MANAGING SADC ROADS AGENCIES IN THE NEW MILLENNIUM: THE ROLE OF ROAD ASSET MANAGEMENT SYSTEMS

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1. INTRODUCTION

1.1 Background

The Southern Africa Development Community (SADC) road network of approximately 932,000 km (excluding the Democratic Republic of Congo and the Seychelles) is one of the Community's largest public sector assets with current replacement costs estimated at approximately US$50 billion. Productivity in virtually every sector of the Community's economy is affected by the quality and related performance of the road system. It is therefore essential that this vital and costly asset be managed efficiently and effectively, invariably within a constrained budgetary situation, in support of socio-economic development and growth.

Unfortunately, despite the substantial investments that have been made in the past in road transport infrastructure, inefficient management coupled with inadequate funding has led to deteriorated road conditions and increased transport costs in many SADC countries. What has now become abundantly clear is that the traditional approaches to road management and financing, which have relied on managing roads through a government department and financing them through general budget allocations, have generally not worked. Moreover, the prospects for improvement under the existing circumstances appear to be virtually non-existent. Thus, there is now an urgent need for a radical change in approach, which recognises that roads in the SADC region are "big business" and must be managed and financed along more business-like principles.

In accordance with the main thrust of SADC's Protocol on Transport, Communications and Meteorology, and in keeping with worldwide trends, the function of roads agencies in the SADC region is now being focused on the 'client role' which concentrates on the core business of managing road networks efficiently, effectively and in an environmentally sustainable manner. Much as this is a welcome development, the task of managing a road system in an optimal manner still remains a technically complex one, particularly where there are competing demands for limited resources. Fortunately, this task can be greatly simplified by employing an appropriate "systems engineering" approach in combination with modern day "management" techniques. Such an approach has resulted in the development of asset management systems that are increasingly being used in many roads agencies for providing a systematic process for maintaining, upgrading and operating the physical assets under their responsibility in an optimal manner.

Against the above background, the objectives of this paper are to introduce the concepts of asset management, to highlight the potential benefits of operating asset management systems by roads agencies and to outline the strategy proposed by the SATCC Technical Unit for the development and implementation of such systems in the SADC region. The paper also illustrates how such systems can be operated to assist roads agencies in managing their road networks efficiently and effectively by adopting strategies and implementing programmes that allow them to utilize available funds in an optimal manner.

2. ASSET MANAGEMENT

2.1 What is Asset Management?

Asset management has been defined as:

"….a systematic process of maintaining, upgrading and operating physical assets effectively, combining engineering principles with sound business practice and economic theory and providing tools to facilitate a more organized, logical approach to decision making."

(U.S. Federal Highway Administration, 1996)

In its broadest sense, asset management may be viewed as a comprehensive process that employs people, information and technology to allocate funds effectively and efficiently amongst competing asset needs based on defensible principles that are technically, economically and environmentally sound.

2.2 Components of an Asset Management Systems

Management systems of various kinds have been around for a number of decades now. However, the older generation systems have generally concentrated on just a few components of the overall road system – traditionally the pavement component – which controls probably less than half of any roads agency's budget. Moreover, they have tended to be stand alone systems with independent databases operated independently of each other and have often lacked economic optimization procedures for determining the optimum distribution of funds across the *total* road network.

What sets current generation asset management systems apart is the merging of these single-asset systems into an integrated whole. This merger of individual management systems provides roads agencies with consistent system-wide data, enabling them to allocate available funds across competing pavement, structure and other infrastructure needs (1).

Conceptually, an asset management system consists of a number of inter-related components that collectively integrate into a loosely structured system that allows full functional integration between the Information System and the Decision Support Systems (DSS) as illustrated in Figure 1.

