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Committee of Urban  
Transport Authorities

**DRAFT UTG 6**

**MAINTENANCE  
MANAGEMENT FOR  
LARGE MUNICIPALITIES**

OCTOBER 1989



**URBAN TRANSPORT GUIDELINES**

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LARGE MUNICIPALITIES**

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COMMITTEE OF URBAN TRANSPORT AUTHORITIES  
FOR THE MANAGEMENT OF  
LARGE MUNICIPALITIES

October 1989

UTG 6

## **PREFACE**

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**URBAN TRANSPORT GUIDELINES (UTG) is a series of documents written for practising transportation engineers which describes current recommended practice in selected aspects of urban transportation. They are based on South African experience and research and have the full support and approval of the Committee of Urban Transport Authorities.**

**To confirm their validity in practice, UTGs are circulated in draft form for a two-year period before receiving the final approval of CUTA. During this period, suggestions for improvement may be sent to:**

**The Secretary  
Committee of Urban Transport Authorities  
PO Box 395  
0001 PRETORIA**

**After final approval by CUTA, the revised document will be issued as a full UTG in both official languages.**

## **SYNOPSIS**

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The purpose of these guidelines is to present to municipal engineers and managerial staff the rationale of maintenance management systems, to explain how the systems' components function and interrelate and to give an insight into what is involved in establishing such a system.

## **SINOPSIS**

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Die doel van hierdie riglyne is om aan munisipale ingenieurs en bestuurspersoneel die logiese gronde vir instandhoudingsbestuurstelsels uiteen te sit, om te verduidelik hoe die stelselkomponente funksioneer en onderling verbind is, en om 'n insig te gee in dit wat betrokke is by die vestiging van so 'n stelsel.

## **KEYWORDS**

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Maintenance management systems

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# **1 INTRODUCTION**

## **1.1 Background**

### **1.1.1 General**

The management of the maintaining of roads and streets as it is practised in many parts of the world today was developed in North America in the 1960s. Before that decade, road maintenance had generally been considered a task too unpredictable, and too difficult to define, to lend itself to systematic planning and organizing. After the 1950s many American road authorities found that they had to prepare themselves to cope with the increasing maintenance needs of the nation's road network which was not only expanding but also subject to accelerated wear and tear caused by a growing vehicle population. Aggravating this situation was the fact that the increasing maintenance needs were hardly ever matched by an increase in maintenance funds.

Many of the road authorities responded to the demands made on them by developing methods and procedures aimed at improving the effectiveness of their maintenance operations. By 1970 there was general agreement among the road authorities on the concepts and objectives of maintenance management. This uniformity of approach was largely due to the efforts of engineers and researchers who pioneered maintenance management by applying industrial engineering techniques and a systems approach to road maintenance.

Since the implementation of the first maintenance management systems a wide variety in the methods and procedural details has evolved. It is perhaps their flexibility and their capacity to satisfy unique demands which have given maintenance management systems their wide practical appeal.

Today, organizations ranging from highway departments to local authorities in a number of countries find maintenance management an indispensable tool for their road and street maintenance. In South Africa, however, maintenance management has, for various reasons, made little impact. It is nonetheless within the capability of many South African municipal authorities to develop a maintenance management system. These guidelines explain how it can be done.

The principles of maintenance management do not preclude the option of privatising aspects of the maintenance work, either by contracting out part or the whole of the actual maintenance operation or the management of maintenance. As a first step in providing guidelines on maintenance management in general, this document concentrates on the management of in-house resources as this seems most urgent, being the approach most prevalent among South African municipalities in undertaking maintenance. This does not imply that privatisation is in anyway a less desirable option, nor is it intended either to promote nor discourage it.

### **1.1.2 Maintenance management in South Africa.**

South African municipalities, like many of their counterparts elsewhere in the world, rarely have enough funds for properly maintaining their roads and streets. Sometimes appropriations are limited by revenue or funds may be directed to needs which are perceived to be greater than those of road maintenance.

It is estimated that in the 1984/85 financial year South Africa's 342 municipalities spent more than R60 million on the maintenance of their combined 43 000 km road network. A dearth of adequate and up-to-date statistics on municipal road maintenance does not permit the making of meaningful comparisons. Two facts, however, clearly emerge from the information which is available. Firstly, owing to the pernicious effect of inflation there has been a general decline in the real value of the money spent on road maintenance. Secondly, the motor vehicle population which travels on the country's road network continues to grow steadily.

Whilst in real terms maintenance expenditure fell some 40 per cent from 1977 to 1983, the vehicle population during the same period grew by 30,78 per cent, from 3,129 million to 4,093 million. Bearing in mind also that road networks need more attention as they age, it is clear that municipal engineers and administrators who are concerned with road maintenance are increasingly called upon to do more work with less money. Maintenance management systems can assist them in this task and as an added bonus can lead to happier and better motivated maintenance staff. How they can do this is explained in broad concept in the remainder of this section.

## **1.2 Maintenance management concepts**

### **1.2.1 Maintenance**

Maintenance management deals with the maintenance of the works which make up road and street networks. Maintenance in this sense has the objective of preserving, repairing and restoring the maintainable features of the networks to their designed or other predetermined condition. The maintainable features comprise roadway elements such as the carriageways, shoulders, kerbing, sidewalks, verges, drainage facilities, bridges, tunnels, signs, markings, signals, lighting, street furniture and fixings.

The term maintenance is normally associated with those activities which are designed to preserve rather than improve the roadway. There is, however, no clear dividing line between preservation measures and small improvements. A result of this is that road authorities interpret the term maintenance differently according to their particular needs and internal organizations.

Generally, maintenance is understood to comprise routine tasks and a

number of projects which require special authority, such as resurfacing by chip and spray or slurry seal and thin overlays. Major projects which involve upgrading, rehabilitation or reconstruction are not normally included among maintenance activities. All maintenance activities may with advantage be planned, performed and controlled within the ambit of a maintenance management system.

### 1.2.2 Maintenance management systems

The maintenance of a road network involves the performance of many different tasks. Large networks require a large work force to carry out this multiplicity of tasks. Maintenance management is principally concerned with managing the people who have a responsibility for maintaining the road network. Stated more comprehensively, maintenance management has the objective of promoting the effectiveness of maintenance operations by managing resources, i.e. by managing labour, equipment and material. To achieve this aim, use is made of the well-established management functions of planning, doing and comparing. For the purpose of maintenance management these functions can be more appropriately stated as planning, budgeting, scheduling, organizing, implementing, reporting and evaluating.

When the process of planning, budgeting, organizing, scheduling, work completion, reporting and evaluation is carried out in a continuous sequence as shown in Figure 1, it can be said that systems concepts have been met. Maintenance management systems thus consist of systematic and integrated procedures to be followed for coordinating road maintenance activities in an organized manner.

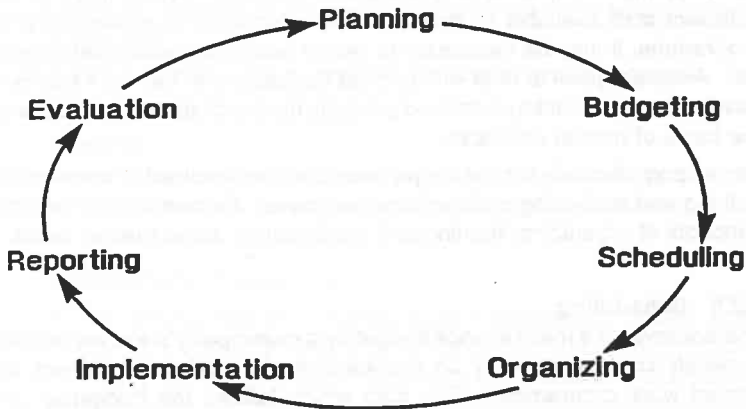


FIGURE 1: Relationship of system components

### **1.2.3 Planning**

In the planning phase of maintenance management an estimate is made of the total amount of work which must be performed on an annual basis to meet a predetermined level of service for an entire road network. The amount of work so estimated is referred to as the annual work programme for the network.

