cally estimates the number of personnel required to provide the selected level of service chosen for the various highway systems for use in developing personnel needs.

2. The performance-budgeting subsystem automatically estimates the need for various subclasses of equipment so that equipment needs can be evaluated.

3. The performance-budgeting subsystem automatically estimates the requirement for various stores items and their cost so an evaluation of needs can be easily and efficiently prepared.

4. Construction, betterment, and major contract resurfacing projects are entered in the system by a simple process and are properly accounted for by the performance-budgeting subsystem.

5. Information from the performance-budgeting subsystem is accessed by the management information subsystem and monthly reports show expenditures versus budgeted amounts by both maintenance activity and line item in simple and easily understood matrix format. In addition, information from the payroll, stores, and accounting systems is automatically shown on the same document providing a complete, up-to-date evaluation of the current financial status of a district or maintenance region. This is to become the key document for this purpose because of its completeness and timeliness.

6. Detailed information regarding the use of all resources by activity or group of activities and by location can be automatically obtained for use in the pavement management system or for other purposes such as evaluation of design or construction practices.

7. Detailed itemized invoices can be prepared by the Accounting Division from information obtained directly from the MMS within days of the completion of the work.

8. Equipment utilization by subclass is captured by the MMS, allowing the effectiveness of various types and sizes of equipment for various applications to be evaluated. Current rental rates of equipment as established by the equipment management system are automatically accessed by the MMS (computer file to computer file).

9. Stockpiles of all bulk materials are automatically managed by the MMS for the stores system as to value and quantity for both material used and material added. Only the simplest input is required for this purpose.

10. Contract maintenance is recorded on the same forms as work by in-house forces, and reports permit rapid and full comparison of costs for work done by contract and by maintenance employees.

11. A yearly field evaluation is made of the results of performing key activities to compare work required and work estimated by work models.

12. Detailed up-to-date complete inventory information can be obtained on request for any section of highway of a mile or more in length.

13. A greatly simplified improved audit trail for all materials used in maintenance activities was developed within the MMS for the stores system.

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Contract Maintenance in Ontario

J. HUGH BLAINE

ABSTRACT

The Ontario Ministry of Transportation and Communications has substantially increased the use of private contractors to provide winter maintenance during the last few years. Some summer operations also are now being done by contractors, but total maintenance of sections of the highway has not been carried out by contract. At this time almost all sand spreaders are mounted on contractors' tracks. Approximately 23 percent of the snowplow trucks are now supplied and operated by contractors. In the large urban areas, large contracts are awarded for the stockpiling and spreading of winter sand and salt. Most surface treatment, liquid calcium chloride application, crushed gravel supply, dome construction, and picnic site maintenance is done by contract. In addition, some grass mowing, street sweeping, catchbasin cleaning, and brush clearing is contracted. Almost all of this work was done by the highway department at one time. The increased use of contracts has resulted from a number of changes, both internal and external to the Ministry. It is a strategic policy of the Ministry to use contractors where financial analysis and assessment indicate that the total cost will be reduced. Maintenance management system costs are used in these analyses.

The trend toward use of private contractors to maintain parts of the highway system started in the 1950s in Ontario. This trend has been accelerating during the past few years, particularly in the large summer operations such as surface treatment, gravel crushing, and hot-mix patching and in winter maintenance. Many service functions are now carried out by contract. These changes have led to a need to reorganize many maintenance activities and a need for a comprehensive maintenance management system to

monitor the cost of private operations and to ensure the selection of the least-cost alternatives.

CONSIDERATIONS FOR CONTRACT MAINTENANCE

The decision to contract certain maintenance operations must eventually be based on overall cost savings or on the availability of expertise or special licenses in the private sector that could not be warranted in the provincial highway department. Various other factors must also be considered when a decision is made whether to use Ministry resources or contracts.

Strategic Guidelines

The Ontario Ministry of Transportation and Communications (MTC) has a strategic planning process that has identified advantages and disadvantages resulting from increasing the amount of maintenance done by private firms. Advantages quoted are that such a policy

1. Satisfies public demand for less government,
2. Meets Ontario government's desire to reduce the Civil Service,
3. Strengthens the construction community to better compete for the ultimate benefit of the economy,
4. Raises the expertise of the engineering firms in the application of new technologies to enable them to capture a slice of the international market,
5. Enables ready adjustment of program costs to fluctuations of the economy and budgets, and
6. Stimulates the local economy.

