through each project's implementation. Benefit-cost analyses were conducted for each demonstration project utilizing the before and after study data collected.

Project Evaluation Techniques

Individual demonstration projects were evaluated through the determination of a benefit-cost ratio for each project. In order to determine this ratio it was necessary to measure traffic conditions before and after each project was implemented. These measurements of traffic conditions were collected and analyzed in a form such that a cost factor could be applied to obtain a dollar value associated with the condition. For this study it was determined that the following traffic conditions would be used; stops, delay in vehicle-hours, fuel consumption in gallons, and travel time in vehicle hours. These conditions were determined by performing a particular study method dependent upon the nature of the project (isolated intersection or arterial route). The individual studies were conducted before and after implementation of individual demonstration projects.

ISOLATED INTERSECTIONS

The method used to collect data at an isolated signalized intersection was the Intersection Delay and Percent Stopping Study. The technique for this study is outlined in the Federal Highway Administration's manual entitled Procedure For Estimating Highway User Costs, Fuel Consumption and Air Pollution, dated March, 1980.

Studies at isolated intersection locations were completed utilizing a two person team which collected a point sample of vehicles at the intersection. The team started the study by selecting one of the intersection approaches for data collection. A member of the team kept a total count of approaching vehicles classified by "stopping" or "not stopping". This data was used to determine the percent of cars stopping before they could proceed through the intersection. The other team member collected the number of stopped vehicles on the approach at a given instant of time. This sampling point occurred at a set interval of time dependent upon the type of signal operation. If the signal was in a fixed cycle length a 13 second interval was used between sample points. If the signal was operating in an actuated mode a 15 second interval was used. Both members continued to collect the data for a period of 15 minutes, or 13 minutes, depending upon whether the 15 second or 13 second sampling interval was used. Once the time limit was reached the team would begin data collection on the next approach and continue around the intersection repeating the data collection technique for each approach.

The studies were completed during AM, OFF, and PM peak traffic intervals. Each approach at an intersection was studied for a minimum of 30 minutes during each peak traffic interval. Traffic counts on each intersection approach were also collected by the placement of machine traffic counters to obtain a 24 hour traffic volume. The field data was analyzed by the technique described in the manual and resulted in an estimate of total delay, fuel consumption, and stops per vehicle at the intersection. These values were used with the traffic volumes and cost factors to determine an annual cost to motorists at the intersection.

ARTERIAL ROUTES

The methodology used to collect data on an arterial route was the Travel Time Study. The study determined the time it takes to travel from the beginning of a route to the end and the delays incurred while traveling along the route. From these values fuel consumption and other travel measures can be determined.

The travel time studies were completed utilizing the floating car technique (as many vehicles were passed as passed the study vehicle). Data collection was performed utilizing an instrumented vehicle which uses a hand held device (similar to a computer) which is connected to a sensor installed in the transmission of the study vehicle. The device records input from the sensor and stores it until it can be uploaded directly into a micro-computer. The operator can also manually input information regarding reasons for delay (signal, right turn vehicle, etc.), direction of travel and street names. Once the data is collected the device is returned to the office and connected to a micro-computer. Data can then be uploaded and used with software to produce a number of results such as travel time, number of delays, delay time, and fuel consumption for each link or for the entire route.

The travel time studies were performed during the AM, OFF, and PM peak traffic intervals. A minimum of 5 Travel Time runs were made in each direction of travel during each of the peak traffic intervals. Traffic volumes on the route were collected by machine counters placed so that a 24 hour, directional count was collected. After the necessary Travel Time runs and traffic counts were completed the data was analyzed and an estimate of stops, total delay, fuel consumption, and travel time was calculated using the travel time software.

BENEFIT-COST

The benefit-cost ratio was used to determine the comparative worth of a project by examining the ratio of annual benefits (or savings) to annual highway costs. Annual benefits were calculated by determining the cost to the road user before and after the project was completed. The difference was equal to the annual benefits. Annual highway costs were determined by calculating the yearly maintenance cost of the existing facility and the annualized project cost and maintenance cost of the completed project.

ANNUAL BENEFITS . . . The annual benefit to the road user is the difference between the road user cost before the project and the road user cost after the project was completed. These before and after costs were calculated using the data collected in the before and after evaluation studies outlined above. The studies provided a daily estimate of stops, delay, fuel consumption, and travel time on a per vehicle basis. Each of these values were then multiplied by the corresponding directional traffic volume (AM, OFF, PM peak) to obtain a daily total for each measure. The daily totals for each peak period and direction of travel were then combined and multiplied by 300 vehicle travel days per 365 day year to obtain an annual total of each measure. Each annual total (stops, delay, fuel, and travel time) was multiplied by a cost factor to determine a cost associated with each total. The cost factors which were used in the study are shown in the table below.

Cost Factors

Measure	Cost	Units
Stops	$0.0145	per stop
Delay	$0.313	per vehicle hour
Fuel Consumption	$1.00	per gallon
Travel Time	$3.35	per vehicle hour

The cost factors for stops and delay have been used in similar studies and are based upon national standards. The cost factor for fuel was the average price for a gallon of fuel at the time of the study. The travel time cost factor was equal to the current minimum wage rate.

Costs were calculated for each measure before and after implementation of the project. With these values the difference was calculated to determine if any savings were obtained. Once the savings were determined for each measure they were summed to determine the total annual savings incurred by the motorists.

ANNUAL HIGHWAY COST . . . The annual highway cost consisted of two parts; the before (or "no-build") highway cost and the after (or "build") highway cost. Since all of the projects in the study involved traffic signal improvements, the only maintenance costs incurred were upkeep and power to operate the signals. This cost was determined to be $1,500 per year for each signal. The before highway cost was equal to the number of signals multiplied by the maintenance and power cost per signal. The after highway cost was equal to the maintenance and power cost plus the annualized project cost. The annualized project cost is equal to the total project cost multiplied by a capital recovery factor of 0.10979 which is based on an interest rate of 7% and an expected project life of 15 years.

The benefit-cost ratio was calculated by dividing the annual savings by the difference between the after highway cost and the before highway cost. It should be noted that many other savings which were difficult to quantify in the scope of this study should be considered when examining the benefit cost ratio of each project. Some examples of these savings might include; reduction in accidents, and fewer maintenance calls initially.

Project Evaluations

The before and after evaluation of each of the nineteen (19) demonstration projects of the Iowa Motor Vehicle Fuel Reduction Program has resulted in the computation of a benefit-cost ratio for each project. The following pages document the results of that evaluation on a project by project basis.

ALGONA

PROJECT LOCATION:

South Phillips Street (U.S. 169) & McGregor Street

South Phillips Street is a north-south four lane highway which is designated as U.S. 169 through the City. McGregor Street is a two lane arterial which crosses the south side of the City of Algona. Traffic volumes are approximately 6,300 vehicles per day on South Phillips and 3,700 vehicles per day on McGregor.

PROJECT DESCRIPTION:

The project included the replacement of an electro-mechanical pretimed controller with a solid state, NEMA type, fully actuated controller and cabinet to provide traffic responsive operations at the signal location. A total of 4 new detector amplifiers and 12 new vehicle detector loops were installed at the intersection. A total of 4 new "Walk", "Don't Walk" pedestrian signal heads were installed with the appropriate push button actuation for pedestrian traffic needs. The final project cost was $14,114.

BEFORE / AFTER STUDY RESULTS:

The before and after intersection delay studies were performed during the AM, OFF, and PM peak hour travel periods. The data was analyzed with the results shown in the following table.

COST FACTOR	BEFORE	AFTER
Daily Stops	5,113	4,727
Daily Delay (veh-hrs)	12.5	8.5
Daily Fuel Use (gals)	6.7	4.6

BENEFIT-COST ANALYSIS:

ANNUAL ROAD USER COSTS

COST FACTOR	BEFORE	AFTER	SAVINGS
Annual Stops (1,000 stops)	1534	1418	116
Annual Cost ($0.0145 / stop)	$22,243	$20,561	$1,682
Annual Delay (1,000 veh-hrs)	3.75	2.54	1.21
Annual Cost ′$0.313 / veh-hr)	$1,174	$795	$379
Annual Fuel Use (1,000 gals)	2.02	1.37	0.65
Annual Cost ($1.00 / gal)	$2,020	$1,370	$650
ROAD USER SAVINGS			$2,711

ANNUAL HIGHWAY COST

	BEFORE	AFTER
Signal Maintenance & Power ($1500 per signal)	$1,500	$1,500
Project Cost		$14,114
Annual Cost (CRF = 0.10979)		$1,550
HIGHWAY COST TOTAL	$1,500	$3,050

BENEFIT COST RATIO

$$\frac{B}{C} = \frac{\text{Annual Road User Savings}}{\text{(Ann. Project Cost - Ann. Maint.)}} = \frac{\$2,711}{\$3,050 - \$1,500} = 1.75$$

REMARKS:

The before and after study of this project demonstrates that improvements at the signal location will save motorists approximately 650 gallons of fuel per year. Savings will also be realized by the reduction of stops and delay time at the intersection.

