*Abridgment*

# Contracting Maintenance for Traffic Signal Systems

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ABSTRACT

Traffic signal system maintenance by contract has become a trend for large and mid-sized metropolitan areas in New York state, particularly where labor is highly unionized. One reason for this trend is that it is often possible to increase the level of maintenance services provided at a comparable cost while avoiding personnel administration problems. Between 1985 and 1986, the New York State Department of Transportation (NYSDOT) will let a contract for the maintenance of the Integrated Motorist Information System (IMIS) on Long Island. Before the contract documents for the IMIS were prepared, however, the NYSDOT studied the policies and practices of other public agencies that currently user traffic signal maintenance contracts. These agencies were the State of Indiana Department of Highways, the Illinois Department of Transportation, the Westchester County Department of Public Works, and the Nassau County Department of Public Works. The Nassau County example serves as a case study for this paper. A brief cost evaluation of the Sunrise Highway contract is presented. It is concluded that there are many applications where contracting maintenance for traffic signal systems is cost-effective. Contracting traffic signal system maintenance will play an increasing role inthe future of New York State.

All traffic signal systems that are operating today have at least one common element: the need for maintenance. Some of the most sophisticated traffic control systems in the United States have progressed from design to construction to operation with only minimal emphasis on planning for and estimation of future 'maintenance requirements. Without proper maintenance, traffic control systems that were justified on the basis of an attractive benefit-cost ratio will increase in cost and decrease in benefits. Over time, this results in a system that falls far short of the original estimation of payback to the general public.

The first step toward proper maintenance of existing traffic signal systems is an inventory of the system hardware. A complete set of "as-built" plans and specifications for the system are a necessity. When contractual maintenance is performed, duplicate sets should be given to the contractor at the outset of the job, and returned when the contract is completed.

In general, traffic signal system maintenance can be classified as remedial, preventive, and modification. Urban traffic control systems have a tendency to increase both the need for maintenance and the awareness of maintenance needs. The increase in maintenance activity results from the sheer increase in the quantity and complexity of equipment needed to control remote sites from a central location by using a computer. The increased awareness of the need for maintenance results from the high degree of monitoring of equipment possible with central computer control. Many systems produce failure reports that list the type and location of equipment that has failed. New aspects of maintenance that arise with some urban traffic control systems (such as the maintenance and repair of a control center and communication subsystem) often require specialized training for existing technicians or the expansion of the technical staff to include specialists in the computer and data communications technologies. In most cases, competent specialists are hard to find and harder to keep on a governmental agency payroll when the need for specialists in private industry is very strong and salaries are high. Some agencies responsible for operating and maintaining traffic control systems today are finding contractual services for maintenance to be a viable alternative to the use of strictly in-house forces.

## ADVANTAGES OF CONTRACTED MAINTENANCE

When contract maintenance is properly obtained and administered, the following advantages can be realized:

1. Technical expertise and labor can be available on an as-needed basis;
2. Cost control and accountability of maintenance activities can be assessed on monthly and yearly bases;
3. Knockdowns of traffic signal equipment can be quickly repaired; and
4. Preventive maintenance can be scheduled and performed on a routine basis.

Contractual services for maintenance can solve some of the problems associated with providing preventive and remedial maintenance, and in many cases, can lower maintenance costs with competitive bidding. A maintenance contract is not dissimilar to a service agreement, in which the technical expertise and labor required are always available and only paid for when needed.

## A CASE STUDY

In recent years, the New York State Department of Transportation (NYSDOT) has turned to contractual services for maintenance in a very limited capacity; foremost example is the Sunrise Highway on Long Island. In the future, NYSDOT plans to maintain the Integrated Motorist Information System (IMIS) on Long Island with contractual services. Because of the size of this system, both geographically (128 miles of roadways in a 35-mile corridor) and quantitatively (104 intersections, 70 ramp metering stations, 76 changeable message signs, and more than 2,000 vehicle detectors), NYSDOT maintenance forces alone will not be sufficient to provide the level of service that is crucial to the operation and evaluation of the system.