Disadvantages quoted are the following:

1. Early retirements may result in a loss of valuable expertise;
2. Restricted hiring of younger employees results in a loss of vigor;
3. The policy creates conflict with unions;
4. Staff are demoralized because of conflict and uncertainty;
5. In-house expertise necessary for planning, budgeting, monitoring, and control are lost; and
6. Change in the recruitment policy in favor of more experienced employees may be necessary, which would cut off upward mobility of the current staff.

Cost

Any use of contractors to maintain the highway system in Ontario should reduce the Ministry's total costs. These costs should cover the total expenditures resulting from the operation and should include contract charges, contract preparation, supervision, and materials. For comparison purposes, in-house costs should include salaries, benefits, materials, and equipment. MTC endorses a financial analysis and assessment of all projects. In this process the cost of funding operations (interest on the money invested) is considered.

Present-Value Analysis of Snowplow Rental Versus Ownership

The calculations used to determine the 1983 break-even hourly rental rate above which the Ministry would not want to award a snowplowing contract are given in the following paragraphs. This analysis assumes that the administration cost of plowing will be the same for a private operation and a Ministry one and that this operation will only be performed by private contractors to an extent where sufficient Ministry staff and equipment remain to perform the other winter maintenance operations.

Equipment Operating and Labor Costs (1983)

Equipment	Purchase Price ($)
Cab (5 tons), chassis, and body	37,450
Plow	2,260
Wing	1,290
Hydraulics (installed)	5,885
Outfitting (lights, etc.)	3,500

Life expectancy of equipment = 11 years.

Labor costs:

Hours (four men) x number of weeks x labor distribution rate = 160 x 20 x $11.75 = $37,600.

Equipment operating costs:

Hours x internal rental rate (excluding auxiliary) = 500 x $29.05 = $14,525.

Overtime costs:

Labor: hours x two men x overtime pay rate = 75 x 2 x $17.63 = $2,645.
Equipment: hours x internal rental rate = 75 x $29.05 = $2,179.

Estimated total of labor and operating costs for 1982-1983: $56,949.

Owning Costs

To express as a present value (1983 dollars) the costs of owning and renting over an 11-year period, the following rates were applied: inflation rate, 8 percent; discount rate, 13 percent.

Capital Costs

If a 13 percent discount rate is applied to the estimated resale value, the capital costs are as follows:

Cab, chassis, and body:

$37,450 x 0.18 = $6,741 (estimated resale value after 11 years) ≈ $1,795 (expressed as present value).
Capital cost = $37,450 - $1,795 = $35,655 - $7,131 (20 percent summer use) = $28,524.

Plow:

$2,260 x 0.53 = $1,120 (estimated resale value after 11 years) ≈ $295 (expressed as present value).
Capital cost = $1,120 - $295 = $825.

Wing:

$1,290 x 0.7 = $903 (estimated resale value after 11 years) ≈ $238 (expressed as present value).
Capital cost = $1,290 - $238 = $1,052.

Hydraulics (including installation):

Capital cost = $5,885 (residual value included in truck sale price).

Outfitting costs (lights, etc.):

Capital cost = $3,500 (residual value included in the sale price).

Total capital costs: $28,524 + $825 + $1,052 + $5,885 + $3,500 = $39,786.

Labor (Operators') and Operating Costs (Present Value)

To express all costs as present values, an inflation rate of 8 percent and a discount rate of 13 percent were applied over an 11-year period.

1983 labor and operating costs = $56,949.

By applying the preceding rates, the labor and operating costs over 11 years expressed as a present value was $481,788.

Total cost of owning = total capital costs + total labor and operating costs = $39,786 + $481,788 = $521,574.

Hired-Truck Costs

Standby: 140 days x $60.00/day = $8,400.

By applying an 8 percent inflation rate and a 13 percent discount rate over 11 years, hired-truck costs were $71,064.

Break-Even Point

The maximum hourly rate should not exceed the following:

(Total owning costs - hired standby costs)/(hours per year x 11) = ($521,574 - $71,064)/$6,325 = $450,510/$6,325 = $71.23/hr.