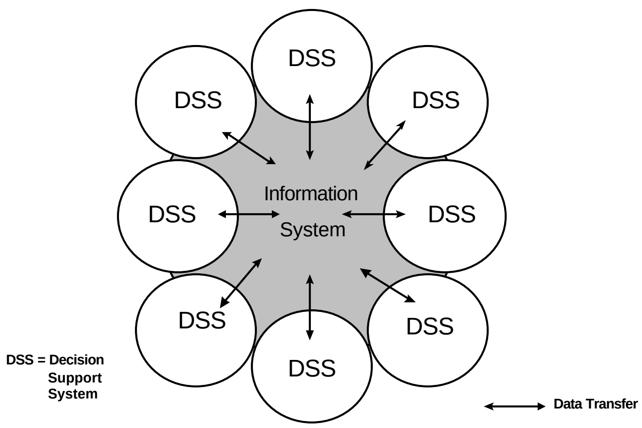

Figure 1- Conceptual Framework of an Asset Management System

As indicated in Figure 1, an asset management system framework comprises two major components:

- an **information system**, which collects, organizes and manages data and information;
- **decision-support systems**, which comprise applications modules to process data and provide the information on which decisions can be based and ultimately implemented.

A comprehensive asset management system should also address a broad range of procedures and outputs and, in so doing, it should:

- include both inventory information and condition measures;
- include a performance prediction capability;
- integrate databases to ensure data integrity and enhance data accessibility and compatibility;
- use life cycle cost analysis with all its components
- consider system optimization versus project optimization;
- output useful information on a periodic basis

2.3 Capabilities of Asset Management Systems

In principle, as a decision-making tool, an asset management system is capable of providing decision support for a number of activities undertaken by the roads agency such as pavement management, bridge management, traffic signs management, etc, at all three levels of management, namely, policy/executive, planning and execution. In so doing, an asset management system would include ability to:

- determine the required funding level to meet a specified standard;
- plan network improvements according to budget constraints;
- determine the effects of deferring maintenance on upkeep and road users' costs;
- determine the effects on users' costs of raising/lowering the quality standards of road pavements;

Technically, an asset management system should:

- select the most cost-effective methods of maintaining road assets;
- predict future performance of various road assets and evaluate costs/benefits of alternative strategies;
- learn from past and present facts and figures and improve construction and maintenance techniques;
- develop maintenance strategies.

Administratively, an asset management system should:

- provide comprehensive road network information
- predict long-term road asset performance for given funding levels
- determine backlog requirements

2.4 Benefits of Asset Management

Asset management offers significant benefits to both the roads agency and the public sector, including road users, by allowing the agency to harmonise the technical, financial and political factors that affect their investment decisions. The asset management approach makes use of timely, integrated and valid corporate data and is capable of prioritizing investment options and assessing their impacts within the context of a defined set of objectives. In this regard, as will be illustrated in Section 4 of this paper, asset management systems can be used for a variety of purposes, at various levels of the roads agency, to evaluate the outcome of pursuing alternative strategies and to provide the data needed for considering a range of policy issues, including:

- Determining appropriate strategies for managing the road network in optimal condition and the associated funding requirements;
- Highlighting the implications of obtaining less than less than optimum funding in terms of the additional total costs of using the highway system;
- Optimising expenditures among various components to get the best value for the overall asset;
- Providing reporting information to budget analysts and executives in a quantified manner and instilling confidence that the chosen management strategies are rational and represent best value for money;
- Enhancing the credibility of the roads agency's decision-making processes;
- Putting management tools into the hands of a broad range of front-line staff and involving them in decision-making processes.

The potential benefits of pursuing asset management practice with the use of appropriate management tools will only be fully realised to the roads agency if its strategy is implemented fully and practiced and evaluated regularly for fine-tuning and improvement.

2.5 Impetus for Introducing Asset Management

The impetus for introducing asset management as a process within the operations of a SADC roads agency stems from a number of factors, including:

- the need to employ a more systematic and commercial approach to managing the road asset;
- existing budgetary constraints and the need to optimize network performance and return on investment;
- an increasing need for roads agencies to report the condition of their assets using acceptable public accounting procedures, methods and formats;
- the public's demand for more transparency and greater accountability in the expenditure of scarce public funds;
- increased participation of the private sector in asset provision and maintenance.

2.6 Assets to be Managed

The physical assets to be managed by a roads agency would normally consist of a range of components with substantially different initial costs, maintenance costs and deterioration rates and would typically include the following:

<u>Road Infrastructure Assets</u>

- pavements
- bridges
- culverts
- drainage structures
- traffic signs
- road marking and road reflector studs
- fencing

<u>Other Physical Assets</u>

- road reserve
- borrow pits
- vehicles and equipment
- buildings
- communication equipment

3. THE SADC STRATEGY FOR UNDERTAKING ROAD ASSET MANGEMENT

3.1 General Approach

There are a number of factors that are specific to the SADC region and place special demands on the development of a road asset management system. These factors suggest that the system should be developed and designed in a manner that is:

- Affordable and appropriate to the decision-making needs and scarce human resources normally available within the administrative and institutional environment of a typical SADC road agency;
- Applicable to widely differing institutional circumstances ranging from large to small road agencies with strong to weak institutional capabilities and funding;
- Appropriate for dense to sparse networks with high to very low traffic volumes;
- Flexible for staged development and implementation to suit the changing circumstances of the roads agency;
- Conformable and integrable with the day-to-day activities of the roads agency;
- Sustainable with scarce human resources.

3.2 System Design

Based on the above criteria, a system design concept was established within SATCC (2) which consists essentially of an integrated, modular, computerized system in which a central or core database (the Information System) is linked to and interacts with a number of Decision Support Systems (see Figure 2) that can be operated to achieve a number of objectives. Ultimately, the system framework can encompass a variety of Decision Support Systems to suit the country-specific needs of SADC roads agencies.

The integrated, modular approach for road asset management adopted in the design of the SADC system offers the following important advantages:

In the individual SADC country context:

- Undertakes total infrastructure management in a comprehensive and coherent manner;
- Allows Decision Support Systems to be introduced separately as and when required without affecting the integrity of the system;
- Benefits from data integration and centralized maintenance and upkeep of a common database, including centralized updating;

In the regional SADC context:

- Allows economies to be derived from adopting a common design of the system framework;
- Provides common data standards for technical interchange between SADC countries;
- Allows common training to be undertaken and facilitates sharing of road performance and user characteristics;
- Provides a similar basis for establishing road costs to help in the establishment of equitable user charges for domestic and transit traffic.

The asset management framework described above accords with recent World Bank guidelines on asset management system design (3) that stress the attributes of a modular system development for staged development to meet the changing needs of a roads agency.

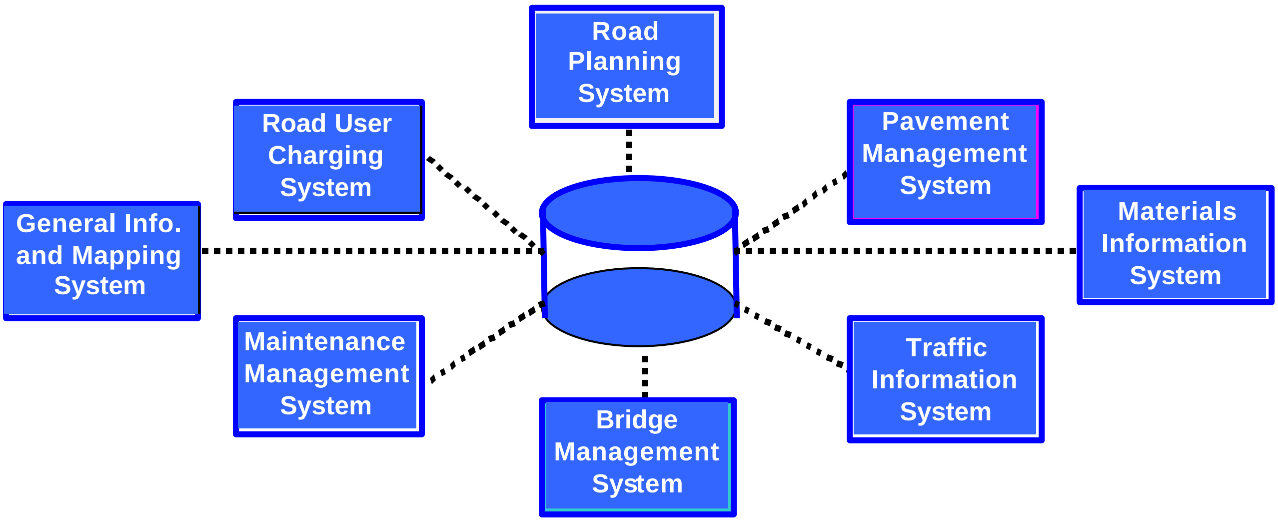

Figure 2 - SADC Road Management System Framework

3.3 Analytical Tools

To achieve a capability for formal economic prioritization and optimization, and to minimize system development time, the World Bank's HDM IV model is recommended as the preferred analytical tool for a road asset management system. Verification studies to assess its applicability to local conditions has led to a number of minor enhancements to the Vehicle Operating Cost and unpaved road deterioration relationships based on research work carried out in Southern Africa since the Brazilian study (4). Ultimately, however, the investigations carried out have shown that, with basic local/regional calibration, HDM-IV remains probably the most reliable quantitative basis for highway project and program appraisals in Southern Africa (5).

The successful operation of a RMS requires that:

- there is a common reference for all sub-systems
- updating (data collection) procedures must be undertaken regularly
- historical data must not be lost in the process of updating
- security of the systems/data must be safeguarded
- a minimum complement of staff is available to operate the system
- training and updating of knowledge is undertaken on a systematic basis

3.4 Data Requirements

(a)Data Type: The type of data to be collected for road management purposes depends on the use to which it will be put in terms of the managerial level of decision-making involved. The data to be collected can be grouped around various primary functional levels which can be identified as follows:

Table 1: Functional Levels of Road Data

Functional Level	Data Usage
Sectoral	Aggregation of data from the asset management system, e.g. annual highway statistics (inventory, performance and utilisation, financial
Network	Planning, programming, budgeting
Operational	Construction, maintenance, traffic, safety
Research and Development	Study specific, detailed and precise data required for problem diagnosis

The amount of detail required for the various functional levels increases progressively from the overall summary statistics at the Sect oral Level, where comparatively broad, low-intensity coverage is required, through to study specific requirements at Research and Development Level where very detailed and precise data are required for problem diagnosis and the development of improved practices and methods.

(b) Data Quality and Detail: The range of detail required can be classified into four Information Quality Levels (IQL) (2) as shown in Table 2. Two parallel trends are apparent in the IQL classification system. Firstly, Global, summary-type data required for sector level statistics is classified as IQL-4 and, as the application progresses to network, project and operations level, the required amount of detail increases, finally reaching IQL-1 for research and development. Secondly, as the IQL level moves from IQL-1 to IQL-4, so the scope for simplicity of data and system requirements and cost implications decrease.

Table 2: Use of Information Quality Levels

IQL	Description	Application	Data Collection
1	Most detailed, comprehensive	Research, advanced design, diagnosis	Short to limited lengths or isolated samples; specialised equipment; slow except for advanced automation
2	Detailed	Project design, advanced programming, advanced planning	Limited lengths semi-automated or full coverage advanced automation; high speed
3	Summarised data	Programming, planning, basic design	Full sample; high speed, low accuracy, semi-automated; or sample processed
4	Most summarised	Sector/network, simple planning and programming	Manual; semi-automated; processed or estimated

4. TYPICAL APPLICATIONS OF ASSET MANAGEMENT SYSTEMS

4.1 Areas of Application

With the introduction of road tariffs in a number of SADC countries, the source of most of the roads agency's revenue, namely the road user public, has begun to display a new attitude to the rising demand on their pockets. They want to be sure that they are getting value for *their* money. In such an environment, roads agencies will be required to routinely face both important policy questions and increasing demands upon the monies allocated to them. What can roads agencies do to achieve economic efficiency in the management of the road networks for which they are responsible, particularly when they have to face the conflicting objectives of improving road user service as well as reducing the cost of providing that service?