A typical example of the use of contracted services for traffic signal maintenance is that of the Nassau County Department of Public Works in Mineola, New York. Nassau County maintains approximately 1,400 signalized intersections, 229 of which are part of a computerized traffic control system. The first phase of Nassau County's computerized traffic control system was completed in 1974. The original system consisted of 108 intersections on 5 arterials. Expansion of the system to a projected 600 intersections is currently underway as part of a 5-year program. The system has been maintained in excellent working order for more than 10 years. Both signalized intersections on the computerized system and other signals throughout the county are maintained by contract.

Nassau County currently uses a combination of in-house forces and three competitively bid contracts. One of the three contracts is a "requirements" contract used to accomplish new signal installations and other major work that involves construction. In this context, a requirements contract is essentially a "furnish and install" construction contract. Work is performed on a work order basis, with plans prepared by county personnel. The county purchases quantities of controllers, poles, and signal heads and supplies them to the contractor for installation. The contractor supplies all necessary cables, conduits, hardware, and labor.

The two maintenance contracts currently used by Nassau County are a computer and telemetry (communications system) contract, and a traffic signal maintenance contract that covers the remainder of the field equipment. The rationale for separating the computer and data communications system from other types of hardware to be maintained results from the need to obtain specialists for trouble-shooting and maintenance of the more sophisticated technologies involved. The contracts specify in an appendix a list of equipment in each cabinet. The responsibilities of the respective contractors are clearly defined to eliminate overlapping work and the gray area between communications system problems and some controller and cabinet problems.

Nassau County requires a 2-hr response time on the traffic signal maintenande contract. This required response time is enforced by inspectors who check that the ordered work is completed. Also, radio communications can be monitored to track the contractor's activities. Required response times for the computer and telemetry system contract are specified somewhat differently than in the intersection maintenance contract. A 2-hr response is only required if a call is placed to the contractor between 7:00 a.m. and 3:00 p.m. For calls placed to the contractor after 3:00 p.m., the required response is ". . . no later than 7:00 a.m. the next business day . . . ." This difference in philosophy is derived from the nature of the work involved. Although problems with the computer and data communications system cause loss of benefits to the public, they do not create a hazardous situation.

Nassau County contract administrators stress that inspection is the key to level of service and cost control for maintenance contracts. Nassau County maintains an in-house staff of approximately 1 individual for every 100 intersections. Of these approximately 13 technicians, from 3 to 5 may be on the road patrolling the system in vehicles provided by the contractor. The staff develops and issues work orders for the contractor. Nassau County's maintenance contractors are required to repair traffic signal pole and cabinet knockdowns. This work is performed on a time and materials basis. Nassau County has an in-house staff of individuals on 24-hr call that act as inspectors in case time and materials-type work becomes necessary.

Intersection maintenance is paid for on a monthly basis. Payments to the contractor consist of the price bid per intersection month multiplied by the number of intersections the contractor maintains, less any charges accrued as a result of failure to perform on time. At present, all three contracts are 2-yr contracts that cost Nassau County approximately $1.7 million per year. The traffic signal maintenance contract, effective from July 1984 to June 1986 costs $1,070,000 per year. The requirements contract (January 1984 to December 1985) costs $520,000 per year, and the computer and telemetry system contract (February 1984 to January 1986) costs $115,000 per year.

## COST EVALUATION

The decision to go from in-house to contractual services for maintenance is seldom based strictly on a cost comparison. The advantages of contracted maintenance are often personnel administration-related. In New York, the decision to use contractual services has typically been based on necessity and practicality, and not strictly cost-effectiveness. The decision to maintain the Sunrise Highway system by contract was based on the fact that the hardware involved was not the standard for state systems and was relatively difficult to maintain. At least two specialists would have to have been hired on the state payroll and specially trained. At the time, this was not possible. Also, replacement parts for the specialized equipment would have had to be added to the state shop. The decision to maintain the IMIS by contract was the result of a cost study in which several alternatives for operations and maintenance were evaluated (1). Contract maintenance was determined to be cost-effective for this system. The Nassau County Department of Public Works has used contract maintenance for more than 20 years to avoid problems with high overhead and personnel turnover. Nassau County is highly unionized, and electronics technicians are able to earn higher wages working for contractors.

The cost-effectiveness of contracting traffic signal maintenance depends on a number of variables about the traffic signal system to be maintained:

1. The number of intersections,
2. The location of the intersections,
3. The geographic density of intersections,
4. The ratio of the amount of central (system) control equipment versus field equipment for the system, and
5. The type and complexity of the hardware.