AMES

PROJECT LOCATION:

Lincoln Way, Duff Avenue, and Grand Avenue Arterials

Lincoln Way is a major east-west, four lane arterial with 18 signalized intersections. All of the signals along the arterial were improved from Duff Avenue westerly to North Dakota Avenue. Traffic volumes on the route range between approximately 11,000 vehicles per day (vpd) to 24,000 vpd.

Duff Avenue is a north-south, four lane arterial facility and is designated as U.S. Highway 69 through a portion of the City. The project included improvements at 5 signalized locations from South 5th Street (south end) to 6th Street (north end). Approximately 20,000 vpd use the route.

Grand Avenue is a north-south, four lane, arterial facility. It serves as the continuation of U.S. Highway 69 northerly from its intersection with Lincoln Way. The improvements included 3 signal locations between 6th Street and 13th Street. Approximately 15,000 vpd use the route.

PROJECT DESCRIPTION:

The project included the installation of computerized traffic responsive on-street arterial master controls with remote dial-up control capabilities (Closed Loop System). A total of 25 new actuated system controllers were installed at the signal locations along each of the routes. A new on-street master controller was installed and connected to the system controllers with 25,000 feet of communications cable placed in conduit. A micro-computer was installed at the public works department to complete the system. The final project cost was $160,375.

BEFORE / AFTER STUDY RESULTS:

The before and after travel time studies were performed during the AM, OFF, and PM peak hour travel periods. A minimum of 5 travel time runs were completed in each direction of travel during each peak travel interval. Data from all of the three study routes was analyzed with the results shown in the following table.

COST FACTOR	BEFORE	AFTER
Daily Stops	117,942	104,157
Daily Delay (veh-hrs)	643.3	438.2
Daily Fuel Use (gals)	4.031.1	3,938.5
Daily Travel Time (veh-hrs)	2,696.9	2,527.4

BENEFIT-COST ANALYSIS:

ANNUAL ROAD USER COSTS

COST FACTOR	BEFORE	AFTER	SAVINGS
Annual Stops (1,000 stops)	35,383	31,247	4,136
Annual Cost ($0.0145 / stop)	$ 513,054	$ 453,082	$ 59,972
Annual Delay (1,000 veh-hrs)	193.0	131.5	61.5
Annual Cost ($0.313 / veh-hr)	$ 60,409	$ 41,160	$ 19,249
Annual Fuel Use (1,000 gals)	1,209.3	1,181.6	27.7
Annual Cost ($1.00 / gal)	$1,209,300	$1,181,600	$ 27,700
Annual Travel Time (1,000 veh-hrs)	809.1	758.2	50.9
Annual Cost ($3.35 / veh-hr)	$2,710,485	$2,539,970	$170,515
ROAD USER SAVINGS			$277,436

ANNUAL HIGHWAY COST

	BEFORE	AFTER
Signal Maintenance & Power ($1500 per signal)	$ 39,000	$ 39,000
Project Cost		$ 160,375
Annual Cost (CRF = 0.10979)		$ 17,608
HIGHWAY COST TOTAL	$ 39,000	$ 56,608

BENEFIT COST RATIO

$$\frac{B}{C} = \frac{\text{Annual Road User Savings}}{\text{(Ann. Project Cost - Ann. Maint.)}} = \frac{\$277{,}436}{\$56{,}608-\$39{,}000} = 15.76$$

REMARKS:

The before and after evaluation of this project demonstrates that installation of the "Closed Loop System" will save motorists approximately 28,000 gallons of fuel per year. Savings of nearly $250,000 per year will also be realized by the reduction of stops, delay, and travel time.

ATLANTIC

PROJECT LOCATION:

7th Street (U.S. Highway 6) Arterial

The 7th Street Arterial, which is designated as U.S. 6 through the City, consists of 7 signalized intersections beginning at Whitney Street, westerly to Poplar Street. The arterial provides four traffic lanes from Whitney Street to Hospital Drive, and two through lanes with a two-way left turn lane (TWLTL) for the roadway segments from Hospital Drive to Olive Street and from Walnut Street to Poplar Street. Traffic volumes along the route are approximately 12,000 vehicles per day.

PROJECT DESCRIPTION:

The project included the installation of computerized traffic responsive on-street arterial master controls with remote dial-up control capabilities (Closed Loop System). The arterial was divided into two systems. The first was an actuated system consisting of 4 signal locations from Whitney to Olive. A total of 4 new NEMA type, actuated system controllers, 2 new controller cabinets and a master controller were installed.

The second was a pretimed system which consisted of 3 signal locations from Walnut to Poplar. A total of 3 new NEMA type, pre-timed system controllers with cabinets and a new master controller were installed Communications cable and sampling detectors (15) were installed and connected to the master controllers for both systems. The system was completed with the installation of a micro-computer at the City Hall. The final project cost was $117,778.

BEFORE / AFTER STUDY RESULTS:

The before and after travel time studies were performed during the AM, OFF, and PM peak hour travel periods. Travel time runs were completed in each direction of travel on the arterial during each peak travel interval. The data for the arterial was analyzed with the results shown in the following table.

COST FACTOR	BEFORE	AFTER
Daily Stops	21,345	17,367
Daily Delay (veh-hrs)	70.6	44.4
Daily Fuel Use (gals)	880.1	847.8
Daily Travel Time (veh-hrs)	552.7	498.5

BENEFIT-COST ANALYSIS:

ANNUAL ROAD USER COSTS

COST FACTOR	BEFORE	AFTER	SAVINGS
Annual Stops (1,000 stops)	6,404	5,210	1,194
Annual Cost ($0.0145 / stop)	$ 92,858	$ 75,545	$ 17,313
Annual Delay (1,000 veh-hrs)	21.2	13.3	7.9
Annual Cost ($0.313 / veh-hr)	$ 6,636	$ 4,163	$ 2,473
Annual Fuel Use (1,000 gals	264.0	254.3	9.7
Annual Cost ($1.00 / gal)	$ 264,000	$ 254,300	$ 9,700
Annual Travel Time (1,000 veh-hrs)	165.8	149.6	16.2
Annual Cost '$3.35 / veh-hr)	$ 555,430	$ 501,160	$ 54,270
ROAD USER SAVINGS			$ 83,756

ANNUAL HIGHWAY COST

Signal Maintenance & Power ($1500 per signal)	$ 10,500	$ 10,500
Project Cost		$ 117,778
Annual Cost (CRF = 0.10979)		$ 12,931
HIGHWAY COST TOTAL	$ 10,500	$ 23.431

BENEFIT COST RATIO

$$\frac{B}{C} = \frac{\text{Annual Road User Savings}}{\text{(Ann. Project Cost - Ann. Maint.)}} = \frac{\$ 83,756}{\$23,431-\$10,500} = 6.48$$

REMARKS:

The before and after evaluation of this project demonstrates that the installation of the closed loop systems will save motorists approximately 9,700 gallons of fuel per year. Additional savings of nearly $75,000 will be realized by the reduction of stops, delay and travel time to motorists using the system.

BETTENDORF

PROJECT LOCATION:

Ten Isolated Signalized Intersections

The City improved 10 isolated signalized intersections. A total sample of 3 intersections were chosen for the study analysis; 13th Street and Grant Street. 14th Street and State Street, and 18th Street and Tanglefoot Lane.

13th Street is a one-way southbound, 3 lane arterial which also serves traffic exiting I-74. Grant Street is a one-way westbound, 4 lane arterial. Approximately 12,000 vehicles per day (vpd) use 13th while 10,000 vpd use Grant.

14th Street is a one-way northbound, 3 lane exit ramp from I-74 and State Street is a one-way eastbound, 3 lane arterial. Approximately 12,000 vpd use 14th and 11,000 vpd use State.

18th Street and Tanglefoot Lane are multilane facilities with traffic volumes of approximately 6,500 vpd on each route.

PROJECT DESCRIPTION:

The project included the installation of loop detectors and loop detector amplifiers, with and without delay capabilities, to improve intersection operations. 13th Street and Grant Street was a pretimed signal which was upgraded to a semi-actuated signal by installing 3 detector amplifiers (1 with right turn delay) and 6 detector loops on 13th Street. 14th Street and State Street was a pretimed signal which was upgraded to a semi-actuated signal by installing 3 detector amplifiers (1 with right turn delay) and 6 detector loops on 14th Street. 18th Street and Tanglefoot Lane was a semi-actuated signal which was upgraded to a fully-actuated signal by installing 5 detector amplifiers and 10 detector loops at the intersection. The project cost for the 3 study intersections was $17,440. (The total project cost for all 10 intersections was $43,371.)

BEFORE / AFTER STUDY RESULTS:

The before and after intersection delay studies were performed during the AM, OFF, and PM peak hour travel periods. Data from all of the 3 study intersections was analyzed with the results shown in the following table.