Capital Cost

During periods of funding constraint, the change to contract maintenance allows the Ministry to achieve short-term savings by reducing the substantial capital cost of major equipment. As an example, MTC has, during the last 4 years, switched to contracts for 199 snowplows, which has resulted in a saving of $10,000,000 for vehicles and equipment.

Flexibility

Contract maintenance also provides flexibility to increase or decrease the size of various programs as may be considered necessary as a result of funding or need. This may be more difficult if programs are performed by government employees, and it may be difficult to effectively redeploy the personnel and equipment that become surplus as the result of changes.

Expertise and Special Equipment

Another reason to consider contract maintenance is the availability of special expertise or special equipment. In Ontario it has been found that structural steel repairs and hot-mix patching are best done by contract. The contractor often has larger, more productive equipment that enables completion of the work in less time and thus reduces the inconvenience to the traveling public. The ready availability of contractors with experienced staff reduces the need for special training of Ministry staff.

Work-Load Leveling

The use of private contractors enables the Ministry to handle peak load requirements and reduce nonproductive standby. Work can also be scheduled at an opportune time and is not dependent on having Ministry staff available. As an example, contract sewer cleaning can be scheduled early in the spring, so that winter sand can be removed before the heavy rains.

Potential Disadvantages

There are a number of potential disadvantages that must be analyzed for each operation that might be performed by private firms. These include

1. Reduced Ministry capability to react to emergency requirements;
2. Ministry vulnerability to higher costs if the work available to the contractors in localities expands beyond their capacity;
3. Cost and inconvenience incurred in awarding contracts;
4. The cost of instructing the contractor's staff on Ministry requirements, particularly when there is a high turnover; and
5. A reduction in the candidates for supervisory positions because of the reduced Ministry labor force, particularly in remote regions.

ONTARIO EXPERIENCE

More than 20 percent of all Ministry maintenance operations are now performed by private contractors. No system has been set up to rigidly define contract work for this purpose, and there is no defined method of collecting the data. As a result, there are some differences in interpretation in the districts and the amount of contracting to private firms is probably somewhat higher there.

Winter Maintenance

The greatest use of contractors is for winter maintenance. The seasonal nature of the work coupled with the idle staff and available equipment of contractors has enabled the Ministry to achieve considerable savings in this work. Nearly all of the Ministry's 800 salt spreaders are mounted on contractors' trucks. In order to facilitate the annual installation and removal of this equipment, the Ministry's spreaders are custom-built, self-contained units.

The contractor is paid an hourly operating rate, which he bids, plus a fixed daily standby rate. Sanding and salting operations have been performed in this manner since the early 1960s. Half of the 280 large loaders required for winter maintenance are also rented.

Ontario removed snow from all provincial highways by using only Ministry-owned snowplows and MTC staff until 1979. It was believed that the Ministry's plows provided the best possible service and that the Ministry was able to minimize road closings because of severe storms, equipment failures, or operator problems.

In 1979 contract snowplowing was tested in order to reduce expenditures. Most of the private truck owners did not have experience operating snowplows, so the Ministry carried out extensive training programs for them. Because few truckers owned snowplow equipment, the Ministry initially supplied snowplows, wings, plow harnesses, and safety equipment. These trials demonstrated that there was considerable interest in the snowplowing contracts, so that competitive bids could be obtained.

The performance of the contract snowplows was satisfactory, and few problems were encountered. As a result, this program has been expanded and the

Ministry had 199 plows operated by private contractors in 1983. This is 23 percent of the total snowplow requirement. There was some concern initially that the private contractors would not match the productivity of the Ministry, but the maintenance management reports show that the average speed of private-contractor plows, 50 km/h, is now only 3 percent slower than that of MTC plows. Gradually, all districts are reducing the equipment supplied to the contractor and most contractors now supply all snowplow and safety equipment.

In a few locations the Ministry still supplies tungsten carbide snowplow blades. The contractors have suggested that there is a cost saving to the Ministry, because volume purchase of blades results in much lower prices. When the Ministry supplies the blades, the contractor does not attempt to minimize blade wear by reducing the pressure on the blade.

Most of the contracts are awarded to owner-operators who can bid lower than the larger contractors because of low overhead. The contractor is paid his bid rate for each hour worked plus a fixed daily standby rate. The bid rates are monitored closely because there is a substantial variation across the province, and a major increase in the bid rates could make these contracts uneconomical.

Initially the specifications for the trucks were not as rigid as for the MTC-owned trucks, but as competition has increased, the districts have been able to upgrade the specifications to obtain diesel engines, radial tires, and the other features of the Ministry's trucks. This enables the contract trucks to keep up with the Ministry's trucks when they are plowing in echelon, which all of the trucks first rented could not do.

On urban expressways the Ministry awards sand contracts. The contractor is responsible for supplying all sand and for applying salt and sand as directed by the Ministry's foreman. The contractor must maintain a crew at the Ministry yard at all times. Loading of the material and mixing of the salt and sand are also included. The Ministry has supplied the sand spreader bodies to the contractors in the past, but the trend is to have the contractor supply these. A limited number of snowplows is also supplied by the contractor.

Summer Maintenance

The most extensive use of contractors in summer maintenance has been in the work requiring specialized heavy equipment for short periods of time. The climate in Ontario limits the construction and heavy-maintenance season. When the Ministry performed most of this maintenance using its own forces and equipment, large numbers of personnel were required for the operations and to service the equipment. As the contractors increased their capabilities, an increasing amount of this work was transferred to them. As a result, most hot-mix patching, crushed gravel supply, prime and surface treatment, and winter sand screening is now done by contract. Earth moving, drainage construction, and ditching are increasingly being done by using small contractors. Consequently the Ministry's requirement for the large expensive equipment has diminished. The contractors are able to use larger equipment, which is better suited to some jobs, and thus complete the operations more quickly. This reduces the inconvenience to the traveling public and reduces their exposure to hazardous situations.

In general, the Ministry has slowly phased in these operations when equipment needed replacing or when major changes were made. As a result, most operations were being performed simultaneously by contractors and by MTC personnel. Usually there were substantial cost savings on the contract operations, particularly on the larger jobs. It was possible to schedule jobs at the opportune time because it was not necessary to keep a crew busy or to limit the operations to the capacity of a particular crew. Some short-term flexibility was lost because of the time required to process and award contracts and the need to be exact about specifications and standards. Because the contract and MTC operations were being carried out simultaneously, it was possible to evaluate the advantages and disadvantages of the two and to decide which operations should be performed by private contractors in the future. In most operations, this could be done with little risk. Over the longer term, it must be realized that the conversion to maintenance by contract may be difficult to reverse. The skills required to operate asphalt and crushing plants are lost and it would now be difficult to recruit workers with the required expertise. The equipment required is expensive and would often be beyond the capacity of the Ministry's yearly budget for the acquisition of equipment.

Patrols

Smaller jobs, which have traditionally been done by the patrol staff, have also been contracted to private firms, and the patrol staff has been reduced accordingly. Increasingly, picnic site and service center maintenance is contracted. As is common for many of these contracts, a minimum of equipment is required, and therefore there is considerable interest in the contracts. In many cases, summer students bid on the contracts because only a pickup truck, a power mower, and small tools are required. Again, these are seasonal jobs, so that the contracts level the annual work load for the regular staff and eliminate the need to increase staff during the summer. The picnic site maintenance contracts provide service 7 days per week. If patrol staff was used, it would necessitate overtime payment in many cases. Other operations being contracted that were normally performed by the patrol crews are guiderail repair, fencing, bridge washing, and mowing. The Ministry has eliminated most of its backhoes, and these are now hired on an hourly basis to work with Ministry crews. It has been found that owner-operators have higher productivity because of their experience, which also results in less damage to their equipment and lower costs. The Ministry is also increasing its use of street sweepers when they are available from the private sector.

Service Crews

Contracts have not been used as extensively to date for the operations performed by the service crews. This has been because of a lack of expertise in the private sector and a lack of the special equipment required. Increasingly, private companies are acquiring this equipment and are taking on more complex work. Electrical repairs to traffic signals and street lighting have been contracted in some regions. Tree maintenance, tree moving, and weed spraying have been done by contract on a limited basis, although most of this work is still done by the Ministry. Sign manufacturing and sign erection are also contracted. As the contractors become more experienced and acquire more equipment, the number and size of the contracts will increase.