The number of intersections to be maintained will affect the cost per intersection that can be obtained. With contract maintenance of a traffic signal system, the cost per intersection has a tendency to decrease with the number of intersections. This is because the costs associated with system hardware, such as central computers and central data communications, are typically low quantity, high-priced items that remain fixed within the range of intersections that the central equipment is capable of controlling. Figure 1 shows the projected total

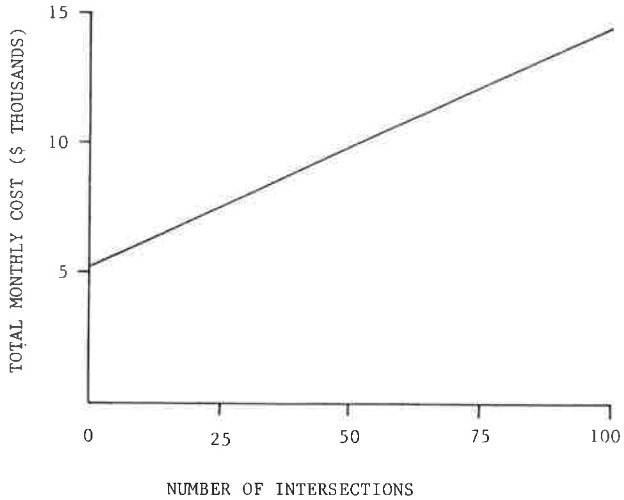


**FIGURE 1 Sunrise Highway: projected total contract cost for a range of numbers of intersections.**

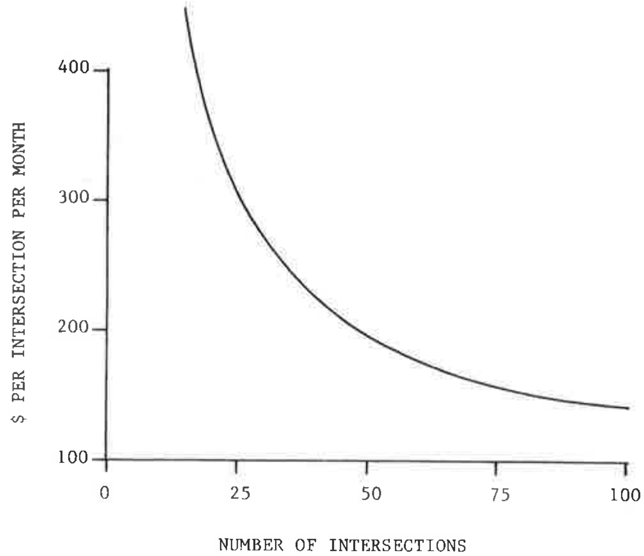


**FIGURE 2 Sunrise Highway: projected cost per intersection for a range of numbers of intersections.**

cost of the Sunrise Highway maintenance contract for a range of numbers of intersections. The prices used are based on those actually bid for the system with 76 intersections. The items and prices used are given in Table 1. Only the costs related to intersection and detector maintenance increase with the number of intersections, whereas the contract costs that are attributable to master controller stations and other system elements remain stable. Figure 2 shows the total contract cost divided by the number of intersections maintained, or the cost per intersection. As the number of intersections increases, the cost per intersection approaches a minimum of about $90 per month. It is interesting to note that if the cost (based on the Sunrise Highway data) is projected to 1,400 intersections--the size of the Nassau County contract--then the yearly total contract cost would be $1.68 million. The actual Nassau County costs are $1.7 million. This similarity is a result of both contracts being in the same geographic area (signal density, labor, and materials are similar), the same contractor that holds the Sunrise Highway contract also holds two of the three Nassau County contracts, and the specifications used are similar. The hardware involved is very different for the two systems, but the percent of the total contract cost spent on central control versus field equipment is similar. Three of the five variables listed previously are similar.

To compare contract costs with in-house costs, the cost of personnel, materials and supply costs, and overhead should be considered (2). In the highly developed urban and suburban areas of New York, NYSDOT uses a rule of thumb of 1 man per 30 intersections. This is possible because of the geographic density of traffic signals in these areas. In the less dense regions of the state, travel time to some intersections can be as high as 5 hours. The numbers of intersections per crew members in these regions are much lower.