COST FACTOR	BEFORE	AFTER
Daily Stops	16,620	16,847
Daily Delay (veh-hrs)	27.3	40.7
Daily Fuel Use (gals)	14.7	40.7

BENEFIT-COST ANALYSIS:

ANNUAL ROAD USER COSTS

COST FACTOR	BEFORE	AFTER	SAVINGS
Annual Stops (1,000 stops)	4,986	5,054	0
Annual Cost ($0.0145 / stop)	$ 72,297	$ 73,283	$ 0
Annual Delay (1,000 veh-hrs)	8.2	12.2	0
Annual Cost ($0.313 / veh-hr)	$ 2,567	$ 3,819	$ 0
Annual Fuel Use (1,000 gals)	4.4	6.6	0
Annual Cost ($1.00 / gal)	$ 4,400	$ 6,600	$ 0
ROAD USER SAVINGS			$ 0

ANNUAL HIGHWAY COST

Signal Maintenance & Power ($1500 per signal)	$ 4,500	$ 4,500
Project Cost		$ 17,440
Annual Cost (CRF = 0.10979)		$ 1,915
HIGHWAY COST TOTAL	$ 4,500	$ 6,415

BENEFIT COST RATIO

$$\frac{B}{C} = \frac{\text{Annual Road User Savings}}{\text{(Ann. Project Cost - Ann. Maint.)}} = \frac{\$\ 0}{\$\ 6{,}415 - \$\ 4.500} = 0$$

REMARKS:

The before and after study of the improvements at the study locations did not demonstrate any savings, however the study included only 3 of the 10 intersections included in the project. The type of improvements made as part of the demonstration project would be more beneficial to motorists during the light traffic periods of early morning and late evening which were not studied as part of the project evaluation.

COUNCIL BLUFFS

PROJECT LOCATION:

East Broadway Arterial

The East Broadway Arterial consists of 13 signalized intersections beginning at 8th Street easterly to North Avenue. The arterial is a four lane roadway which passes through the central business district of the City. Traffic volumes range from approximately 12,000 vehicles per day (vpd) to 16,000 vpd.

PROJECT DESCRIPTION:

The project included the installation of computerized traffic responsive on-street arterial master controls with remote dial-up control capabilities (Closed Loop System). A total of 11 new actuated system controllers and 9 cabinets were installed at the signal locations. Each signal location is operating semi-traffic actuated control. For pedestrian activity needs 72 pedestrian pushbuttons were installed along the route. A new on-street master controller was installed and connected to the system controllers with the placement of new communications cable. Various sampling detectors were installed throughout the arterial for traffic data collection purposes. A micro-computer was installed at the public works department to complete the system. The final project cost was $128,271.

BEFORE / AFTER STUDY RESULTS:

The before and after travel time studies were performed during the AM, OFF, and PM peak hour travel periods. A minimum of 5 travel time runs were completed in each direction of travel during each peak travel interval. Data from the arterial was analyzed with the results shown in the following table.

COST FACTOR	BEFORE	AFTER
Daily Stops	46,400	40,550
Daily Delay (veh-hrs)	205.6	180.2
Daily Fuel Use (gals)	1,070.3	1,036.7
Daily Travel Time (veh-hrs)	789.3	731.6

BENEFIT-COST ANALYSIS:

ANNUAL ROAD USER COSTS

COST FACTOR	BEFORE	AFTER	SAVINGS
Annual Stops (1,000 stops)	13,920	12,165	1,755
Annual Cost ($0.0145 / stop)	$ 201,840	$ 176,393	$ 25,447
Annual Delay (1,000 veh-hrs)	61.7	54.1	7.6
Annual Cost ($0.313 / veh-hr)	$ 19,312	$ 16,933	$ 2,379
Annual Fuel Use (1,000 gals)	321.1	311.0	10.1
Annual Cost ($1.00 / gal)	$ 321,100	$ 311,000	$ 10,100
Annual Travel Time (1,000 veh-hrs)	236.8	219.5	17.3
Annual Cost ($3.35 / veh-hr)	$ 793,280	$ 735,325	$ 57,955
ROAD USER SAVINGS			$ 95,881

ANNUAL HIGHWAY COST

Signal Maintenance & Power ($1500 per signal)	$ 21,000	$ 21,000
Project Cost		$ 128,271
Annual Cost (CRF = 0.10979)		$ 14,083
HIGHWAY COST TOTAL	$ 21,000	$ 35,083

BENEFIT COST RATIO

$$\frac{B}{C} = \frac{\text{Annual Road User Savings}}{\text{(Ann. Project Cost - Ann. Maint.)}} = \frac{\$ 95,881}{\$35,083-\$21,000} = 6.81$$

REMARKS:

The before and after evaluation of this project demonstrates that installation of the closed loop system will save motorists approximately 10,000 gallons of fuel per year. Additional savings of nearly $86,000 per year will also be realized by the reduction of stops, delay, and travel time.

DECORAH

PROJECT LOCATION:

Water Street Arterial

Water Street is a two lane arterial which is the main street in the Decorah central business district. There are 7 signalized intersections which were improved as part of this project beginning with Mill Street continuing easterly to State Street. The speed limit on the arterial is 20 mph and traffic volumes are approximately 6,000 vehicles per day.

PROJECT DESCRIPTION:

The project included the installation of computerized traffic responsive arterial master controls with remote dial-up control capabilities (Closed Loop System). A total of 7 new solid state system controllers replaced the existing electromechanical pre-timed controllers at each signal location. A master controller was installed at the Police Station along with a micro-computer to complete the system. Interconnect cable was placed to provide communication between the master and system local controllers. The system controllers are operating in a pretimed mode so the system can perform with fixed cycle length timing plans. The final project cost was $120,473.

BEFORE / AFTER STUDY RESULTS:

The before and after travel time studies were performed during the AM, OFF, and PM peak hour travel periods. Travel Time runs were completed in each direction of travel on the arterial during each peak travel interval. Data from the arterial was analyzed with the results shown in the following table.

COST FACTOR	BEFORE	AFTER
Daily Stops	18,925	8,550
Daily Delay (veh-hrs)	49.9	23.4
Daily Fuel Use (gals)	159.1	138.8
Daily Travel Time (veh-hrs)	154.6	121.0

BENEFIT-COST ANALYSIS:

ANNUAL ROAD USER COSTS

COST FACTOR	BEFORE	AFTER	SAVINGS
Annual Stops (1,000 stops)	5,678	2,565	3.113
Annual Cost ($0.0145 / stop)	$ 82,331	$ 37,193	$ 45,138
Annual Delay (1,000 veh-hrs)	15.0	7.0	8.0
Annual Cost ($0.313 / veh-hr)	$ 4,695	$ 2,191	$ 2,504
Annual Fuel Use (1,000 gals)	47.7	41.6	6.1
Annual Cost ($1.00 / gal)	$ 47,700	$ 41,600	$ 6,100
Annual Travel Time (1,000 veh-hrs)	46.4	36.3	10.1
Annual Cost ($3.35 / veh-hr)	$ 155,440	$ 121,605	$ 33,835
ROAD USER SAVINGS			$ 87,577

ANNUAL HIGHWAY COST

Signal Maintenance & Power ($1500 per signal)	$ 10,500	$ 10,500
Project Cost		$ 120,473
Annual Cost (CRF = 0.10979)		$ 13,227
HIGHWAY COST TOTAL	$ 10,500	$ 23.727

BENEFIT COST RATIO

$$\frac{B}{C} = \frac{\text{Annual Road User Savings}}{\text{(Ann. Project Cost - Ann. Maint.)}} = \frac{\$ 87,577}{\$23.727-\$10,500} = 6.62$$

REMARKS:

The before and after evaluation of this project demonstrates that installation of the "Closed Loop System" will save motorists approximately 6,000 gallons of fuel per year. Additional savings of nearly $81,000 per year will also be realized by the reduction of stops, delay, and travel time.

DES MOINES

PROJECT LOCATION:

40 Isolated Signalized Intersections
Eastside Signal System
East University Signal System
Southeast 14th Signal System

A total of 40 isolated signalized intersections located throughout the City were included in the project. These locations included pretimed, semi-traffic actuated, and fully actuated controlled signals on major arterials which carry up to 20,000 vehicles per day (vpd).

The Eastside Signal System is a grid network consisting of 19 signalized intersections. The majority of the signal locations are on East 14th Street, East 15th Street, and Grand Avenue near the State Capitol area. Traffic volumes on the system range from approximately 7,000 vpd to 20,000 vpd.

The East University Signal System is an arterial network consisting of 5 signalized intersections on University Avenue from East 21st easterly to East 33rd and 2 signalized intersections on East 30th Street. Traffic volumes on the system range from approximately 11,000 vpd on East 30th Street to 28,000 vpd on University Avenue.

The Southeast 14th Signal System is an arterial network consisting of 8 signalized intersections on SE 14th from Army Post Road northerly to Maury, 2 signalized intersections on Army Post Road at SouthRidge Mall and SE 5th, and 4 signalized intersections on Indianola Road from Park northerly to SE 1st. Traffic volumes on the system range from approximately 15,000 vpd on Indianola Road to 27,000 vpd on Army Post Road to 37,000 vpd on SE 14th.

PROJECT DESCRIPTION:

Isolated Intersections . . . This portion of the project included the installation of 3 Type 170, fully actuated signal controllers and cabinets to upgrade 3 pretimed intersections to fully actuated control. A total of 22 loop detector amplifiers at 8 intersections were installed to upgrade from semi-traffic actuated to fully actuated control. Additional work at the 11 intersections included the installation of loop detectors, conduit and handholes. Manual turning movement counts were taken during AM, OFF, and PM peak travel period hours at all of the intersections. These counts were analyzed and used to develop new signal timing plans at each of the 40 intersections. A sample of 19 intersections were randomly selected for the study analysis. The project cost for the study intersections (19) was $139,930. The total project cost for all 40 of the intersections was approximately $172,021.

Eastside Signal Systems . . . This part of the project included performing manual turning movement counts during AM, OFF, and PM peak travel hours at all of the signalized intersections in the system. These counts were analyzed and used to develop new signal timing plans and coordination offsets for the 19 intersections in the system. A timing plan was developed for each of the peak travel period intervals. The project cost for this part of the project was $11,321.

East University System . . . The East University system is one of four arterial signal systems in the City's "Closed Loop System". Manual turning movement counts during AM, OFF, and PM peak travel hours were collected at the 7 intersections. These counts were analyzed and used to develop new signal timing plans and coordination offsets for the signal locations. A total of 9 system timing plans were developed based upon directionality and volume of traffic in the system. The project cost for this part of the project was $7,514.

SE 14th System . . . The SE 14th System is another one of the arterial signal systems in the City's "Closed Loop System". Manual turning movement counts during AM, OFF, and PM peak travel hours were collected at the 15 intersections. These counts were analyzed and used to develop new signal timing plans and coordination offsets for the signal locations. A total of 9 system timing plans were developed based upon directionality and volume of traffic in the system. The project cost for this part of the project was $8,496.

The project cost subtotal of the study intersections was $167,261. The entire project cost for all of the intersections was $199,352.

BEFORE/AFTER STUDY RESULTS:

The before and after intersection delay studies were performed at each of the 19 sample isolated intersections during AM, OFF, and PM peak hour travel periods. The before and after travel time studies were performed on selected routes in the Eastside grid system and on the two arterial systems (East University and SE 14th Street). Travel time runs were made in each direction during the AM, OFF, and PM peak hour travel periods. Data from all of the study locations was analyzed with the results shown in the following table.

COST FACTOR	BEFORE	AFTER
Daily Stops	114,630	97,846
Daily Delay (veh-hrs)	616.4	516.2
Daily Fuel Use (gals)	7,956.0	7,895.7
Daily Travel Time (veh-hrs)	4,426.0	4,282.8

BENEFIT-COST ANALYSIS:

ANNUAL ROAD USER COSTS

COST FACTOR	BEFORE	AFTER	SAVINGS
Annual Stops (1,000 stops)	34,389	29,246	5,143
Annual Cost ($0.0145 / stop)	$ 498,641	$ 424,067	$ 74,574
Annual Delay (1,000 veh-hrs)	184.9	154.9	30.0
Annual Cost ($0.313 / veh-hr)	$ 57,874	$ 48,484	$ 9,390
Annual Fuel Use (1,000 gals)	2,386.8	2.368.7	18.1
Annual Cost ($1.00 / gal)	$2,386,800	$2,368,700	$ 18,100
Annual Travel Time (1,000 veh-hrs)	1,327.8	1.284.8	43.0
Annual Cost ($3.35 / veh-hr)	$4,448.130	$4,304,080	$144,050
ROAD USER SAVINGS			$246,114

ANNUAL HIGHWAY COST

Signal Maintenance & Power ($1500 per signal)	$ 90,000	$ 90,000
Project Cost		$ 167,261
Annual Cost (CRF = 0.10979)		$ 18,364
HIGHWAY COST TOTAL	$ 90,000	$ 108,364

BENEFIT COST RATIO

$$\frac{B}{C} = \frac{\text{Annual Road User Savings}}{\text{(Ann. Project Cost - Ann. Maint.)}} = \frac{\$246,114}{\$108,364 - \$90,000} = 13.40$$

REMARKS:

The before and after study of this project demonstrates that the improvements of the entire project will save motorists approximately 18,000 gallons of fuel per year and additional savings of nearly $228.000 due to reduced stops, delay, and travel time. However, it is important to note savings of the individual portions of the project.

Isolated Intersections. . . The studies performed at the 19 sample intersections demonstrated that the improvements at the locations resulted in only $250 of savings per year due to a reduction in stops. Delay and fuel consumption displayed no improvement. However, the study included only 19 of the 40 intersections and the improvements made might be more beneficial to motorists during lighter traffic periods which were not studied.

Eastside Signal System. . . The study of the timing improvements on the system demonstrated approximately $29,000 of savings per year due to a reductions of stops, delay, and travel time. Fuel consumption displayed no improvement. If these savings were used to calculate a B/C ratio for the Eastside System, (based upon an annual project cost of $1,243), the result would be 23.

East University Signal System. . . The study of the timing improvements on the system demonstrated that motorists will save approximately 27,600 gallons of fuel per year. Additional savings of nearly $265,000 will be realized by the reduction of stops, delay, and travel time. If these savings were used to calculate a B/C ratio for the East University system, (based on an annual project cost of $825), the result would be 355.

S.E. 14th Signal System. . . The study of the timing improvements on the system demonstrated that motorists will save approximately $3,500 per year in reduced delay. Stops, fuel consumption, and travel time displayed no improvement. If these savings were used to calculate a B/C ratio for the S.E. 14th System, (based on an annual project cost of $933), the result would be 4. The low B/C ratio for the S.E. 14th System as compared to the other systems suggests that the existing timing plans were operating satisfactorily.

DES MOINES / URBANDALE

PROJECT LOCATION:

Merle Hay Road and Douglas Avenue Arterials

Merle Hay Road is a major north-south, four lane arterial with 8 signalized intersections. All of the signal locations were improved from Hickman Road northerly to the North Ramp of the I-80/35 interchange. Traffic volumes on the arterial range between approximately 25,000 vehicles per day (vpd) to 36,000 vpd.

Douglas Avenue is a east-west, four lane arterial which intersects Merle Hay Road. There are 2 signalized intersections on Douglas, west of Merle Hay, Road, which were included in the system. Approximately 21,000 vpd use Douglas Avenue.

PROJECT DESCRIPTION:

The project included the installation of computerized traffic responsive on-street arterial master controls with remote dial-up control capabilities (Closed Loop System). A total of 7 new Type 170, fully actuated, solid state system controllers and cabinets were installed at signal locations on Merle Hay Road. Existing controllers were used at 1 intersection on Merle Hay and at the 2 intersections on Douglas Avenue. A new on-street master controller was installed and the necessary communications cable from all 10 system controllers was connected to the master. The closed loop system will use an existing micro-computer at the City of Des Moines. The final project cost was $339,619.

BEFORE / AFTER STUDY RESULTS:

The before and after travel time studies were performed during the AM, OFF, and PM peak hour travel periods. A minimum of 5 travel time runs were completed in each direction of travel during each peak travel interval. Data collected along the two study routes was analyzed with the results shown in the following table.

COST FACTOR	BEFORE	AFTER
Daily Stops	127,587	46,753
Daily Delay (veh-hrs)	531	232
Daily Fuel Use (gals)	3,492	3,235
Daily Travel Time (veh-hrs)	2,279	1,835

BENEFIT-COST ANALYSIS:

ANNUAL ROAD USER COSTS

COST FACTOR	BEFORE	AFTER	SAVINGS
Annual Stops (1,000 stops)	38,276	14,026	24,250
Annual Cost ($0.0145 / stop)	$ 555,002	$ 203,377	$351,625
Annual Delay (1,000 veh-hrs)	159.3	69.6	89.7
Annual Cost ($0.313 / veh-hr)	$ 49,861	$ 21.785	$ 28,076
Annual Fuel Use (1,000 gals)	1,047.6	470.5	77.1
Annual Cost ($1.00 / gal)	$1,047,600	$ 970,500	$ 77,100
Annual Travel Time (1,000 veh-hrs)	683.7	550.5	133.2
Annual Cost ($3.35 / veh-hr)	$2,290,395	$1.844,175	$446,220
ROAD USER SAVINGS			$903.021

ANNUAL HIGHWAY COST

Signal Maintenance & Power ($1,500 per signal)	$ 15,000	$ 15,000
Project Cost		$ 339,619
Annual Cost (CRF = 0.10979)		$ 37,287
HIGHWAY COST TOTAL	$ 15,000	$ 52.287

BENEFIT COST RATIO

$$\frac{B}{C} = \frac{\text{Annual Road User Savings}}{\text{(Ann. Project Cost - Ann. Maint.)}} = \frac{\$903,021}{\$52,287-\$15,000} = 24.22$$

REMARKS:

The before and after evaluation of this project demonstrates that the installation of the necessary equipment to make the arterials' signalization compatible with the City's existing "Closed Loop System" will save motorists approximately 77,000 gallons of fuel per year. Additional savings of nearly $825,000 will be realized by the reduction of stops, delay, and travel time.

INDIANOLA

PROJECT LOCATION:

Jefferson Way (U.S. 65/69) Arterial

Jefferson Way is a four lane arterial which is designated as U.S. Highway 65 and U.S. Highway 69 through the City. There are 5 signalized intersections along the route from East Second Avenue northerly to Iowa Avenue. Approximately 19,000 vehicles per day use the route.

PROJECT DESCRIPTION:

The project included the installation of a time-based coordinated, fully actuated signal system. A total of 4 new NEMA type, fully actuated, solid state signal controllers and cabinets were installed at all but one of the signal locations. New detector loops were installed at each intersection to replace old, malfunctioning loops. The existing 2 phase signal operation at East Second was replaced with 4 phase signal operation which required 2 new 5-section signal heads. The new phasing provides better service to heavy eastbound and southbound left turn volumes. A pushbutton was installed at the fire station to provide for emergency vehicle preemption at Ashland Avenue and Jefferson Way. The final project cost was $58,686.

BEFORE / AFTER STUDY RESULTS:

The before and after travel time studies were performed during the AM, OFF, and PM peak hour travel periods. Travel time runs were completed in each direction of travel along the arterial during each peak travel interval. Data from the evaluation studies was analyzed with the results shown in the following table.

COST FACTOR	BEFORE	AFTER
Daily Stops	31,609	10,734
Daily Delay (veh-hrs)	96.2	35.6
Daily Fuel Use (gals)	670.0	611.5
Daily Travel Time (veh-hrs)	469.8	372.6

BENEFIT-COST ANALYSIS:

ANNUAL ROAD USER COSTS

COST FACTOR	BEFORE	AFTER	SAVINGS
Annual Stops (1,000 stops)	9,483	3,220	6,263
Annual Cost ($0.0145 / stop)	$ 137,504	$ 46,690	$ 90,814
Annual Delay (1,000 veh-hrs)	28.9	10.7	18.2
Annual Cost ($0.313 / veh-hr)	$ 9,046	$ 3,349	$ 5,697
Annual Fuel Use (1,000 gals)	201.0	183.5	17.5
Annual Cost ($1.00 / gal)	$ 201,000	$ 183,500	$ 17,500
Annual Travel Time (1,000 veh-hrs)	140.9	111.8	29.1
Annual Cost ($3.35 / veh-hr)	$ 472,015	$ 374,530	$ 97,485
ROAD USER SAVINGS			$211,496

ANNUAL HIGHWAY COST

Signal Maintenance & Power ($1,500 per signal)	$ 7,500	$ 7,500
Project Cost		$ 58,686
Annual Cost (CRF = 0.10979)		$ 6,443
HIGHWAY COST TOTAL	$ 7,500	$ 13,943

BENEFIT COST RATIO

$$\frac{B}{C} = \frac{\text{Annual Road User Savings}}{(\text{Ann. Project Cost} - \text{Ann. Maint.})} = \frac{\$211,496}{\$13.943 - \$7,500} = 32.83$$

REMARKS:

The before and after evaluation study of this project demonstrates that the installation of a signal system utilizing time-based coordination will save motorists approximately 17,500 gallons of fuel per year. Additional savings of nearly $195,000 will be realized by the reduction of stops, delay, and travel time.

IOWA CITY

PROJECT LOCATION:

U.S. Highway 6 Arterial

U.S. Highway 6 is a east-west, divided four lane arterial which has 8 signalized intersections. All of the intersections beginning with Riverside Drive easterly to Fairmeadows Avenue were included in the project. Traffic volumes on the route range between 9,000 vehicles per day (vpd) to 26,000 vpd.

PROJECT DESCRIPTION:

The project included the installation of computerized traffic responsive on-street arterial master controls with remote dial-up control capabilities (Closed Loop System). A total of 8 new fully actuated, solid state system controllers were installed at the signal locations. A new master controller was installed at the City Traffic Engineering Department which is located adjacent to the Riverside Drive intersection. Interconnect cable was installed to link the system controllers to the master controller. A microcomputer was installed at the Traffic Engineering Department to complete the system. The final project cost was $119,554.

BEFORE / AFTER STUDY RESULTS:

The before and after travel time studies were performed during the AM, OFF, and PM peak hour travel periods. Travel time runs were completed in each direction of travel on the arterial during each peak travel interval. Evaluation data for the arterial was analyzed with the results shown in the following table.

COST FACTOR	BEFORE	AFTER
Daily Stops	65,127	32,018
Daily Delay (veh-hrs)	309.0	152.8
Daily Fuel Use (gals)	2,199.5	2,058.2
Daily Travel Time (veh-hrs)	1,373.7	1,128.3

BENEFIT-COST ANALYSIS:

ANNUAL ROAD USER COSTS

COST FACTOR	BEFORE	AFTER	SAVINGS
Annual Stops (1,000 stops)	19,538	9,605	9,933
Annual Cost ($0.0145 / stop)	$ 283,301	$ 139,273	$144,028
Annual Delay (1,000 veh-hrs)	92.7	45.8	46.9
Annual Cost ($0.313 / veh-hr)	$ 29,015	$ 14,335	$ 14,680
Annual Fuel Use (1,000 gals)	659.9	617.5	42.4
Annual Cost ($1.00 / gal)	$ 659,900	$ 617,500	$ 42,400
Annual Travel Time (1,000 veh-hrs)	412.1	338.5	73.6
Annual Cost ($3.35 / veh-hr)	$1,380,535	$1,133,975	$246,560
ROAD USER SAVINGS			$447,668

ANNUAL HIGHWAY COST

Signal Maintenance & Power ($1,500 per signal)	$ 12,000	$ 12,000
Project Cost		$ 119,554
Annual Cost (CRF = 0.10979)		$ 13,126
HIGHWAY COST TOTAL	$ 12,000	$ 25,126

BENEFIT COST RATIO

$$\frac{B}{C} = \frac{\text{Annual Road User Savings}}{\text{(Ann. Project Cost - Ann. Maint.)}} = \frac{\$447{,}668}{\$25{,}126 - \$12{,}000} = 34.11$$

REMARKS:

The before and after evaluation of this project demonstrates that the installation of a "Closed Loop System" will save motorists approximately 42,700 gallons of fuel per year. Additional savings of nearly $405,000 will be realized by the reduction of stops, delay, and travel time.

MASON CITY

PROJECT LOCATION:

U.S. Highway 18 Arterial

The U.S. 18 arterial consists of 7 signalized intersections from Eisenhower Avenue easterly to Beaumont Drive. The arterial is a divided four lane highway from Eisenhower to Winnebago Way and a four lane arterial from Winnebago Way to Beaumont Drive. Traffic volumes on the arterial range between 16,000 vehicles per day (vpd) to 21,000 vpd.

PROJECT DESCRIPTION:

The project included the installation of computerized traffic responsive on-street arterial master controls with remote dial-up control capabilities (Closed Loop System). A total of 6 new solid state, fully actuated system controllers and 4 new cabinets were installed at the signal locations. The remaining signal location was installed and funded by a previous City project. A new on-street master controller was installed and connected to the system controllers with approximately 12,000 feet of communications cable. A micro-computer was installed at City Hall to complete the system. The final project cost was $84,002.

BEFORE / AFTER STUDY RESULTS:

Before and after travel time studies were performed during the AM, OFF, and PM peak hour travel periods. Travel time runs were completed in each direction of travel along the arterial during each peak travel interval. Evaluation data for the arterial was analyzed with the results as shown in the following table.

COST FACTOR	BEFORE	AFTER
Daily Stops	47,693	17,045
Daily Delay (veh-hrs)	110.4	68.0
Daily Fuel Use (gals)	1,776.5	1,732.5
Daily Travel Time (veh-hrs)	969.1	897.4

BENEFIT-COST ANALYSIS:

ANNUAL ROAD USER COSTS

COST FACTOR	BEFORE	AFTER	SAVINGS
Annual Stops (1,000 stops)	14,308	5,114	9,194
Annual Cost ($0.0145 / stop)	$ 207,466	$ 74,153	$133,313
Annual Delay (1,000 veh-hrs)	33.1	20.4	12.7
Annual Cost ($0.313 / veh-hr)	$ 10,360	$ 6,385	$ 3,975
Annual Fuel Use (1,000 gals)	533.0	519.8	13.2
Annual Cost ($1.00 / gal)	$ 533,000	$ 519,800	$ 13,200
Annual Travel Time (1,000 veh-hrs)	290.7	269.2	21.5
Annual Cost ($3.35 / veh-hr)	$ 973,845	$ 901,820	$ 72,025
ROAD USER SAVINGS			$222,513

ANNUAL HIGHWAY COST

Signal Maintenance & Power ($1,500 per signal)	$ 10,500	$ 10,500
Project Cost		$ 84,002
Annual Cost (CRF = 0.10979)		$ 9,223
HIGHWAY COST TOTAL	$ 10,500	$ 19,723

BENEFIT COST RATIO

$$\frac{B}{C} = \frac{\text{Annual Road User Savings}}{\text{(Ann. Project Cost - Ann. Maint.)}} = \frac{\$222,513}{\$19,723 - \$10,500} = 24.13$$

REMARKS:

The before and after evaluation of this project demonstrates that the installation of a closed loop system will save motorists approximately 13,000 gallons of fuel per year. Additional savings of nearly $209,000 will be realized by the reduction of stops, delay, and travel time.