The new technology being applied to the zone-striping operation will probably result in more performance of this work by private firms. Until now,

the Ministry has constructed all its own striping machines and has just completed converting the remaining machines to the use of hot, quick-drying paint. Recently, contracts have been let for the application of hot-sprayed epoxy paint, inlaid extruded thermoplastic, and sprayed thermoplastic lines. All four of these techniques may be used in the future depending on durability, traffic volumes, traffic disruption, safety, and cost. The equipment required is expensive and could quickly become obsolete, so application by contractors is an attractive alternative.

Building and Facility Maintenance

There are many companies and individuals who are competent to build and maintain the Ministry's facilities. As a result, office cleaning, oil and gas tank installations, overhead door maintenance, and sand dome construction are usually contracted. For most of these jobs, there are enough interested contractors to provide competitive bids. The company supplying the sand domes has sufficient production volume to justify a factory with controlled temperature and humidity to facilitate gluing of the timber members. This was not possible for the small number of domes built annually by the Ministry.

TOTAL-MAINTENANCE CONTRACTS

The Ministry has not attempted total-maintenance contracts, in which one contract would be awarded for the total maintenance of a section of highway, although this is being considered. The Ministry has used a form of total contract maintenance on some remote northern roads, but there has not been much information about such contracts. In the north, contracts have been made with papermills to provide maintenance on the roads where their trucks operate. In these cases, however, the company usually provides a better level of service than that called for because of the high speeds at which their heavily loaded trucks operate. The companies decided that it was to their advantage to reduce the repair bills on their trucks by maintaining the road in better condition, regardless of whether it was covered in their contract. There are a number of reasons why total-maintenance contracts have not been used. Use of private firms has increased gradually, and the Ministry has staff and facilities at all locations. No permanent employees have been fired to facilitate contract work, but this would be necessary if total-maintenance contracts were considered. It is expected that problems would be encountered in specifying the work to be done and identifying the terms of payment.

The most promising work for total-maintenance contracts in Ontario would be in winter maintenance, where the sand contracts used on the urban freeways require the contractor to supply all sander trucks, all winter sand, and in some cases sand spreader bodies and snowplows. In these contracts the firms would also have to supply all snowplows and sander bodies, order salt, and provide supervision of the operations.

Total-maintenance contracts require consideration of the course of action to be taken when emergencies develop. In many cases the contractor does not have the capability to deal with these unforeseen problems and an agreement cannot be written to cover all eventualities.

CONTRACT ADMINISTRATION

The Ministry has implemented contract administration procedures that are appropriate for the various types of contracts in use. Authority has been delegated to the regions and districts to administer contracts up to a value of $100,000 for operations such as hot-mix patching, catchbasin cleaning, picnic site maintenance, and structural repair.

Contracts for the acquisition of equipment for day labor construction projects and maintenance activities are administered entirely at the district or regional level, and no monetary limits are imposed. The districts have the authority to acquire winter maintenance equipment such as loaders, sand trucks, and snowplows without monetary limit.

Standard procedures are in place for the administration of all contracts. Contracts for some operations require prequalification. Bid deposits are required for all tenders exceeding $10,000 in value, as are performance and payment bonds. The methods of payment to the contractor and of determining liquidated damages are also set out in the contracts. Procedures for issuing the contractor's infraction reports and performance reports have been established.

EQUIPMENT REPAIR

Following a study of the equipment repair operation, a comprehensive annual review of the relative cost of repairs in the private and Ministry garages was implemented. These reviews have shown that the cost of repairs in the Ministry garages was usually competitive, but that there were substantial advantages to having some repairs done by the private sector. In general, the specialized repairs, such as glass installation, wheel alignment, fuel-injector servicing, body work, and painting, could be done at less cost by the private garages. Heavy truck repairs could usually be performed at less cost by the Ministry garage. This was particularly true when repairs were required to snowplow trucks; the Ministry has a large fleet of trucks built to the same specification, and most of them have the same engine, transmission, rear axle, and alternator. As a result the garages have been able to reduce staff and maintain a level work load, thus reducing nonproductive standby. The Ministry has considerably reduced the time spent by its mechanics traveling to service equipment in the field and transporting equipment into the district garages.