The techniques which are used to determine an annual work programme are explained in Section 2.

### **1.2.4 Budgeting**

The budgeting process is carried out in four steps. The first step is the determination of resources required. In this step the manpower, equipment and materials needed to complete the annual work programme are estimated. In the second step unit costs are applied in order to provide financial estimates for deploying the required resources. The third step comprises the authorization of the financial estimates by the local authority. Step four consists of apportioning authorized funds among maintenance depots or field operating units.

Section 3 deals in some detail with budgeting and the allocation of resources.

### **1.2.5 Organizing**

The budgeting process identifies the resources necessary to implement the work programme. It follows that the next step is to ensure that these resources will be available. This calls for organizing the supply of a suitable work force as well as adequate offices, quarters, stores, plants, vehicles, materials, tools and protective clothing. When there is not sufficient staff available to meet the peak demands of an annual work programme, it may be necessary to recruit temporary additional personnel. Another option to deal with cyclical fluctuations in the work load is to have some of the tasks performed privately by direct labour methods or on the basis of annual contracts.

Organizing also calls for the longer term planning involved in assembling, training and motivating maintenance personnel. Section 6 deals with the concepts of organizing, training and motivation in some greater detail.

### **1.2.6 Scheduling**

The approval of a maintenance budget by a municipality's elected officials generally confers authority on municipal senior staff to implement the annual work programme. The step which follows the budgeting and organizing phases involves the communication of the annual programme's objectives to the maintenance field staff. This communication is achieved

by scheduling. A distinction is made between long-term and short-term scheduling.

In long-term scheduling the maintenance needs identified in the annual work programme are arranged in a practical work plan. Such a work plan makes allowance for the seasonal nature of certain activities and distributes the work load evenly over the year so that work requirements and available resources are in balance. Monthly and fortnightly schedules emphasize the goals of the annual work programme.

Short-term scheduling is the method whereby the annual work plan is translated into action. Weekly and daily schedules assign specific tasks to individual gangs or teams. Short-term schedules also authorize maintenance gangs to perform their work on a day to day basis.

Scheduling and authorization procedures are discussed in Section 4.

### **1.2.7 Reporting and evaluating work performance**

The monitoring of work performance is a fundamental function of a maintenance management system. By evaluating information which is relevant and accurate and reported on time, maintenance managers and supervisors are in a position to make objective management decisions. Effective monitoring establishes where problem areas exist and what corrective measures must be taken to improve performance and to ensure compliance with the work programme.

A balanced evaluation of work performance comprises a review of fiscal expenditure, a comparison of work accomplished with work programmed and an assessment to determine whether resources were used effectively and economically. Criteria used in the planning phase of maintenance management can be kept up to date by the feedback of suitable information from the field.

Procedures for reporting and evaluation are discussed in Section 5.

## **1.3 Benefits**

Municipal authorities may expect many real benefits from a maintenance management system. Some major benefits are described below:

### **(a) *Improved use of resources***

As all components of a maintenance management system are directed towards better utilization of resources, this benefit is self-evident. Planning identifies the most pressing maintenance needs and allocates resources to this work. Careful scheduling ensures that the best use is made of available resources throughout the year. Maintenance gangs are organized and equipped and work

methods are established so that significant maintenance activities can be performed with optimum efficiency. Management information is collected and distributed to allow appraisal of the work done and the taking of corrective action if necessary.

**(b) *Effective expenditure of money***

A major benefit of the system is that it ensures that funds are spent on the most important work first, which results in the most effective expenditure of these funds. Increased worker productivity resulting from maintenance management also contributes to more effective expenditure of maintenance funds. Experience has shown that savings of the order of 20 to 30 per cent can be achieved. Municipalities will thus be able to choose a course of action which embraces the options of keeping maintenance standards unchanged at reduced cost or improving service levels at constant funding.

**(c) *Uniform standards***

Maintenance management introduces uniform standards for planning and work performance. In the planning stage consistently applied quality standards will ensure that maintenance funds are equitably distributed throughout a municipality's maintenance zones, districts and suburbs. In the field effective monitoring and enforcement of uniform work methods will lead to better quality of work.

**(d) *Management information***

Under a maintenance management system information which is necessary for management purposes is made readily available. Costing systems and maintenance inventories make it possible to budget on the basis of realistic costs and actual maintenance needs. The implications of budget cuts can be identified and evaluated by decision makers. Feedback on progress in the field enables managers to direct and control maintenance operations so that budget objectives can be achieved.

**(e) *Employment conditions***

The maintenance of roads and streets is sometimes considered work of low status. Maintenance management systems have been known to remove this stigma by making the maintenance divisions of a city or town engineer's department into a highly efficient and professionally run organization. The quality of workers can be expected to improve as maintenance management systems cre-

ate a work environment in which cost, productivity, and quality consciousness are encouraged and rewarded. Improved communications promote better understanding and cooperation between supervisors and field personnel. Experience shows that a maintenance management system can kindle a high degree of employee morale and job satisfaction.

#### **1.4 Possible pitfalls**

The introduction of maintenance management systems is not always without problems. Some of the pitfalls to be avoided are described below.

**(a) *Inadequate preparation***

The development of a maintenance management system is a major task which must not be undertaken lightly. It is advisable to assess carefully what manpower and funds are required to develop a system and to be prepared to commit these resources for the duration of several years. Even after its implementation a maintenance management system will require members of staff on a full-time basis to service the system and keep it up to date.

**(b) *Lack of staff involvement***

Problems which have arisen in the implementation of maintenance management systems have often been the result of employee resistance. It is important that staff realize that the system will not present a threat to them but will actually assist them in their work. The support and involvement of top management are essential ingredients in the preparation of a successful management system.

Another problem may arise when standards are set without lower and middle management participation. It has been found that standards based on work studies in which maintenance staff have been involved generally give credible results which are more readily accepted. For a system to be successful it is necessary that it be developed with the participation of staff at all levels and that it be thoroughly understood by them.

**(c) *Over-refinement of the system***

It is important to get a maintenance management system in operation as soon as possible. An unduly long development period may dampen the enthusiasm of the staff involved and place the credibility of the entire system at risk. Factors which could unnecessarily prolong the development phase of a maintenance management system are:

- **Too large a number of maintenance activities**
- **Definitive performance standards based on the application of sophisticated time and motion studies**
- **Complicated procedures for reporting and summarizing work performance.**

**The need to adjust and refine standards and procedures will become evident when the system is put to use.**

## 2 ANNUAL WORK PROGRAMME

The first objective in the planning phase of maintenance management is to determine the amount of maintenance which needs to be done. This amount of maintenance or work load when estimated for a municipality's financial year is often referred to as the annual work programme. Four basic questions must be answered before a meaningful annual work programme can be drawn up. These questions are:

- (a) What requires maintenance
- (b) What maintenance is required
- (c) When is maintenance required
- (d) How much maintenance is required

### 2.1 Maintenance features

The answer to the first question clearly must be that the whole of the road or street network must be maintained. The maintenance needs of an entire road network are not readily determined. However, networks consist of a number of physical items which are located in the reserves of the roads and streets. These items can be identified so that each one requires a unique maintenance treatment. Such items are called maintainable, or more simply, maintenance features. Paved or unpaved road surfaces, kerbs and channels, sidewalks, signals, signs and road markings, drainage pipes and structures, bridges, trees and roadside plantings are examples of maintenance features.

Some features such as road surfaces, kerbs and sidewalks are continuous and must be measured; others such as kerb inlet structures and road signs are classified as discrete maintenance features and can be counted. Each feature has its own specific maintenance needs and the annual work programme is based on the needs of all the features in the road network. Some typical maintenance features are listed in Table 1.

The first step in determining the annual work programme is to get a listing or inventory of the quantities of all maintenance features. A maintenance feature inventory is an essential part of a maintenance management system and hence is one of the first system elements to be developed.

#### *Example:*

The features inventory of a municipality may show that it has quantities as follows to maintain for two typical roadway elements.

- Bitumen surfaced roads : 1 000 lane km
- Grassed areas : 200 ha.