MONTICELLO

PROJECT LOCATION:

Main Street (U.S. 151) & 1st Street
Cedar Street (IA 38) & 1st Street

Main Street is a north-south two lane highway which is designated as U.S. 151 through the City. Approximately 10,000 vehicles per day (vpd) use Main Street.

Cedar Street is a north-south two lane highway which is designated as Iowa 38 through the City. Approximately 8,000 vpd use Cedar Street.

1st Street is an east-west two lane arterial which serves the central business district (CBD) in the City. Approximately 7,500 vpd use 1st Street. Both intersections are signalized locations.

PROJECT DESCRIPTION:

The project included the installation of traffic responsive signal operations at each intersection location. At Main Street and 1st Street an electro-mechanical pretimed controller was replaced with a new NEMA type, fully actuated signal controller. A new 5-section signal head was added to provide a lead left turn phase for northbound traffic. The necessary traffic detector loops were installed on each approach to provide complete traffic actuation.

At Cedar Street and 1st Street an electro-mechanical pretimed controller was replaced with a new NEMA type, fully actuated signal controller. New mast arm signal supports were installed to improve visibility of signal faces. The necessary traffic detector loops were installed on each approach to provide complete actuation. The final project cost for both intersections was $87,680.

BEFORE / AFTER STUDY RESULTS:

The before and after intersection delay studies were performed during the AM, OFF, and PM peak hour travel periods. Data from both of the intersections was analyzed with the results as shown in the following table.

COST FACTOR	BEFORE	AFTER
Daily Stops	11,447	12,897
Daily Delay (veh-hrs)	41.0	44.7
Daily Fuel Use (gals)	22.1	24.0

BENEFIT-COST ANALYSIS:

ANNUAL ROAD USER COSTS

COST FACTOR		BEFORE		AFTER		SAVINGS
Annual Stops (1,000 stops)		3.434		3,869		0
Annual Cost ($0.0145 / stop)	$	49,793	$	56,100	$	0
Annual Delay (1,000 veh-hrs)		12.3		13.4		0
Annual Cost ($0.313 / veh-hr)	$	3.849	$	4,194	$	0
Annual Fuel Use (1,000 gals)		6.6		7.2		0
Annual Cost ($1.00 / gal)	$	6,600	$	7,200	$	0
ROAD USER SAVINGS					$	0

ANNUAL HIGHWAY COST

		BEFORE		AFTER
Signal Maintenance & Power ($1,500 per signal)	$	3.000	$	3,000
Project Cost			$	87,680
Annual Cost (CRF = 0.10979)			$	9,626
HIGHWAY COST TOTAL	$	3,000	$	12,626

BENEFIT COST RATIO

$$\frac{B}{C} = \frac{\text{Annual Road User Savings}}{\text{(Ann. Project Cost - Ann. Maint.)}} = \frac{\$\,0}{\$12,626 - \$3,000} = 0$$

REMARKS:

The before and after study of the improvements at the study locations did not demonstrate any savings, however Main Street and !st Street displayed a savings of delay time. The signal improvements made would be more beneficial to motorists during the light traffic periods of early morning and late evening periods which were not studied as a part of the project evaluation process.

MUSCATINE

PROJECT LOCATION:

Central Business District System

The central business district (CBD) system consists of a 30 block area in the City with 26 signalized intersections. A total of 5 routes were chosen for the study analysis of the CBD system. The routes and the approximate traffic volumes are shown below.

2nd Street (from Pine to Mulberry), 5,500 vehicles per day (vpd);
3rd Street (from Pine to Mulberry), 5,000 vpd;
Cedar (from Mississippi Drive to 8th Street), 4,000 vpd;
Mississippi Drive (from Pine to Mulberry), 10,500 (vpd); and
Mulberry (from Mississippi Drive to 8th Street), 5,000 vpd.

PROJECT DESCRIPTION:

The project included the installation of a time-based coordination signal system. Existing pretimed electro-mechanical controllers were replaced with Type 170 solid state, actuated signal controllers. A total of 21 new controllers and cabinets were installed. At the remaining 5 intersections the signals were removed and STOP sign control was installed. Additional equipment included 24 new mast arm signal supports and 48 12-inch 3-section signal heads to improve visibility at various signal locations. For pedestrian traffic needs 48 "WALK", "DON'T WALK" signal heads were installed The controllers are currently operating as pretimed signal controllers with fixed cycle length timing plans. The final project cost was $327,110.

BEFORE / AFTER STUDY RESULTS:

The before and after travel time studies were performed during the AM, OFF, and PM peak hour travel periods. Travel time runs were completed in each direction of travel on the study routes during each peak travel interval. Data from the 5 study routes was analyzed with the results shown in the following table.

COST FACTOR	BEFORE	AFTER
Daily Stops	42,577	33,924
Daily Delay (veh-hrs)	114.9	165.2
Daily Fuel Use (gals)	728.7	746.7
Daily Travel Time (veh-hrs)	572.9	607.4

BENEFIT-COST ANALYSIS:

ANNUAL ROAD USER COSTS

COST FACTOR	BEFORE	AFTER	SAVINGS
Annual Stops (1,000 stops)	12,773	10,177	2,596
Annual Cost ($0.0145 / stop)	$ 185,209	$ 147,567	$ 37,642
Annual Delay (1,000 veh-hrs)	34.5	49.6	0
Annual Cost ($0.313 / veh-hr)	$ 10,799	$ 15,525	$ 0
Annual Fuel Use (1,000 gals)	218.6	224.0	0
Annual Cost ($1.00 / gal)	$ 218,600	$ 224,000	$ 0
Annual Travel Time (1,000 veh-hrs)	171.9	182.2	0
Annual Cost ($3.35 / veh-hr)	$ 575,865	$ 610,370	$ 0
ROAD USER SAVINGS			$ 37,642

ANNUAL HIGHWAY COST

Signal Maintenance & Power ($1,500 per signal)	$ 31.500	$ 27,000
Project Cost		$ 327,110
Annual Cost (CRF = 0.10979)		$ 35,913
HIGHWAY COST TOTAL	$ 31,500	$ 62,913

BENEFIT COST RATIO

$$\frac{B}{C} = \frac{\text{Annual Road User Savings}}{\text{(Ann. Project Cost - Ann. Maint.)}} = \frac{\$37{,}642}{\$62{,}913 - \$31.500} = 1.20$$

REMARKS:

The before and after evaluation demonstrated that the installation of the time-based coordination system produced savings of approximately $37,650 in the number of stops for motorists. Individually, the study routes along 3rd Street, Cedar, and Mulberry demonstrated savings in each cost factor category.

SIOUX CITY

PROJECT LOCATION:

Sioux City's Computerized Traffic Control System

The City's computerized traffic control system utilizes the UTCS - Extended First Generation technology as developed by FHWA. The system controls 77 intersections throughout the City. Approximately 85% of the signal locations are pretimed, electro-mechanical controllers and the other 15% are solid state, actuated controllers used for arterial systems.

For the study analysis two arterial routes were selected. Gordon Drive, (from Pearl easterly to Virginia) a four lane arterial consisting of 5 signal locations with approximately 24,000 vehicles per day (vpd), and Hamilton Boulevard, (from Tri-View northerly to W. 14th) a four lane arterial consisting of 6 signal locations serving approximately 20,000 vpd.

PROJECT DESCRIPTION:

The project included the installation of a new mini-computer to replace the old central computer. A total of 90 controller interface and communications units (CICU's) at the signal locations were upgraded to provide accurate communications between individual signal locations and the new mini-computer. The upgraded CICU's at each controller provide memory to store local timing plans and provide an accurate time clock. CRT terminals were installed at the micro-computer for maintenance purposes and at the City's signal shop. A PC-based graphics workstation to monitor and work on the system was installed at City Hall. The final project cost was $263,026 or $3,416 per signal location.

BEFORE / AFTER STUDY RESULTS:

Before and after travel time studies were performed during the AM, OFF, and PM peak hour travel periods. Travel time runs were completed in each direction of travel on the study arterials during each peak travel interval. Data from the two study arterials was analyzed with the results shown in the following table.

COST FACTOR	BEFORE	AFTER
Daily Stops	62,481	34.031
Daily Delay (veh-hrs)	181.3	166.1
Daily Fuel Use (gals)	1,485.4	1,479.2
Daily Travel Time (veh-hrs)	961.7	953.7

BENEFIT-COST ANALYSIS:

ANNUAL ROAD USER COSTS

COST FACTOR	BEFORE	AFTER	SAVINGS
Annual Stops (1,000 stops)	18,744	10,209	8,535
Annual Cost ($0.0145 / stop)	$ 271.788	$ 148,030	$123,758
Annual Delay (1,000 veh-hrs)	54.4	49.8	4.6
Annual Cost ($0.313 / veh-hr)	$ 17,027	$ 13,587	$ 1.440
Annual Fuel Use (1,000 gals)	445.6	443.8	1.8
Annual Cost ($1.00 / gal)	$ 445,600	$ 443,800	$ 1,800
Annual Travel Time (1,000 veh-hrs)	288.5	286.1	2.4
Annual Cost ($3.35 / veh-hr)	$ 966,475	$ 958,435	$ 8,040
ROAD USER SAVINGS			$135,038

ANNUAL HIGHWAY COST

Signal Maintenance & Power ($1,500 per signal)	$ 16,500	$ 16,500
Computer Maintenance	$ 3.125	$ 1,425
Project Cost		$ 37,575
Annual Cost (CRF = 0.10979)		$ 4,125
HIGHWAY COST TOTAL	$ 19,625	$ 22,050

BENEFIT COST RATIO

$$\frac{B}{C} = \frac{\text{Annual Road User Savings}}{\text{(Ann. Project Cost - Ann. Maint.)}} = \frac{\$135,038}{\$22,050 - \$19,625} = 55.69$$

REMARKS:

The before and after evaluation of this project indicates that the installation of the new computer and CICU's will save motorists approximately 1,800 gallons of fuel per year. Additional savings of nearly $133,000 per year will also be realized by the reduction of stops, delay, and travel time. It is important to note that the B/C ratio only reflects 11 signals along the two study arterials, not the entire system.

SPENCER

PROJECT LOCATION:

Grand Avenue (U.S. Highway 18/71) Arterial

The Grand Avenue arterial which is designated as U.S. 18/71 through the City, consists of 8 signalized intersections beginning at 4th Street South northerly to 8th Street. The arterial is a four lane roadway and is the major street through the central business district (CBD). The speed limit through the CBD is 20 miles per hour. Traffic volumes on the route range between 16,000 vehicles per day (vpd) and 21,000 vpd.

PROJECT DESCRIPTION:

The project included the installation of computerized, traffic responsive on street arterial master controls with remote dial-up control capabilities (Closed Loop System). A total of 8 new solid state system controllers were installed at the signal locations along the route. A new on-street master controller was installed and connected to the system controllers through new interconnect communications cable. Sampling detector loops were installed for traffic data collection purposes. A micro-computer was installed at a City office to complete the system. The final project cost was $104,409.

BEFORE / AFTER STUDY RESULTS:

Before and after travel time studies were performed during the AM, OFF, and PM peak hour travel periods. Travel time runs were completed in each direction of travel along the arterial during each peak travel interval. Data from the arterial was analyzed with the results shown in the following table.

COST FACTOR	BEFORE	AFTER
Daily Stops	30,487	22,807
Daily Delay (veh-hrs)	107.9	76.8
Daily Fuel Use (gals)	850.7	826.8
Daily Travel Time (veh-hrs)	618.9	578.0

BENEFIT-COST ANALYSIS:

ANNUAL ROAD USER COSTS

COST FACTOR	BEFORE	AFTER	SAVINGS
Annual Stops (1,000 stops)	9,146	6,842	2,304
Annual Cost ($0.0145 / stop)	$ 132,617	$ 99,209	$ 33,408
Annual Delay (1,000 veh-hrs)	32.4	23.0	9.4
Annual Cost ($0.313 / veh-hr)	$ 10,141	$ 7,199	$ 2,942
Annual Fuel Use (1,000 gals)	255.2	248.0	7.2
Annual Cost ($1.00 / gal)	$ 255,200	$ 248,000	$ 7,200
Annual Travel Time (1,000 veh-hrs)	185.7	173.4	12.3
Annual Cost ($3.35 / veh-hr)	$ 621,995	$ 580,890	$ 41,105
ROAD USER SAVINGS			$ 84,655

ANNUAL HIGHWAY COST

Signal Maintenance & Power ($1,500 per signal)	$ 12,000	$ 12,000
Project Cost		$ 104,409
Annual Cost (CRF = 0.10979)		$ 11,463
HIGHWAY COST TOTAL	$ 12,000	$ 23,463

BENEFIT COST RATIO

$$\frac{B}{C} = \frac{\text{Annual Road User Savings}}{\text{(Ann. Project Cost - Ann. Maint.)}} = \frac{\$84,655}{\$23,463 - \$12,000} = 7.39$$

REMARKS:

The before and after study of this project demonstrated that the installation of the closed loop system will save motorists approximately 7,200 gallons of fuel per year. Additional savings of nearly $78,000 per year will be realized by the reduction of stops, delay, and travel time.

STORM LAKE

PROJECT LOCATION:

Flindt Drive (U.S. 71/IA 7)/West Milwaukee Avenue Arterial

Flindt Drive, designated as U.S. 71 & IA 7 through the City, is a four lane arterial consisting of 7 signalized intersections. West Milwaukee Avenue, which is the continuation of Flindt Drive, has one signalized intersection (Northwestern Drive). Improvements for this project involved all of the intersections beginning with Park Street northerly to Northwestern Drive. Approximately 11,000 vehicles per day use the route.

PROJECT DESCRIPTION:

The project included the installation of a fully actuated signal system with time-based coordination controls. New NEMA type, fully actuated, solid state controllers were installed at 3 of the 8 signal locations on the route. A total of 25 signal heads and 8 pole/mast arms were installed to replace out of date equipment at 4 signal locations. Time-based coordination units were installed at 4 of the signal locations where no controller change was made to complete the time-based coordination system. The final project cost was $117,870.

BEFORE / AFTER STUDY RESULTS:

Before and after travel time studies were performed during the AM, OFF, and PM peak hour travel periods. Travel time runs were completed in each direction of travel on the arterial during each peak travel interval. Data from the arterial was analyzed with the results shown in the following table.

COST FACTOR	BEFORE	AFTER
Daily Stops	15,928	12,577
Daily Delay (veh-hrs)	48.7	42.5
Daily Fuel Use (gals)	936.0	931.7
Daily Travel Time (veh-hrs)	518.3	511.7

BENEFIT-COST ANALYSIS:

ANNUAL ROAD USER COSTS

COST FACTOR	BEFORE	AFTER	SAVINGS
Annual Stops (1,000 stops)	4.778	3.773	1,005
Annual Cost ($0.0145 / stop)	$ 69,281	$ 54,709	$ 14.572
Annual Delay (1,000 veh-hrs)	14.6	12.8	1.8
Annual Cost ($0.313 / veh-hr)	$ 4,570	$ 4,006	$ 563
Annual Fuel Use (1,000 gals)	280.8	279.5	1.3
Annual Cost ($1.00 / gal)	$ 280,800	$ 279,500	$ 1,300
Annual Travel Time (1,000 veh-hrs)	155.5	153.5	2.0
Annual Cost ($3.35 / veh-hr)	$ 520,925	$ 514,225	$ 6,700
ROAD USER SAVINGS			$ 23,135

ANNUAL HIGHWAY COST

Signal Maintenance & Power ($1,500 per signal)	$ 12,000	$ 12,000
Project Cost		$ 117,870
Annual Cost (CRF = 0.10979)		$ 12,941
HIGHWAY COST TOTAL	$ 12,000	$ 24.941

BENEFIT COST RATIO

$$\frac{B}{C} = \frac{\text{Annual Road User Savings}}{\text{(Ann. Project Cost - Ann. Maint.)}} = \frac{\$23.135}{\$24.941 - \$12,000} = 1.79$$

REMARKS:

The before and after evaluation of this project indicates that the installation of the time-based coordination system will save motorists approximately 1,300 gallons of fuel per year. Additional savings of nearly $22,000 will be realized by the reduction of stops, delay, and travel time.

WATERLOO

PROJECT LOCATION:

University Avenue (U.S. 218) Arterial

The University Avenue arterial, designated as U.S. 218 through the City, consists of 10 signalized intersections beginning with Midway Avenue easterly to U.S. 63. The route is a divided six lane arterial with left turn bays at each signal location. The speed limit along the route is 45 miles per hour and traffic volumes range between approximately 17,000 vehicles per day (vpd) to 25,000 vpd.

PROJECT DESCRIPTION:

The project included the installation of computerized traffic responsive on-street arterial master controls with remote dial-up control capabilities (Closed Loop System). A total of 11 new fully actuated, solid state system controllers were installed at the signal locations. A new on-street master controller was installed and the necessary communication cable was placed to link the system controllers to the master. A total of 25 new loop detector amplifiers were installed to accommodate new detectors placed at the signal locations. A micro-computer was installed at the Traffic Engineering Department to complete the system. The final project cost was $139,743.

BEFORE / AFTER STUDY RESULTS:

Before and after travel time studies were performed during the AM, OFF, and PM peak hour travel periods. Travel time runs were completed in each direction of travel along the arterial during each peak travel interval. Data from the arterial studies was analyzed with the results shown in the following table.