BASIS FOR PAYMENT

The Ministry has selected different bases for payment for various maintenance contracts. The payments are structured so as to minimize record keeping and inspection requirements, provide the contractor with the flexibility to maximize his efficiency and productivity, and also to encourage competition. Payment for accomplishment is used wherever possible. Grass mowing, which was formerly paid for by the hour in some regions, is paid for by the hectare. This has resulted in the use of more productive equipment by the contractor and lower overall costs. Unit prices are used to pay for catchbasin cleaning, calcium chloride application, and gravel supply (per catchbasin, ton, and cubic meter). Picnic site maintenance is paid for by the week in order to provide cash flow for the individuals and small contractors who provide this service.

A different method of payment is required for winter maintenance operations such as snowplowing and salting because of the uncertainties of the weather. The contractors are paid a fixed daily standby rate set by the Ministry plus an hourly rate for the time they operate. This hourly rate is bid by the contractors in competitive tenders.

SUMMARY

The use of contracts to maintain highways in Ontario has been proven to be advantageous in many circumstances. It is possible to reduce expenditures and staff, resulting in a leaner, more flexible organization. The Ministry is now in a position to utilize new technology and is less restricted by obsolete equipment or by staff with the inappropriate expertise or capabilities. Employee morale may be improved if dangerous or unpleasant jobs can be done by contractors who specialize in this type of work.

On some projects, quality control has suffered because the contractor's employees were unskilled or because MTC inspectors were not adequately trained. The Ministry has lost its expertise in operating crushing and asphalt plants, and these operations will have to be contracted in the future. This loss of expertise will certainly be encountered in some other operations in the future. Employee morale may suffer if the employees perceive that their jobs are in jeopardy or if they believe that their opportunities for advancement are restricted because of reduced staff levels.

There are some risks involved with increasing contract maintenance, and these potential problems must be analyzed. During the 1982-1983 winter, two of the Ministry's contractors experienced financial difficulties and were not able to continue operating. In these cases the Ministry was able to obtain some replacement equipment and to relocate some of its own equipment so that there was no reduction in service. As the percentage of maintenance work done by contract increases, the consequences of this action could be more serious, especially if specialized equipment is involved. There were no problems when it was necessary to terminate the contract trucks used for winter sanding, because most of these were standard dump trucks on which a Ministry-owned sand spreader was mounted. There are a large number of these trucks available, and the spreader can be moved from one truck to another in one day. It would be much more difficult to obtain specialized equipment such as snowplows. The consequences of a contractor's being unable to fulfill his contract or of the Ministry's having to cancel a contract because of poor performance will have to be considered for the various types of contracts.

The trend toward increased maintenance by contract will require changes in the future. Patrol supervisors will require different skills to inspect contractors' work and to deal with contractors' staff. As a result, training programs will be necessary to instruct Ministry personnel in the use of contract diaries and reports and in interpreting and administering specifications and contracts. It will also be necessary to prepare operating instructions for many jobs. In the past, the expertise of the patrol staff was relied on, but in some cases this is likely to be lost because of the small crews. More descriptive operating instructions and quality standards will be required in order to tender work.

A more comprehensive maintenance management system will be required in order to document the accomplishment and related costs of contract work, as well as work by the highway department. When the Ministry's maintenance management system was initially developed, there were few contracts, and data relative to contracts were not included in the reporting system. Because an extensive amount of maintenance work is now being done by contract, the decision to use contracts or Ministry forces will depend on having adequate records of all costs.

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Problem Solving—Key to Successful Contracting for Maintenance

JOHN C. WHITMAN

ABSTRACT

Interest in contracting for highway maintenance has increased rapidly in recent years. With this increasing interest have come more and more demonstrations of contracting. Highway agencies are encountering problems that they may not have previously experienced as they begin to demonstrate contracting for highway maintenance. The key to successfully contracting for maintenance is to solve those problems as they arise. Described in this paper are many of the common problems that have been encountered in demonstrations of contracting for maintenance and the solutions that have been developed and successfully applied. These common problems include planning realistic maintenance work programs, encouraging contractors to participate in the procurement process, fostering an atmosphere of cooperation, and monitoring work as it is being performed. Practical guidance is provided to the middle manager and the careful planning processes are described along with the positive approach necessary to ensure that contracting for highway maintenance attains its full potential.

Interest from all levels of government in contract-