The cost of performing traffic signal maintenance in-house will be sensitive to the same five variables listed previously for contractual services. The savings to be obtained by contracting maintenance result from reducing in-house overhead by taking advantage of the resources that a good electrical construction contractor has available (an electronics repair shop, technical expertise, construction and repair equipment).

## ACKNOWLEDGMENT

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**TABLE 1 Sunrise Highway: Contract Bid Items**

| Item Description | Units | Quantity | Price ($) | Total ($) |
|---|---|---|---|---|
| Field Items: | | | | |
| Maintain traffic signal | Per signal | 912 | 60 | 54,720 |
| Relamp traffic signal | Per signal | 76 | 110 | 8,360 |
| Detector installation | Per foot | 1,000 | 4.25 | 4,250 |
| Inductance wire | Per foot | 3,500 | 1.40 | 4,900 |
| System Items: | | | | |
| Repair master controller station | Each | 2 | 16,000 | 32,000 |
| Maintain master controller station | Per station | 24 | 620 | 14,880 |
| Communication inspection and repair | Lump sum | 4 | 2,200 | 8,800 |
| Pedestrian Equipment Items: | | | | |
| Combined | – | – | – | 16,650 |
| Construction and Installation Items: | | | | |
| Combined | – | – | – | 22,030 |
| Total | | | | 166,590 |

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# Platoon Dispersion over Long Road Links

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ABSTRACT

The dispersion of platoons of vehicles as they travel between signalized intersections reduces the potential benefits from coordinating traffic signal timings. The effects of dispersion place a limit on the distance between intersections over which it is beneficial to provide coordination. During a feasibility study for a traffic control system, platoons were observed to remain together for distances up to 2000 m on high-standard arterial roads. Platoon shapes were measured and the results were compared with predictions of the TRANSYT signal timing program by using various values for the TRANSYT platoon dispersion factor. Despite the unusually long distances involved, the most suitable dispersion factor values fell in the same range as those normally used for networks of more typical dimensions. Optimized timings were not found to be unduly sensitive to the dispersion factor used. Requirements to minimize delay throughout the network, and not just on an individual link, act as a constraint on the sensitivity of TRANSYT timings to platoon dispersion rates. On the basis of the observation of platoons on high-standard arterial roads, it was conservatively estimated that coordinated signals could reduce delay by 10 percent, where distances between signals ranged between 1000 and 1500 m.

The dispersion of groups of vehicles as they travel away from a signalized intersection is a familiar characteristic of traffic, created by the differences in speed of travel of the individual vehicles. Models of signalized road networks, including those used within programs to calculate coordinated signal timings, need to account for this phenomenon to provide an accurate representation of vehicle behavior.

The benefits of coordinating neighboring traffic signals are derived through careful timing of the green signals to coincide with the arrival of platoons of traffic from upstream intersections. The longer the distance between intersections, the more dispersed the platoons become and the smaller are the potential benefits from coordination.

Platoon dispersion frequently imposes an upper limit on the distance between intersections over which it is beneficial to provide signal coordination capabilities. This limit is typically between 500 to 1000 m for most road networks. Described in this paper are measurements of the rate of platoon dispersion in a network of arterial roadways of high standard. Through these descriptions, the potential for worthwhile benefits as a result of coordination over distances of 1500 m is demonstrated.

## CONTEXT OF STUDY

In many feasibility studies for coordinated signal systems, it is adequate to simply observe, but not directly measure, platoons as they reach the next downstream intersection and base estimates of benefits on results obtained from other cities with similar characteristics. Relevant characteristics include city size, type of network (grid, arterial, or both), sophistication of existing signal equipment (coordinated or not) and average distance between signals.

However, in a feasibility study conducted in the city of Kuwait, the distance between signals was sufficiently long in parts of the roadway network for special studies of platoon dispersion to be undertaken so that the benefits of signal coordination could be estimated. These studies included analysis of platoon dispersion factors to be used in a coordinated signal timing program for this network and an evaluation of the sensitivity of the optimized timings to the value of factor used. This paper contains descriptions of these studies and presents the conclusions reached.

The work was divided into four phases, as follows: