FHWA-Sponsored Project Proves Cost Effectiveness of Signal Timing Optimization

Gary W. Euler and George W. Schoene

The recently completed National Signal Timing Optimization Project, initiated by the Federal Highway Administration (FHWA) in 1979 as a fuel conservation effort, is part of an overall effort to encourage states and municipalities to undertake traffic signal timing optimization projects to improve the quality of urban driving and thereby reduce fuel consumption. The FHWA estimates that just by optimizing the signal timing (without considering signal system hardware improvements) at the 130,000 intersections that are part of coordinated signal systems nationwide and at most of the other 110,000 noncoordinated signalized intersections, 2 million gallons of gasoline per day could be conserved. Assuming an average gasoline cost of $1.35 per gallon, this represents a daily saving of $2.7 million in direct fuel costs to consumers. When needed signal system hardware improvements at all of the nation's 240,000 intersections are also considered, these estimates increase to daily savings of 5 million gallons of gasoline and $6.75 million in direct fuel costs. Ray A. Barnhart, FHWA Administrator, noted that "this project proved that signal timing optimization is a very cost-effective, and painless, way of conserving fuel."

The National Signal Timing Optimization Project was intended to satisfy several objectives:

1. To establish credible data on the effectiveness of signal timing optimization;
2. To make signal timing optimization projects easier to do; and
3. To define the resources (cost, level of staff, computer, etc.) required to undertake a signal timing optimization project so that traffic engineers and administrators can more effectively budget for this activity.

In order to accomplish these objectives, two primary activities were undertaken: (a) development of the TRANSYT-7F signal timing optimization program and User's Manual, and provision of training in the use of the program; and (b) application of the program in 11 cities nationwide to evaluate the effectiveness of the optimized signal timing plans and to collect data on the needed resources.

Schoene is Chief, Systems Software and Support Team, Office of Traffic Operations, FHWA. Euler is a Senior Traffic Engineer and member of the Systems Software and Support Team.

TRANSYT-7F

The acronym TRANSYT stands for TRAffic Network StudY Tool. TRANSYT is a tool for traffic engineers who desire to optimize the signal timing of their coordinated signal systems to reduce delay and stops and thereby reduce fuel consumption. The TRANSYT program was originally developed and has been modified and improved at the Transport and Road Research Laboratory in the United Kingdom. The program has been extensively used both in this country and throughout Europe. As part of the National Signal Timing Optimization Project, FHWA secured the services of the University of Florida to develop a version of the program that would be easier to use in the United States. This version of the program is called TRANSYT-7F.

As part of the University of Florida contract, a comprehensive, new User's Manual was developed to serve as an instructional and reference guide for traffic engineers who desire to use the TRANSYT-7F program. In addition, a training course on how to use TRANSYT-7F to conduct a signal timing optimization project was developed. To date, the FHWA's National Highway Institute has sponsored nine presentations of this course, and 11 more presentations are scheduled beginning in October 1982.

The second part of the project involved the application of the TRANSYT-7F program in a variety of cities across the country. This part of the project was aimed at determining whether any city, regardless of size, could undertake and successfully complete a signal timing optimization project by using TRANSYT-7F. The cities contracted with FHWA to undertake use of TRANSYT-7F to optimize the signal timing in a portion of their street network, to evaluate the effectiveness of the optimized timing plans, and to determine the resources required to conduct the project.

The 11 cities selected to participate in this phase were Charleston, South Carolina; Denver, Colorado; Des Moines, Iowa; Fort Wayne, Indiana; Gainesville, Florida; Milwaukee, Wisconsin; Nashville, Tennessee; Portland, Oregon; Pawtucket, Rhode Island; San Francisco, California; and Syracuse, New York. These cities were selected as representing a range of geographic locations, populations, number of intersections to be retimed, types of networks, and ages of existing timing plans.

Technician checks on signal optimization system installation.

Table 1. Average personnel and cost requirements.

Activity	Effort	Cost ($)
Initial start-up	20.3[a]	1925 + travel + computer(3)
Preparation of data-collection plans	7.8[a]	700[c]
Data collection and reduction	19.7[b]	166[d]
Data coding	3.3[b]	36[d]
Running TRANSYT-7F		
Personnel	4.1[b]	44[d]
Computer		27[d]
Installation and fine-tuning	3.9[b]	78[d]
Miscellaneous	7.5[a]	720[c]

[a]Person days per project. [c]Dollars per project.
[b]Person hours per intersection. [d]Dollars per intersection.

Data-collection activities were largely completed during the fall of 1980. Coding and computer runs were accomplished during the spring of 1981 (after attendance at one of four pilot TRANSYT-7F training courses) and the optimized signal timing plans were installed and evaluated during the summer of that year. The number of intersections to be retimed per city ranged from 23 to 81; the average was 46.

City personnel performed all the work. The TRANSYT-7F program was implemented on a local (city, county, or state) or a commercial service computer in each city. The cities kept records on the resources required for each project activity at a very detailed level. All 11 cities submitted final reports on project results.

Based on the results of the 11 projects, the cost to retime each signal (nominally, with three timing plans) averaged $456. This cost included data collection, coding, running TRANSYT-7F, analyzing the output, installing the new timing, and fine-tuning the new signal timing plans on the street; project evaluation and overhead were not included. The labor required to retime each signal averaged approximately 40 h/intersection. About one-half of this time was professional; the remainder was mainly technician time (engineering and maintenance). A breakdown of the personnel and cost requirements is shown in Table 1.

FIRST-TIME USE

The first-time use of TRANSYT-7F to retime traffic signal systems requires a relatively extensive learning process. Subsequent projects should involve substantially less effort. For example, training in the use of the program will be required only for new personnel. Furthermore, data coding will go much more smoothly with repeated use. The estimated total project level of effort and costs should be reduced by about 25 percent from $456 to $335. Several of the project cities have already carried out subsequent projects, and their experience confirms this estimate.

According to the before and after TRANSYT-7F estimates, each year for the average intersection in the project 15,470 vehicle-h of delay were saved; 455,921 vehicle stops were eliminated; and 10,524 gallons of fuel were saved. This represents a 12.5 percent reduction in fuel consumption. Assuming that the cost of time delay saved is a conservative $0.50/vehicle-h, non-fuel vehicle operating costs are reduced by $0.014/vehicle stop eliminated, and gasoline costs $1.35/gallon. The equivalent dollar total annual benefit averaged $28,695/intersection. With an average cost of $456/intersection, the benefit/cost ratio is an impressive 63 to 1. If only fuel saving is considered, the benefit/cost ratio is still an impressive 31 to 1. The benefits obtained in each city are shown in Table 2.

When high degrees of saturation for certain traffic

Table 2. Estimated annual benefit.

	Average Annual Improvements per Intersection			
City	Delay (vehicle hours)	Stops	Fuel (gal)	Cost[a] ($)
Charleston, SC	3,187	437,600	4,345	13,586
Denver, CO	74,311	-130,439	31,415	74,598
Des Moines, IA	1,915	238,542	2,926	8,101
Fort Wayne, IN	1,499	438,716	3,681	12,339
Gainesville, FL	21,627	-40,091	9,436	23,935
Milwaukee, WI	4,830	413,788	6,126	17,030
Nashville, TN	20,268	1,129,740	21,012	53,266
Pawtucket, RI	26,345	468,857	14,578	38,688
Portland, OR	3,667	382,554	4,351	12,846
San Francisco, CA	36,377	1,007,032	23,987	67,308
Syracuse, NY	6,428	272,901	4,841	13,909
Avg	15,470	455,921	10,524	28,695

[a]Total cost of delay, stops, and fuel.

movements existed before optimization but were eliminated afterward, the delay and fuel savings predicted from the TRANSYT-7F estimates were overly optimistic. This is because the delay estimated by TRANSYT-7F for these movements before optimization was overstated due to the fact that the cities specified 1 h as the analysis period in TRANSYT-7F when, in fact, saturated conditions did not last for a full hour. Because the estimate of delay is used by TRANSYT-7F to calculate fuel consumption, the estimate of fuel consumption before optimization was also overstated. However, even if the five cities with the highest average fuel savings per intersection are eliminated from consideration, a fuel saving of 4483 gallons/intersection/year still results.

BENEFIT/COST RATIO

As an extremely conservative estimate, a benefit/cost ratio of 10 to 1 can be expected for first-time projects, considering fuel savings only. This ratio increases to approximately 15 to 1 for subsequent projects when costs will be reduced. When the value of time saved and of stops eliminated is considered, the benefit/cost ratio for first-time projects can be expected to be 20 to 1 as a minimum; it increases to 30 to 1 for subsequent projects.

Limited floating vehicle travel-time studies conducted by the cities confirmed that signal optimization did improve traffic performance significantly. With only two exceptions, the floating vehicle studies confirmed improvement in every control period in every city. The measured travel-time improvements ranged from less than 1 percent to 31 percent and averaged 8.5 percent.

Some of the conclusions that can be drawn from the National Signal Timing Optimization Project are as follows:

1. Signal timing optimization is a cost-effective way of achieving significant reductions in vehicle delay, vehicle stops, and fuel consumption.
2. TRANSYT-7F is a very valuable and useful tool in conducting signal timing optimization projects.
3. Data collection, particularly traffic volume data, presented the biggest problem to the cities in terms of the personnel and time resources required over a short period of time.
4. The provision of technical assistance was very helpful to those conducting the projects.
5. Conducting a signal timing optimization project can lead to the discovery of other deficiencies in signal systems that, when corrected, would provide additional benefits.
6. Favorable local media coverage of the projects and positive feedback from citizens substantiate that signal timing optimization is a popular activity for state and local governments because tax dollars are spent on a project from which everyone can benefit.
7. Fuel conservation through optimization of signal timing plans is a valid national objective that can be realized through the actions of state and local governments.

FHWA SUPPORT

The FHWA's Office of Traffic Operations is providing technical support services to users of the TRANSYT-7F program. These services include (a) distribution of the TRANSYT-7F program and User's Manual free of charge to all agencies and consultants requesting it; (b) maintenance of the program and documentation; and (c) technical assistance to users of the program.

Interested parties may receive copies of the TRANSYT-7F program and User's Manual, the National Signal Timing Optimization Project Summary Evaluation Report, and information on the TRANSYT-7F training course by writing to

Chief, Systems and Software Support Team
Office of Traffic Operations (HTO-23)
Federal Highway Administration
Washington, DC 20590

In addition, several state agencies have programs ongoing or planned to provide continuing technical assistance to local jurisdictions that use TRANSYT-7F. Among these states are California, Missouri, and Texas. State agencies and others are being strongly urged to adopt this as a useful, high-payoff activity that can result in major dollar savings to the monitoring public while at the same time aid in the achievement of national goals.