## **2.2 Maintenance activities**

What types of maintenance do roadway features require? Each feature can become defective or deficient in some way and will hence require remedial treatment. For each maintenance feature one or more activities can be identified which will provide this remedial treatment by repairing or replacing the feature and restoring it to some predetermined physical condition. Activities usually describe the work done by units of workmen or gangs and not by individual workers in a gang. Only significant activities need be identified. In practice it has been found that some 40 to 50 activities are sufficient to describe about 90 per cent of the work load. Activities which are not related to maintenance features but describe administrative and overhead work are also necessary.

All activities must have measurable work units assigned to them. The sealing of cracks in blacktop road surfaces may thus be measured in litres of sealant, cleaning of drainage structures may be expressed in the number of structures to be cleaned and overhead activities, such as travelling to the job, are measurable in man-hours. The classification of maintenance work into specific activities is, therefore, another essential element of a maintenance management system which must be developed before an annual work programme can be drawn up. A number of typical maintenance activities is listed in Table 1.

## **2.3 Maintenance levels**

When is maintenance required? The answer to this question depends on the level of service which a local authority envisages for its road network. This means that criteria are required to describe what a maintenance feature should look like or how it should perform if the service to road users is not to fall below minimum levels defined in terms of maintenance policy. In maintenance management systems quality standards describe for each maintenance activity the condition or deficiency of specific roadway features which will initiate a maintenance effort. Quality standards thus help to determine what action must be taken and when to take it.

The selection of quality standards is influenced by the safety and comfort of the road user, economic considerations and, to some extent, by aesthetics. In practice it is not unusual that maintenance levels are set in an intuitive and informal manner by senior maintenance personnel who rely on past experience. However, for a more scientific approach, there are comprehensive methodologies for the selection of quality standards, one of them in the form of a manual published by The Transportation Research Board, Washington D.C.\*

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Manual for the selection of optimal maintenance levels of service: NCHRP Report 273, Washington D.C., December 1984.

ACTIVITY	CODE	WORK UNIT	APPLICABLE FEATURE	FEATURE INVENTORY UNIT
<b>SURFACED ROADS</b> 100				
Making up depressions	101	square metre	Bituminous road surface	lane kilometre
Pothole patching	102	square metre	Bituminous road surface	lane kilometre
Crack sealing	103	kilolitre sealant	Bituminous road surface	lane kilometre
Slurry seal	104	square metre	Bituminous road surface	lane kilometre
Chip and spray resal	105	square metre	Bituminous road surface	lane kilometre
Premix resurfacing	106	square metre	Bituminous road surface	lane kilometre
After hours emergencies	107	man-hours	N/A	N/A
<b>UNSURFACED ROADS</b> 110				
Reforming earth roads	111	square metre	Gravel or earth road surface	kilometre
Grading earth roads	112	kilometre	Gravel or earth road surface	kilometre
<b>ROAD EDGES</b> 120				
Repair and maintain kerb & channel	121	metre	Concrete kerb and channel	kilometre
Repair and maintain precast haunching	122	metre	Precast haunched edges	kilometre
<b>FOOTWAYS</b> 130				
Repair and maintain blacktop footways	131	square metre	Bituminized footways	kilometre
Repair and maintain paved footways	132	square metre	Concrete paved footways	kilometre
Level unconstructed footways	133	square metre	Unconstructed footways	kilometre
<b>ROAD VERGES</b> 140				
Mow grass	141	hectare	Grassed verges	kilometre
Cut and trim trees	142	kilometre	Tree lined verges	kilometre
<b>STORMWATER DRAINAGE</b> 150				
Repair and maintain KI's & MH's	151	number	Stormwater inlet structures	number
Repair and maintain stormwater pipes	152	metre	Stormwater pipes	kilometre
Repair broken KI tops	153	number	Kerb inlets	number
Clear stormwater blockages	154	man-hours	Stormwater pipes	kilometre
After hour emergencies, stormwater	155	man-hours	N/A	N/A
Clear open drains	156	metre	Open stormwater drains	kilometre
<b>BRIDGES</b> 160				
Repair and maintain bridges	161	man-hours	Bridges	number
Clear and maintain streamwork	162	man-hours	Bridges	number
<b>ROAD TRAFFIC SIGNS</b> 170				
Replace road traffic signs	171	number	Road traffic signs	number
Renovate road traffic signs	172	number	Road traffic signs	number
Replace street name plates	173	number	Road intersections	number
Renovate street name plates	174	number	Road intersections	number
Stencil street names on kerb	175	number	Road intersections	number
<b>ROAD TRAFFIC MARKINGS</b> 180				
Renovate road striping	181	litre paint	Bituminous road surface	kilometre
Renovate lettering and symbols	182	litre paint	Bituminous road surface	kilometre
<b>TRAFFIC SIGNALS</b> 190				
Repair and maintain signals	191	number	Traffic signals	number
<b>OVERHEADS</b> 200				
Inspection	201	man-hours	N/A	N/A
Plant servicing	202	man-hours	N/A	N/A
Plant standby	203	man-hours	N/A	N/A
Travelling	204	man-hours	N/A	N/A
Depot maintenance	205	man-hours	Maintenance depots	number
Supervision and clerical	206	man-hours	N/A	N/A

**TABLE 1 : List of Typical Maintenance Activities and Applicable Features**

*Example:*

A local authority may define service levels with regard to potholes and grass verges by selecting quality standards as follows :

- Pothole patching : potholes must be filled in as soon as they exceed 5 cm in depth and/or 15 cm in diameter.
- Grass mowing : grass must be cut when it has grown longer than 15 cm.

## **2.4 Quantity standards**

A method for estimating the amount of work needed to provide the desired levels of service for the road user public involves using work quantity planning values or quantity standards for the various maintenance activities. Quantity standards are commonly expressed as the number of activity work units which must on average be performed each year on a maintenance feature in order to maintain a predetermined level of service. The work units can be based on frequency of work application or on estimated quantity of work performance. Quantity standards represent average planning values for all roads with similar characteristics and not for individual sections of a particular road.

*Example:*

The quantity standards given below for pothole patching and grass cutting exemplify respectively the use of quantitative measure and the concept of frequency for estimating purposes.

- Pothole patching : Patch 30 m<sup>2</sup> per lane km of bitumen surface roadway per year.
- Grass mowing : Cut grass three times per year, i.e. cut three hectares of grass for each hectare of grass area.

Although denoting average values for a whole road network, quantity standards must be sufficiently accurate to provide realistic bases for estimating the amount of each kind of work required to maintain an adequate level of service. It is, accordingly, important that quantity standards are periodically reviewed to ensure that they remain appropriate. If a cut must be made to maintenance funding, it may be necessary to adjust quantity standards and corresponding levels of service to reflect the change. For instance, more potholes may be allowed to develop or the standards for the cutting of grass may have to be relaxed before maintenance must take place.

## 2.5 Work programme computation

The computation of an annual programme is a straightforward matter once the features of a road network have been inventoried and quantity standards for each maintenance activity established.

For any maintenance activity the total yearly amount of work to be done can be calculated as follows:

Work load = Quantity from inventory x Quantity standard.

The sum of the work loads for all maintenance activities represents the annual work programme.

For large municipalities, the process of computing a work programme by using the concept of quantity standards is normally performed as a head office function. Smaller municipalities may prefer to estimate the work loads by assessing the actual needs of every road during comprehensive inspections of the road system. In such a case a preliminary programme may be drawn up by superintendents and submitted to management in the head office for adjustment and approval.

### *Examples:*

The following examples show how work loads can be estimated from inventory quantities and quantity standards.

Maintenance activity	:	pothole patching
Work measurement unit	:	square metres of premix patching
Quantity standard	:	30 m <sup>2</sup> per lane km per year
Maintenance feature	:	bituminous road surface
Quantity from inventory	:	1 000 lane km
Work load	:	1 000 x 30 = 30 000 m <sup>2</sup> of patching

Maintenance activity	:	grass mowing
Work measurement unit	:	ha
Quantity standards	:	3 ha per ha
Maintenance feature	:	grassed areas
Quantity from inventory	:	200 ha
Work load	:	200 x 3 = 600 ha

However before the annual work programme can be estimated the following system elements must be developed.

- Features inventory (or estimated features summary)
- Activity identification
- Quality standards
- Quantity standards.

The development of each of these elements is dealt with in turn in Section 7.

### **3. BUDGETING**

The step which follows the computation of the annual work programme is the determination of the resources necessary to act upon the programme. This step consists of converting work loads expressed in the measurement units of a number of activities into man and machine hours and quantities of material and eventually to estimated cost per activity. The number of hours of labour and the plant and the amount of material needed to complete the annual maintenance programme clearly depend on the effectiveness with which the maintenance activities are performed. Maintenance management systems promote effective maintenance work by setting standards for each maintenance activity and by measuring work performance against these standards.

#### **3.1 Performance standards**

Performance standards, sometimes called maintenance standards, for a maintenance activity specify how the activity can be most effectively performed. Performance standards can be derived from the results of time and motion studies, but this time-consuming method could unduly delay the implementation of a maintenance management system. A more practicable approach is to set reasonable initial standards which are based on available information and on the judgment of experienced maintenance staff. Such initial uniform standards can be refined and updated upon feedback of appropriate data when the maintenance management system is in operation.

Municipalities which make use of work study methods in their construction and maintenance organizations may prefer to use this technique to set performance standards for some activities in the long term.

Performance standards provide the following kinds of information for each maintenance activity:

- Description and purpose of the activity.
- The most appropriate size and manpower composition of the maintenance gang.
- The equipment most suited for performing the activity.
- The materials to be used.
- The proper method to do the work, described in a step by step fashion.
- A realistic estimate of the daily amount of work which the gang is expected to perform.

The last-mentioned criterion, also called the production standard for the activity, plays a key part in the budgeting process as it is used in determining the resources required to achieve an annual work programme. Performance standards can be conveniently summarized on a single sheet of paper as illustrated in Figure 2.

The Figure is given as an example of what a performance standard looks like; it does not necessarily represent the recommended method for the maintenance activity concerned.

### 3.2 Computation of resource requirements

Work load quantities can readily be converted into the resources needed to do the work by using the concept of production standards as shown in the relationship below:

Resources needed = Work load : Production standard.

#### *Examples:*

The principle involved is illustrated by extending the examples from Section 2.5.

Maintenance activity : Pothole patching  
Work load : 30 000 m<sup>2</sup>  
Production standard : 15 m<sup>2</sup> per gang per day  
Resources needed - labour :  $30\ 000 \div 15 = 2\ 000$  gang days

Maintenance activity : Grass mowing  
Work load : 600 ha  
Production standard : 1 ha per gang per day  
Resources needed - labour :  $600 \div 1 = 600$  gang days

In the first example the quantity of material required can be readily calculated whereas in the second there is no construction material involved. In both examples one can, by applying performance standards criteria, convert gang days to man-hours and machine-hours, which are convenient units for costing purposes. After the system has been working for some time the average cost per gang day can be determined and this will assist in calculating total costs.

### 3.3 Financial budget

The step which follows after the assessment of resource needs is the determination of the cost of employing the manpower and providing the

PERFORMANCE STANDARD	
<b>ACTIVITY:</b>	POTHOLE PATCHING.
<b>WORK UNITS:</b>	Square Metres. (m <sup>2</sup> )
<b>ACTIVITY DESCRIPTION:</b>	
Repair potholes in road surface with bituminous premix.	
<b>PURPOSE OF ACTIVITY:</b>	
To maintain the quality and protect the road base from further deterioration and to avoid damage to vehicles.	
<b>POSSIBLE DEFICIENCIES:</b>	
Road surface breaking up causing holes to develop and exposing the road foundation.	
<b>POSSIBLE CAUSES OF DEFICIENCIES:</b>	
Excessive weathering of the road surface; Excessive traffic load; Base failures; Water ingress.	
<b>WHEN IS WORK REQUIRED:</b>	
<ol style="list-style-type: none"> <li>1. A: Work to be done immediately. Danger to life e.g. if the hole is 50mm or greater in depth.</li> <li>2. A: Work to be done immediately. Danger to life if e.g. if hole is deeper than 25mm on a bus route or main road.</li> <li>3. B: Work to be done within 2-5 working days. Danger to property e.g. if the hole is less than 25mm in depth on a bus route or main road.</li> <li>4. B: Work to be done within 5 working days. Danger to property e.g. if the hole is between 50 &amp; 25mm in depth (Minor Road).</li> <li>5. C: Work to be scheduled to prevent further deterioration. Potential danger e.g. if the hole is less than 25mm in depth. (Minor Road).</li> </ol>	
RESOURCES	WORK-METHOD
<b>GANG SIZE</b> 1 Operator 3 Labourers  2 tonne truck (or 4.5t truck shared with another gang) and labourers for loading.	<ol style="list-style-type: none"> <li>1. Set out safety equipment as per manual.</li> <li>2. Repair deficiencies as per manual.</li> <li>3. Clean up site and remove surplus material.</li> <li>4. Remove safety equipment.</li> </ol>
<b>EQUIPMENT</b> 1 Hand stamper 1 generator with pavement breaker; Mechanical rammer; Tack coat brushes, Gas bottle and torch (in rainy weather) Hand tools, Safety equipment (see manual)	<b>PRODUCTION PER DAY.</b>
<b>MATERIAL</b> Buildup; Emulsion (Tackcoat); Riversand;	15m <sup>2</sup>

**FIGURE 2: Sample of Performance Standard**

(Source: Johannesburg C.E.D.)

plant and materials necessary for the year in question. This cost can be estimated by applying average unit costs to man-hours of labour, hours of plant hire and materials quantities. The calculation involved is again a simple one as is demonstrated by the expression given below:

**Resource requirement x Unit cost = Budget.**

Personnel who prepare budgets hence rely on the availability of appropriate unit cost information. Most municipalities have an accounting department which collects data on wages and salaries, equipment hire and purchase price of materials. These data can be converted to unit rates as a matter of course.

Detailed breakdowns of labour cost by class of personnel is not necessary. Weighted average rates applied to all field staff is normally sufficient for the purpose of budget preparation. Plant hire should reflect the cost of purchasing, operating and maintaining of the various classes of equipment and not of individual plant items. Materials unit cost can conveniently be based on the average purchase price and handling cost for a class of material determined for a period of a year or more. The procedures involved in budget submissions and approvals, although very important, have little relevance to maintenance management techniques and are accordingly not dealt with in these guidelines. The approval of a budget, however, confers authority for the implementation of the work programme for which the budget was prepared. The approved budget also functions as a control on the implementation of the work programme.

### **3.4 The performance budget**

Budgets which show the cost of labour, equipment and material based on the requirements of each maintenance activity are performance budgets. Maintenance management systems which use performance-based budgeting are commonly known as performance budgeting systems.

Performance budgeting represents a major advance over budgeting techniques which rely solely on historical data. Performance budgeting systems provide detailed and comprehensive information which can be used to allocate resources effectively. Performance budgeting enables maintenance managers to justify requests for maintenance funds and inform elected officials and decision makers of the effect of a budget cut. Management is furthermore offered a means of assessing alternative options should the available money be insufficient for an annual programme.

Although one of the aims of a maintenance management system is to reduce unplanned work, it is usually necessary to make provision in maintenance budgets for emergency work which cannot conveniently be categorized as a specific activity.

## **4. SCHEDULING**

Work scheduling starts the execution phase of a maintenance programme. Scheduling is the process whereby the objectives of an approved work programme are communicated to maintenance supervisors who, in turn, will assign the work as definite tasks to maintenance gangs on a day to day basis. Scheduling clearly is a vital part of a maintenance management system as without effective communication a work programme cannot be successfully executed. Important steps in the scheduling process are the annual work calendar, priority classification and inspection of the assets to be maintained and short-term scheduling. When maintenance work is to be contracted out, scheduling will be done in consultation with the contractors to ensure that the needs of both parties are met.