COST FACTOR	BEFORE	AFTER
Daily Stops	28,352	25,534
Daily Delay (veh-hrs)	141.2	131.7
Daily Fuel Use (gals)	2,214.3	2,241.6
Daily Travel Time (veh-hrs)	1,084.9	1,133.5

BENEFIT-COST ANALYSIS:

ANNUAL ROAD USER COSTS

COST FACTOR	BEFORE	AFTER	SAVINGS
Annual Stops (1,000 stops)	8,506	7,660	846
Annual Cost ($0.0145 / stop)	$ 123,337	$ 111,070	$ 12,267
Annual Delay (1,000 veh-hrs)	42.4	39.5	2.9
Annual Cost ($0.313 / veh-hr)	$ 13.271	$ 12,364	$ 907
Annual Fuel Use (1,000 gals)	664.3	672.5	0
Annual Cost ($1.00 / gal)	$ 664,300	$ 672,500	$ 0
Annual Travel Time (1,000 veh-hrs)	325.5	340.1	0
Annual Cost ($3.35 / veh-hr)	$1,090,425	$1,139,335	$ 0
ROAD USER SAVINGS			$ 13.174

ANNUAL HIGHWAY COST

	BEFORE	AFTER
Signal Maintenance & Power ($1,500 per signal)	$ 15,000	$ 15,000
Project Cost		$ 139,743
Annual Cost (CRF = 0.10979)		$ 15,342
HIGHWAY COST TOTAL	$ 15,000	$ 30,342

BENEFIT COST RATIO

$$\frac{B}{C} = \frac{\text{Annual Road User Savings}}{\text{(Ann. Project Cost - Ann. Maint.)}} = \frac{\$ 13{,}174}{\$30{,}342-\$15{,}000} = 0.86$$

REMARKS:

The before and after study of this project indicates that the installation of the closed loop system will save motorists approximately $13.000 in reduced stops and delay time. However, these estimated savings will not offset the annual project cost. During the after study of the project it was noted that vehicle platoons were driving at speeds lower than the posted speed limit. Perhaps further adjustment of system timing plans to more closely approximate actual conditions in the field may produce additional savings to the road user.

WEBSTER CITY

PROJECT LOCATION:

2nd Avenue Arterial

The 2nd Avenue arterial consists of 5 signalized intersections beginning with Superior Avenue westerly to Prospect Avenue. The arterial provides one through lane in each direction with left turn bays at each signal location. The route is the main street through the central business district of the City. The speed limit on the route is 20 mph and traffic volumes are approximately 7,500 vehicles per day.

PROJECT DESCRIPTION:

The project included the installation of a time-based coordination signal system. A total of 5 new solid state, pretimed signal controllers and cabinets replaced existing uncoordinated electro-mechanical controllers. To accommodate pedestrian needs, 16 new "WALK", "DONT WALK" pedestrian signals were installed at two of the signal locations. It was also necessary to install new power service to each signal location to correct a low voltage problem with existing lines. The signal controllers are operating with fixed cycle length timing plans. The final project cost was $40,821.

BEFORE / AFTER STUDY RESULTS:

Before and after travel time studies were performed during the AM, OFF, and PM peak hour travel periods. Travel time runs were completed in each direction of travel on the arterial during each peak travel interval. Data collected for the arterial was analyzed with the results shown in the following table.

COST FACTOR	BEFORE	AFTER
Daily Stops	20,495	5,994
Daily Delay (veh-hrs)	40.1	21.3
Daily Fuel Use (gals)	197.5	178.5
Daily Travel Time (veh-hrs)	179.3	143.7

BENEFIT-COST ANALYSIS:

ANNUAL ROAD USER COSTS

COST FACTOR	BEFORE	AFTER	SAVINGS
Annual Stops (1,000 stops)	6,149	1,798	4,351
Annual Cost ($0.0145 / stop)	$ 89,161	$ 26,071	$ 63,090
Annual Delay (1,000 veh-hrs)	12.0	6.4	5.6
Annual Cost ($0.313 / veh-hr)	$ 3,756	$ 2,003	$ 1,753
Annual Fuel Use (1,000 gals)	59.3	53.6	5.7
Annual Cost ($1.00 / gal)	$ 59,300	$ 53,600	$ 5,700
Annual Travel Time (1,000 veh-hrs)	53.8	43.1	10.7
Annual Cost ($3.35 / veh-hr)	$ 180,230	$ 144,385	$ 35,845
ROAD USER SAVINGS			$106,388

ANNUAL HIGHWAY COST

	BEFORE	AFTER
Signal Maintenance & Power ($1,500 per signal)	$ 7,500	$ 7,500
Project Cost		$ 40,821
Annual Cost (CRF = 0.10979)		$ 4,482
HIGHWAY COST TOTAL	$ 7,500	$ 11,982

BENEFIT COST RATIO

$$\frac{B}{C} = \frac{\text{Annual Road User Savings}}{\text{(Ann. Project Cost - Ann. Maint.)}} = \frac{\$106,388}{\$11,982 - \$7,500} = 23.74$$

REMARKS:

The before and after evaluation of this project indicates that the installation of the time-based coordination system will save motorists approximately 5,700 gallons of fuel per year. Additional savings of nearly $100,000 per year will be realized by the reduction of stops, delay, and travel time.

WEST DES MOINES

PROJECT LOCATION:

35th Street Arterial

The 35th Street Arterial consists of 7 signalized intersections beginning at Ashworth Road northerly to University Avenue. The arterial is a four lane roadway with left turn bays at 4 of the signal locations. Traffic volumes on the route range between approximately 20,000 vehicles per day (vpd) to 27,000 vpd.

PROJECT DESCRIPTION:

The project included the installation of computerized traffic responsive on-street arterial master controls with remote dial-up control capabilities (Closed Loop System). A total of 7 new solid state, fully actuated system controllers and cabinets were installed at the signal locations. A new on-street master was installed and linked to the system controllers with communications cable. A micro-computer with special software was installed at the Public Works Department to complete the system. A total 51 loop detector amplifiers were installed to accommodate the loop detectors for the fully actuated system. Additional equipment included 13 new 12-inch, 3 section signal heads, 3 new 12-inch 5 section signal heads and 12 new pedestrian signal heads. The final project cost was $209,457.

BEFORE / AFTER STUDY RESULTS:

Before and after travel time studies were performed during the AM, OFF, and PM peak hour travel periods. Travel time runs were completed in each direction of travel along the arterial during each peak travel interval. Data collected for the arterial was analyzed with the results shown in the following table.

COST FACTOR	BEFORE	AFTER
Daily Stops	65,259	46,832
Daily Delay (veh-hrs)	264.4	161.0
Daily Fuel Use (gals)	1,440.8	1,343.3
Daily Travel Time (veh-hrs)	1,029.0	879.4

BENEFIT-COST ANALYSIS:

ANNUAL ROAD USER COSTS

COST FACTOR	BEFORE	AFTER	SAVINGS
Annual Stops (1,000 stops)	19,578	13.915	5,663
Annual Cost ($0.0145 / stop	$ 283.881	$ 201,768	$ 82,113
Annual Delay (1,000 veh-hrs)	79.3	48.3	31.0
Annual Cost ($0.313 / veh-hr)	$ 24,821	$ 15,118	$ 9,703
Annual Fuel Use (1,000 gals)	432.2	403.0	29.2
Annual Cost ($1.00 / gal)	$ 432,200	$ 403,000	$ 29.200
Annual Travel Time (1,000 veh-hrs)	308.7	263.8	44.9
Annual Cost ($3.35 / veh-hr)	$1,034,145	$ 883,730	$150,415
ROAD USER SAVINGS			$ 271.431

ANNUAL HIGHWAY COST

	BEFORE	AFTER
Signal Maintenance & Power ($1,500 per signal)	$ 10,500	$ 10,500
Project Cost		$ 209.457
Annual Cost (CRF = 0.10979)		$ 22.996
HIGHWAY COST TOTAL	$ 10,500	$ 33,496

BENEFIT COST RATIO

$$\frac{B}{C} = \frac{\text{Annual Road User Savings}}{\text{(Ann. Project Cost - Ann. Maint.)}} = \frac{\$271,431}{\$33,496 - \$10,500} = 11.80$$

REMARKS:

The before and after evaluation of this project demonstrates that the installation of the closed loop system will save motorists approximately 29,000 gallons of fuel per year. Additional savings of nearly $243,000 per year will be realized by the reduction of stops, delay and travel time.

SUMMARY

The before and after evaluations completed at the nineteen (19) demonstration project locations generally reflected reduced fuel consumption, fewer stops, delay reduction, and travel time savings following implementation of the traffic signal improvements. Projects which involved signal system coordination along arterial routes typically recorded higher benefit-cost ratios. Larger communities, with higher volumes of traffic, generally showed more savings due to the magnitude of motorist's receiving benefits of the system savings. Savings recorded at isolated intersections and in smaller communities where traffic volumes are lower experienced more modest road user savings.

The results of the Iowa Motor Vehicle Fuel Reduction Program verifies that substantial savings can be realized by motorists in communities which have installed new signal timing plans and upgraded traffic signal controls to provide operations responsive to traffic demands and progressive movement. In most cases significant benefits can be realized by relatively modest expenditures for improvements.

The traffic signal improvements completed as part of the Iowa Motor Vehicle Fuel Reduction Program will provide savings to motorists for many years to come. Additionally, the individual communities participating in the program will reap the benefits which will accrue from having state of the art traffic signal controls which should not need to be replaced or upgraded for several years.