### **4.1 Annual work calendar**

A work calendar indicates when the most significant activities are to take place during the year. Most activities can be performed throughout the year, but some, such as mowing of grass or cleaning of stormwater catchpits, are of a seasonal nature. This means that demand for resources could peak during some months of the year and slacken off at other times. As labour resources are normally available at a fairly constant rate throughout the year, it is not practicable to meet a fluctuating demand for manpower. This can be overcome by contracting out some of the peak work load and, where practicable, by distributing activities which are not of a seasonal nature over the slack periods. A balanced work calendar thus links, in a practical way, maintenance needs with resources in relation to a time scale.

The annual work calendar, suitably subdivided into quarters or four-monthly periods, is the work plan which authorizes field supervisors to allocate resources and expend the necessary money to meet the maintenance needs. Maintenance superintendents do this by means of short-term scheduling and assigning daily tasks to the maintenance gangs. It is their task to determine when, where and by whom the work must be done. In this way they are directing work rather than meeting emergency situations only.

### **4.2 Priority of maintenance work**

When must the work be done? The amount of work which can be assigned at any particular time is limited. Some work must, in the interest of public safety, be carried out as soon as the need for it occurs. Such urgent work includes repair of a road which has become dangerous or impassable and the reinstatement of pavements which have been cut to lay essential services at short notice. Seasonal activities, as already mentioned, must be performed within a particular time period or season.

The remaining activities may be scheduled almost any time of the year. The supervisor responsible for the scheduling actually makes the decisions when and where the day to day routine activities are to be performed. The scheduler can be much assisted in his task if the roads are regularly inspected and their condition reported.

A procedure which has been used to good effect by the Johannesburg City Engineer's Department (C.E.D.) is that the inspector enters the maintenance needs perceived by him or reported by the public on a sheet of paper which has been prepared to give full particulars of the job to be done. This form also serves as a work report which must be completed by the maintenance ganger or foreman assigned to do the work. An example of an Inspection and Work Report Sheet is given in Figure 3. The inspector records on his part of the form the seriousness of the deficiency and assigns a priority coding which indicates when the work must be scheduled. This priority coding is based on a simple ranking system to assist the scheduler when to schedule a particular job.

i.e. Priority A: danger to life - do immediately

Priority B: danger to property - do within the week; etc.

#### **4.3 Short-term scheduling**

In the procedure used by Johannesburg, field data are entered on a Job Register and Summary of Completed Jobs form. This form, which is shown in facsimile in Figure 4, is completed in successive stages by filling in the data reported by the inspectorate staff and the work details recorded by the field staff respectively on the Inspection and Work Report Sheet. Maintenance tasks which have been identified but not yet completed are entered on a Bi-weekly Work Schedule. The work scheduler chooses work for daily assignment from the tasks listed on the Bi-weekly Schedule, an example of which is shown in Figure 5.

As mentioned before, the day to day scheduling is done with the aid of the Inspection and Work Report Sheet. The inspectorate staff have described on this form the activity to be performed, the amount of work to be done and the location of the job. This information enables the scheduler to assign to the correct place an appropriate gang, manned and equipped according to the activity's performance standard.

The Inspection and Work Report Sheet issued by the scheduler authorizes and instructs the maintenance gang to do the work. The information which must be entered on completion of the job serves as a record of the work accomplished, the resources used and the gang's efficiency.

<b>ROADS AND WORKS BRANCH</b>				<b>TAK PAAJE EN WERKE</b>			
INSPECTION AND WORK REPORT SHEET				VERSLAGSTAAT : INSPEKIE EN WERK			
<b>INSPECTION REPORT</b>				<b>INSPEKSIEVERSLAG</b>		NO NR	070980
LOCATION OF JOB / WERKPLEK						DATE DATUM	
TOWNSHIP VOORTAAR		STREET STRAAT					
SETBACK TUSSEN		STREET AND STRAAT NO		SIDE KANT		STREET STRAAT	
OFFICER/INSPEKTOUR KLEIN NO / HUIS NO		SP READABLE SINNIG OORLESBAAR					
<b>JOB DESCRIPTION / TAAKBESKRYWING</b>				<b>JOB CODE TAAKKODE</b>			
ACTIVITY WERKSAAMING				SUB CODE SUBKODE			
ISSUES/ISSUES AFKORTINGS				PRIORITY CODE PRIORITEITSKODE			
REQUIREMENTS OF URGENCY SINNE VAN TOEGESTROMING							
AMOUNT OF WORK REQUIRED HOEWELVEEL WERK VERVAAG							
ESTIMATED COST GESKATTE KOSTE				AUTHORIZED BY GEMAKTE OOR			
<b>WORK REPORT</b>				<b>WERKVERSLAG</b>			
DATE DATUM				START BEGIN		STOP EINDE	
				HOURS URE		RATE KOSTE	
<b>SUPERVISION / TOESIG</b>							
<b>LABOUR / ARBEID</b>							
WHITE BLANK		HRS URE		HRS URE		HRS URE	
BLACK SWART							
<b>TRANSPORT PLANT EQUIPMENT &amp; LABOUR VERVOER MASJINERIE UITRUSTING EN ARBEID</b>				<b>NO OF LABORERS GETAL ARBEIDERS</b>			
1.		LB ARB		LB ARB		LB ARB	
2.							
3.							
4.							
<b>MATERIAL / MATERIAAL</b>				UNIT OF MEASURING MAATSTAF		TOTAL TOOTAAL	
1.							
2.							
3.							
4.							
5.							
COMMENTS KOMMENTAAR				<b>JOB COST/TAARDE</b>			
				<b>WORK UNITS ACCOMPLISHED/VERVOLGDE OOR</b>			
				<b>PRODUCTIVE PRODUKTIEF</b>		<b>PRODUCTIVITY PRODUKTIEFTYD</b>	
				<b>COST PER UNIT/STUK WERK/STUK</b>			
				<b>JOB NO CHARITATAM NO OORSTAF</b>			
WORK DONE BY WIESE GEDONE OOR				<b>FROM AND DATE OPERTYD</b>			
SUPERVISOR TOESIGER							

55CS9798

RW 139

**FIGURE 3: Inspection and Work Report Sheet**  
(Source: Johannesburg C.E.D)





## **5 REPORTING, EVALUATING AND CORRECTIVE ACTION**

We have seen how an annual maintenance work programme is planned and translated into a performance budget and how the programme objectives are communicated to the field staff by means of scheduling. The steps which follow scheduling are the execution of the programme and making sure that the work is carried out as planned. The latter step involves control. Control consists of verifying whether activities are performed according to plans adopted, standards set and instructions issued.

Control for a given plan is exercised by evaluating performance in relation to the plan and correcting undesired deviations from the plan. The control phase in maintenance management consists of gathering and reporting of information, evaluating performance with this information and taking corrective action if necessary.

### **5.1 Reporting**

The entire control process is based on information recorded on daily returns which are completed by the field staff. Figure 3 shows the form in which this may take place. The data recorded here are also the source of information for financial accounting. While a maintenance management system extracts information on work accomplishment and resource expenditure, data relating to time sheets, plant use and store issue dockets are usually wanted to satisfy accounting needs.

The information pertinent to maintenance management includes the activity performed, the amount of work done and the manpower, equipment and materials used to do the work.

The concept of work activity is fundamental to maintenance management. Standards and work methods apply to specific activities and annual work programmes are summaries of the amount of work estimated for all activities. A work report would be of little use if the activity were not correctly identified. On the example given in Figure 3 the inspector must indicate on his part of the form what activity is involved.

In order to evaluate performance it is necessary to know what resources have been used and what work has been accomplished. There is provision on the work report sheet for the ganger to record the number of hours worked by each category of worker, the time booked against various classes of machine, the materials used and the amount of work actually done.

The work recorded in Figure 3 is costed by administrative staff who enter and extend the appropriate unit rates. This basic information can be further processed and summarized and presented in suitable form for

scrutiny and evaluation by maintenance managers. Typical information useful to maintenance managers is listed on the weekly summary used by Johannesburg and shown in Figure 6.

With the aid of electronic processing it is possible to handle vast amounts of data and produce a large array of reports with relative ease. There is, however, a danger that managers who are supplied with too much information may be discouraged from using even the more valuable reports.

## **5.2 Evaluating**

Two types of evaluation are necessary to ensure the effectiveness and efficiency of a municipality's maintenance operations. The first type involves analyzing how the maintenance actually performed measures up with that which has been planned. The more important aspects of maintenance which need to be examined for this purpose are:

- financial expenditure
- work accomplishment
- productivity
- planning standards.

The second type of evaluation concerns quality of work and level of service. This is a review process which is based on observations conducted in the field. In order to remain realistic, a maintenance management system requires continuous reassessment of quality standards and work methods

### **(a) *Financial expenditure***

The evaluation of financial expenditure involves summarizing money actually spent and comparing it with the budgeted figure. Summaries can be made for each activity, for individual maintenance areas or for any other expenditure category which may be required. This financial analysis, if performed regularly each month, gives timely warning on possible over- or under-expenditure of authorized maintenance funds and permits managers to redirect resources to correct any undesired trend.

### **(b) *Work accomplishment***

In this evaluation the amount of work actually accomplished in any one activity is compared with the amount planned. For this purpose the work done by the maintenance gangs is extracted from the daily Work Report Sheets and summarized weekly (or at any other desired interval) and for the year to date. The information reported



enables managers to take measures to ensure that the activities are not overrun and to keep the work in line with the annual programme. When urgent work, which in the interest of road safety cannot be curtailed, exceeds the budgeted amount, other activities may have to be adjusted in order to keep the annual programme in balance.

(c) *Productivity.*

Productivity is a measure of the efficiency with which maintenance gangs are accomplishing work. It is usually expressed in terms of work accomplishment units per man-hour. Another useful means of measuring the efficiency and effectiveness of a gang's performance is the overall cost of the gang's operation per unit of work achieved. This measure is valuable when different options or approaches, such as the use of labour-intensive and machine-intensive methods, are compared.

The output of a gang in any activity can conveniently be evaluated against the daily production rate for the activity, i.e. the estimated amount of work which a standard gang can, on average, be expected to perform in one day. The outputs reported in daily work returns and weekly summaries afford supervisors the chance to control the work while it is actually taking place. When performance figures depart significantly from the established norm, timely corrective action can be taken.

(d) *Planning standards*

Quantity or work planning standards and productivity standards are both used in budget computations. Realistic budgets require accurate planning standards. It is important, therefore, that these standards are regularly reviewed and brought up to date.

The quantity standard of an activity can readily be determined by dividing the annual work accomplishment by the total inventory quantity of the maintained feature. It is probable that productivity standards which are consistently above or below the values achieved in practice have been incorrectly set. Such standards should be re-assessed in the light of the statistical evidence and by reviewing the prescribed work method.

(e) *Quality standards*

The levels of service which a municipality provides are usually not static but may change under social and economic influences. Periodic observations of the road system are required to evaluate

whether the current maintenance operations and practice can meet the quality standards which implicitly reflect the levels of service in vogue.

### **5.3 Corrective action**

The main reason for work reporting and performance evaluation is to identify unwanted deviations from a programme of work so that the necessary corrective action can be taken. In most cases when something is not going according to plan the required action is self-evident and has already been suggested in the previous section. A brief summary of corrections which can be made follows.

- Deviations from an expenditure plan indicate that a speeding up or a slowing down of the maintenance effort is called for. Normally, adaptive action of a short-term nature is necessary. Steps with a permanent effect, such as changes to the work force, may not be the correct way to deal with the problem. An over-expenditure of authorized funds can sometimes be rectified by an allocation of more money.
- Deviations from a work programme can often be corrected by curtailing some activities and placing more emphasis on others. It may be necessary to make adjustments to programmes which have been affected by unforeseen work of a high priority in order to keep the plan in balance.
- Standards which are used in preparing work plans and budgets may, in the absence of appropriate statistical information, be based initially on personal judgment and experience. More meaningful results will be obtained if quantity and production standards are reviewed and brought up to date and used in subsequent rounds of planning.
- It is normally not practicable or desirable to base work methods for maintenance activities on time and motion studies in the first instance. Performance standards are thus best drawn up by engineers and maintenance staff with appropriate knowledge and experience. Such initial standards must, however, be updated when improved methods, new equipment and materials or practical innovations come to light. In the long term it may be advantageous to use work study methods in drawing up performance standards for some of the more important activities.

Ultimately the effectiveness of a maintenance management system depends on the performance of the personnel in the maintenance organization. The system will not function properly unless all persons in the organization know what is expected from them and how they must

accomplish their tasks. This not only calls for effective organizing but also for monitoring of staff performance. Hence there may also be a need to take corrective action when staff performance does not measure up to the expectations.

Ongoing training of workmen and supervisors will do much towards making staff work effectively. When individuals are seen to underperform consistently, corrective action is indicated. Such action may involve counselling or special training, but in extreme cases a change of job or disciplinary action may be called for.

Control of maintenance activities operates through people. This control can, however, not be properly exercised unless the responsibilities of supervisory and work staff are clearly defined in terms of an organization structure. The next section briefly deals with the organizing involved in maintenance management.

## 6 ORGANIZING

The maintenance of roads and streets consists mostly of numerous small routine tasks performed by an organization which may involve a large number of people. It is a prime function of a maintenance management system to get the people to work effectively together. Individuals will work together most effectively if they know what is expected from them and how their roles relate to those of others. The management function of organizing in essence consists of designing and maintaining these systems of roles within the framework of a defined structure.

The structure of a road maintenance organization may consist of several levels of management and the personnel who carry out the maintenance work. In the hierarchy of a large municipality maintenance management may involve:

- Top management, comprising senior engineers in head office who determine policy for the organization and assess its effectiveness.
- Middle management, consisting of engineers and superintendents in the districts who manage the maintenance work force and see to it that the work is carried out to the set standards.
- Field supervision, which is performed by foremen and maintenance gang leaders who authorize and oversee operations on site.

The exact composition of a maintenance organization structure, which may be influenced by such factors as local custom or availability of suitably qualified staff, is of lesser significance. What is important, however, is that:

- The organization's objectives are clearly defined.
- The duties and activities which must be performed by each person are understood, so that the objectives can be achieved.
- Every person knows the area of discretion and authority of his position and what decisions he can make to accomplish results.

An organization is effective if it attains its objectives. The organization is also efficient if it accomplishes its objectives with minimum undesired effects and costs. To make a maintenance management system effective requires not only a sound organization structure, but is also necessary that:

- Sufficient staff is available at all levels to operate the system.
- Training must be provided as an ongoing endeavour. Most large municipalities have training schools and facilities where this can take place.
- Staff must be motivated - they must be made aware of the advantages of the system and not be allowed to feel that it is imposed on them. Field staff can be effectively motivated by incentive schemes.

Bonus payments for better than average work performance are known to have improved worker productivity and quality of work. Rivalry among a municipality's maintenance depots, which was fostered by a prestigious and officially run competition, achieved the same objectives.

Operations must be properly supervised at all levels by staff who have been properly trained and who adopt a professional attitude in the performance of their duties.

## **7 DEVELOPING A MAINTENANCE MANAGEMENT SYSTEM**

In the previous sections of this guide the principles of maintenance management and the components which make up a management system have been described. In this section, the development of a maintenance management system is discussed. The development of a system essentially comprises the structuring of an organization and the design of basic system elements and procedures to facilitate the planning, budgeting, scheduling, performance, evaluation and control of maintenance operations.

Planning requires inventory data, field inspections, identification and priority classification of maintenance activities, standards and cost data.

Performance budgeting involves cost data for estimating purposes and procedures for obtaining budget approvals and for the allocation of funds.

Scheduling relies on strict procedures for communicating work programmes to the field staff.

Work performance requires that maintenance gangs be organized, trained, directed, monitored and controlled.

Evaluation and control need a data collection and reporting system.

Table 2 enumerates the actions which need to be taken during the development phase of a maintenance management system and may be used as a check list by authorities intending to introduce maintenance management.

Most of South Africa's larger municipalities have longstanding experience in road and street maintenance. They have built up organizations staffed by competent people and established workable methods and procedures for maintenance purposes. It is neither necessary nor desirable to discard the useful features of existing maintenance practices. These features should rather be adapted and supplemented for conversion into new maintenance management elements. Existing organizations can be restructured, costing systems adjusted, budgeting procedures modified and training schemes updated to embrace maintenance management principles. Because there is such a diversity in existing maintenance practice it is not practicable to produce universal guidelines for this conversion process.

These guidelines are more concerned with tasks which must be performed in a similar fashion by all large municipalities which wish to turn to maintenance management. These tasks, which include defining of maintenance activities, the compilation of a features inventory and the selection of relevant standards, are described later in this section. However, a step which should precede the design of system elements is the preparation of a preliminary plan or study for the development phase.

*Table 2 : Check list of actions for system development phase*

<b>System element</b>	<b>Required action</b>
Data collection	Establish features inventory and referencing system Collect traffic data Compile data base Collect cost data
Maintenance activities	Define significant maintenance activities
Priority rating	Classify work in order of priority
Standards	Define quality standards Set quantity standards Formulate performance standards
Costing system	Design system for costing resource expenditure for each activity per day
Organization	Restructure maintenance organization to meet management system requirements Initiate orientation course to introduce systems concepts to maintenance staff Initiate ongoing staff training programme

### **7.1 Planning the system**

Some of the tasks listed in Table 2 can be done relatively quickly, while others will require a large and sustained effort to complete. The whole of the system development will involve a large amount of work which should not be underestimated. Municipalities would be well advised to prepare, as a first step, a plan showing how the development phase is to be managed.

This advance planning will indicate the resources required and include a timetable for the completion of each of the system's component parts. From this information it should also be possible to estimate the costs of the development phase.

It is desirable that the system development be completed in a reasonably short time. A prolonged development period may lead to a flagging of interest among staff and a loss of creditability for maintenance management systems as a whole. It is suggested that an organization incorporating a steering committee and a project team assisted, when necessary, by consultants and knowledgeable departmental staff, should be well suited to do the development work efficiently and expeditiously.

The work could best be dealt with as a project by a team of workers

appointed on a full-time basis. Such a team would ideally be composed of senior municipal engineers and technical staff well-versed in maintenance matters. Panels selected from experienced supervisors and field staff could from time to time make useful contributions. Expertise at a different level can, when necessary, be obtained from consultants.

The ultimate authority for the development of a maintenance management system would be vested in a committee of top-level municipal officials. Such a steering committee would lend its support to the project team and coordinate and monitor the team's efforts.

Preliminary planning may also involve a critical examination of a municipality's existing maintenance organization. It may in some cases be possible for an authority to adopt a maintenance management system without having to make large changes to its organization. In other instances major adjustments may have to be considered. Where it is not feasible to effect desired changes in the short term it may be necessary to proceed temporarily with the development of only a part of a maintenance management system. There may, for instance, be a need to defer the inclusion of certain maintenance activities until organizational changes can be introduced.

A preliminary plan can conveniently be presented in the form of a feasibility study. This would give the appropriate municipal authorities an opportunity to evaluate the implications of adopting a maintenance management system and give a base on which to make their decisions. Once the study's proposals have been approved, project staff appointed, funds voted and target dates set, a start can be made with the development of the salient system elements as discussed hereafter in this section.

## **7.2 Developing system elements**

### **7.2.1 Defining maintenance activities**

The first step which must be taken is to define and describe the work activities which must be performed for the upkeep of a road network. Each activity must have assigned to it a unit of measurement so that the effort involved in the maintenance of a specific road feature can be ascertained and clearly expressed as a distinct parcel of work. The total maintenance effort of a municipality will be the sum of the work parcels for all activities.

Activities must be clearly defined so that maintenance staff will have a thorough understanding of the operation to be performed. The measurement unit to be selected for each activity must be meaningful to field personnel and provide a realistic and practical way of determining quantities of work done by work gangs with reasonable accuracy.

Activities can be conveniently grouped together by listing them under collective headings which relate to parts of the road network or which

combine services or work of a similar nature. Maintenance work may be coded to simplify identification of activities either single or in groups. A suitably designed coding system can facilitate the processing of data for accounting and management purposes.

An appropriate number of activities must be selected to represent the maintenance work effort. If too many activities are identified, the task of planning, scheduling and reporting of the work becomes unduly complex and onerous. Too few activities, on the other hand, may give rise to ambiguity as more than one method may be used to perform an activity. It has been found that for performance budgeting it is sufficient if the work defined by all activities covers about 90 per cent of the work load. The remaining ten per cent can be combined as 'other' or 'miscellaneous' activities under the appropriate group headings.

The actual number of activities which is required depends on the nature of the infrastructure to be maintained and may vary from one municipality to another. It has been found that 40 to 50 activities are normally adequate to cover most of the maintenance for an average road network. The number may, however, increase substantially if, in addition to normal network requirements, a municipality must also maintain less conventional facilities such as rail transport, ferry services and the like. Table 1 lists some of the activities which may typically be used for municipal work.

### **7.2.2 Compiling a features inventory**

Maintenance activities describe the sort of work which must be performed for the upkeep of a maintainable road feature. Other information which is required to compute a work programme involves the quantity of each feature and the standard to which it must be maintained. A roadway inventory, which is a compilation of pertinent information for each road feature, is ideally the source of the quantities required. Inventory summaries for individual maintenance districts or management units form the bases for developing performance budgets and allocation of funds.

The compilation of an inventory, which may be an arduous and time-consuming task, should not be permitted to delay the introduction of a maintenance management system. Until an inventory is compiled it may be necessary to use, on an interim basis, estimates based on maps and other available records.

The basic information required for a maintainable features inventory comprises the identification, the quantity and the location of each feature. The identification of the road features is normally accomplished in the phase during which maintenance activities are defined. Typical features to be placed on the inventory include road surfaces in blocks and in intersections, road drainage structures such as catchpits and stormwater pipes, bridges, kerbs and gutters, verges, footways, fences and road

signs. The quantity and location of road features may be obtained from existing records, such as logs, plans and maps, or must otherwise be obtained in the field. Personnel gather data in the field by filling in forms which have been designed to ensure that information is accurately and uniformly recorded. Where inventories are to be computerized the forms can also be designed so that the data recorded can be readily entered into computer files.

Computers are logical tools for storing inventory data and for use in performance budgeting in general. Even the relatively inexpensive microcomputer has the capacity to handle vast amounts of data. User-friendly database and spreadsheet programs written for the microcomputer will enable maintenance managers to store, manipulate and update data and generate a variety of reports with minimum training. These and other advantages have enhanced the potential of microcomputers as valuable instruments in maintenance management.

### **7.2.3 Establishing quantity standards**

Quantity standards are a key element in performance budgeting. They are required for estimating the amount of work which must be performed for each activity during the course of a year to maintain a desired level of service. It is through quantity standards that a municipality's goals and objectives in terms of levels of service to be provided are reflected in the funds budgeted for maintenance. Accordingly, changes in the level of maintenance funding often result in corresponding adjustments to the quantity standards.

Realistic budgets can be prepared only if accurate quantity standards are available. Yet quantity standards can be established with any degree of precision only with the experience which comes from operating a maintenance management system for several years at least. A problem thus arises when quantity standards must be established for a new performance budgeting system. The problem is usually compounded by the fact that the quantity standards must be developed in a short time if the implementation of a new maintenance management system is not to be unnecessarily delayed. It is, however, possible to initiate quantity standards as an interim measure on the basis of historical data, local experience or engineering judgment. Initial quantity standards can later be reviewed and updated or refined when the maintenance management system starts producing the appropriate feedback information.

To facilitate the preparation of yearly budgets quantity standards are stated as annual quantities. The annual quantity is expressed in terms of the work measurement units of each activity and the unit of measurement of the road feature towards which the activity is directed. Annual quantities can also be based on the frequency with which the activity must be

performed, the quantities of material involved in the work performance, or simply in man-hours.

**(a) Quantities based on frequency**

Examples of activities with quantity standards based on frequency are litter collection on streets and cleaning of stormwater inlet structures. The experience of maintenance staff can play a major role in initiating quantity standards for work of this nature.

If it is judged that weekly litter collection is appropriate, the quantity standard for this activity can be expressed as 52 km per street km per year. Likewise, if experience indicates that, on average, stormwater inlet structures must be cleaned out twice a year, a suitable quantity standard would be two cleanings per structure per year.

**(b) Quantity standards based on materials usage**

The work units of some of the activities which involve the use or application of road maintenance materials are most conveniently expressed in terms of the quantity of material handled. One such activity is the sealing of cracks in blacktop road surfaces with a bituminous sealant and an appropriate unit of measurement for this is the litre of sealant used per lane km of surfaced road. As most municipalities keep records of materials usage it is often possible to establish initial quantity standards for this type of activity from historical data. The quantity standard for crack sealing could thus be determined by dividing the total amount of sealant used for sealing in one year by the total number of lane km of surfaced roads in the network. This quantity standard could conceivably be 50 litres of sealant per lane km of surfaced road per year.

**(c) Quantity standards based on man-hours**

Man-hours as a unit of measurement are suited to overhead and non-standard activities. The quantity standard for an overhead activity such as supervision and clerical can be expressed in man-hours per employee per annum. Data from salary and wage records are generally available for computing an appropriate planning value. Non-standard activities which may be classified as 'other' or 'miscellaneous' under the relevant group headings can usually be expressed directly in man-hours or man-days for budgeting purposes.

#### **7.2.4 Selecting production standards**

Production standards represent the work output criteria of performance standards. They can be expressed as productivity rates or daily production rates. A productivity rate is a measure of gang efficiency in terms of man-hours per unit of work. A daily production rate is an estimate of the amount of work which a standard gang can, on average, perform in a day. The daily production rate is a useful planning tool for converting the annual work load for each activity into gang-days. The examples in Section 3 illustrate how this conversion can be made.

The yearly number of gang-days necessary to complete an activity can be broken up into the constituent requirements for labour, equipment and materials by making use of the resource criteria of the activity's performance standards. The estimating phase of the budgeting process can be completed by applying the approximate unit costs to resource requirements.

It is clear that daily production standards play a key role in performance budgeting. Realistic budgets are based on accurate production rates, which in turn must be derived from properly established performance standards. When a maintenance management system is newly introduced, estimates may have to be made for activities for which performance standards have not been fully established.

In such a situation the best course of action may be to adopt the most suitable of current known practices. For this purpose a maintenance organization should investigate its own practices as well as the methods used by other authorities which perform their maintenance activities effectively. The evaluation of current practice should be carried out by experienced maintenance engineers in consultation with their superintendents and gang supervisors. Participation by the field staff in the selection of new standards will ensure that changes of practice are more readily accepted. Standards can subsequently be refined on the basis of observations, data analysis and the testing of possible improvements in methods and techniques. By going through the process described above substantial savings in maintenance expenditure are possible.

## **8 IMPLEMENTATION OF THE SYSTEM**

The basic elements of what may be considered a model maintenance management system have been described. The elements can generally be expected to have relevance in all the larger municipalities but may need to be adapted to suit local needs. The way in which a maintenance management system is brought into operation will also vary with the needs, resources and preferences of a local authority.

One approach to making a maintenance management system operational is by first developing all system elements in full. The elements are then implemented all at once after a period of orientation and training. Another approach is to implement each element as it is developed. Short training sessions are provided with the introduction of each element.

The time required to bring a maintenance management system into effect depends on such factors as the size of the municipal maintenance operation and its facilities, the sophistication of the existing organization which operates it and above all, the effort which will be applied to achieve its successful implementation. This time should not be underestimated - experience in South Africa has shown that it may take as much as three years to develop, try out and implement a system.

Although no hard and fast rules and procedures are prescribed for the implementation phase, it is important that certain fundamental necessities be observed. A maintenance management system cannot, for instance, be effectively implemented without commitment on the part of key personnel and without proper orientation and training of maintenance staff.

### **8.1 Commitment**

The successful implementation of a maintenance management system requires the wholehearted support of everyone involved in maintenance work. Vital to the success is top management's commitment which must find its expression in the allocation of sufficient staff and funds and the formulation of a work plan to establish the system. Also required is the willingness of senior managers to examine their maintenance organization and restructure it to suit maintenance management concepts.

It is desirable that management communicate to their department's staff that they are seriously committed to changing over to a maintenance management system. This can be done by writing down a clearly expressed policy statement and letting it be known to everyone concerned.

#### **8.1.1 Personnel**

Ideally the same team which was responsible for the system development should also be involved in providing direction and guidance during the

implementation phase. This has the advantage that there will be at least some key staff members who fully understand the system's procedures and interactions. Where possible these same key members of staff should remain involved in the system when it is in operation and when standards must be evaluated and updated.

Part-time staff may have to be appointed to help with such tasks as the gathering and processing of road inventory data. The assistance of typing staff will be required for the preparation of manuals for system operation and training.

### **8.1.2 Work plan**

The implementation of a maintenance management system should take place according to a carefully prepared work plan in the same way that the system's development phase should be programmed. Such a work plan expresses management's commitment to system implementation by certain target dates and thus ensures that the deployment of resources is planned in advance.

The implementation programme should allow for periods of testing when the system elements are tried out in the field before being permanently adopted. The work plan should also coordinate the efforts of personnel who must provide the necessary orientation and training to the maintenance field staff.

## **8.2 Orientation and training**

A prerequisite for an effective maintenance management system is a complete understanding by managers, at all levels, of the system's planning, work performance and evaluation processes. Managers must not only be thoroughly familiar with the new maintenance management techniques, but they should also fully understand the nature of their duties and responsibilities within the system. This calls for a comprehensive initial programme of orientation and training. The larger municipalities with established training facilities may wish to prepare and present formalized instructional material on maintenance management. Other local authorities will find that much can be achieved by conducting a series of workshop meetings and seminars on the subject.

Training can be greatly facilitated by the use of instruction manuals. There are several types of manuals, each with a different function. Head office staff would mostly benefit from a planning or management manual which describes the procedures for setting standards, preparing work programmes and budgets, for authorizing work and performance evaluation. Field supervisors require an operations manual which gives a complete set of performance standards covering all maintenance activities and provides detailed instruction on scheduling and the performing and reporting of

work. Manuals are also required to instruct gangers in detail how each maintenance activity must be performed.

## **9 SUMMARY**

The flow chart on figure 7 graphically summarizes how a model municipal maintenance management system operates. The purpose of these guidelines is to present to municipal engineers and managerial staff the rationale of maintenance management systems, to explain how the systems' components function and interrelate and to give an insight into what is involved in establishing such a system.

Maintenance management systems are not restrictive. System components can be adapted to suit needs which may be related to a municipality's locality, climate, traffic conditions or to specific maintenance requirements. It may be possible to leave traditional organizational structures largely intact provided maintenance management concepts are complied with. These guidelines, therefore, do not prescribe fixed procedures and routines, nor do they advocate uniformity in maintenance standards, costing systems or training methods as a precondition. Each municipality should thus be free to develop a maintenance management system which characteristically reflects its own experience and preferences.

A maintenance management system, properly designed and operated, will enable senior maintenance managers to plan and schedule work and to budget, allocate and control resources effectively. This can be expected to result in better returns for maintenance funds, improved quality of work and more job satisfaction among maintenance personnel. For a maintenance management system to remain effective it must be dynamic. Maintenance standards, methods and procedures must be constantly scrutinized and brought up to date when necessary. Only in this manner can the achievement of good quality maintenance work, performed in the correct order of priority and at the lowest practicable costs, be continuously ensured.

Finally, the key to successful maintenance management is firm commitment. This commitment is wanted from the team selected to take charge of developing, implementing and operating the system in order to help them persevere with their mission. It is also wanted from the most senior maintenance department staff without whose guidance and support the system has little chance of success.