As indicated in previous sections, and will be illustrated below, the use of a road asset management system can assist roads agencies in meeting that challenge in four main areas of application (1) strategic planning, (2) Programme Analysis, (3) Project Analysis and (4) Research and policy studies. Each of these levels of application represent successive levels of decision making, each of which takes decisions at its respective level and assigns a total amount of funding to the level below together with objectives and instructions to implement these objectives as well as possible and in greater detail.

In the following sections, examples will be given to illustrate how asset management systems can be operated at various levels of application to achieve the desired objectives of the road agency.

4.2 Strategic Level Application

The focus at the strategic level of application is on policy in which the roads agency pursues its over-riding goal of managing the road asset efficiently and cost-effectively. In terms of "best practice" in resource allocation decisions, the road agency's goal would typically be minimization of total transport costs to society. This concept is shown conceptually in Figure 3 which can refer to a road network and which indicates the network wide optimal road standard and the budget associated with that standard.

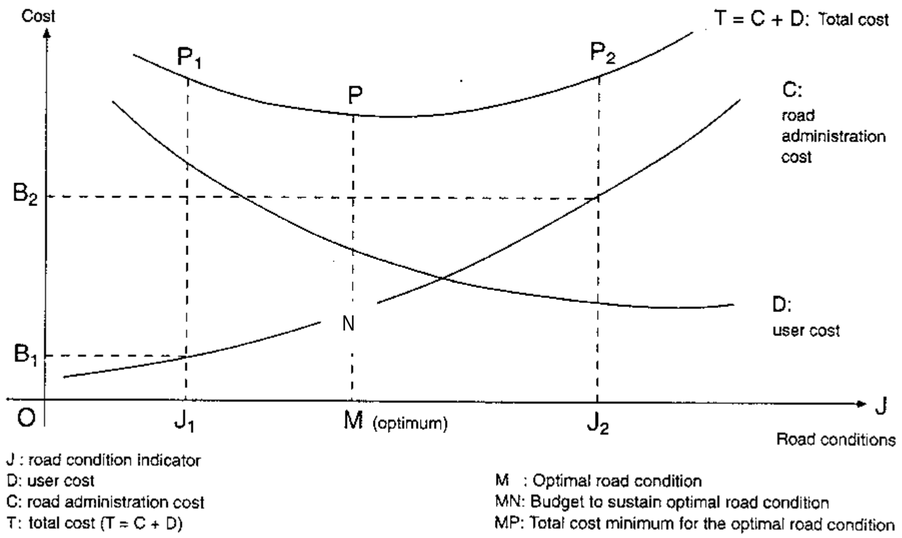

Figure 3- Effects of budget and road condition constraints to optimizing road rehabilitation and maintenance

In Figure 3, the total cost curve T is the sum of the road user costs (D) and road administration costs (C) which decrease and increase respectively with improving road conditions and has a minimum cost value at P which represents the theoretical economic optimum which minimises the total costs of road transport. The shape of the curve is very much traffic related in that cost shares under optimal maintenance conditions vary quite significantly in relation to traffic levels.

Should there be under-funding of maintenance, as is the case in many SADC countries, then the implications would be as clearly illustrated in Figure 3. If the available agency budget is only B_1, i.e. less than the optimum, then the best the agency can do, *if the available money is optimally spent*, is to deliver a road condition at J_1. The consequence of this funding constraint is that for the society, the costs will be J_1 P_1 which is much more than the minimum social cost MP. In such a situation, the road users pay more out of their pockets than what is saved in the agency budget. Worse, if the full costs of maintenance are to be recovered through an appropriate road user charge,

then road users will be paying more for roads whose condition will be getting worse! This approach to network level intelligence serves the roads agency and road fund administration's needs to inform the public about their policies and also provides an informed basis for public debate about them.
Should the optimal maintenance funding required to minimize total transport costs not be available, as is inevitably the case in most countries, what strategy should the roads agency pursue to ensure that it spends its limited budget in the "best" way? The "best" way will depend on the policy objectives of the agency. What should such policy objectives be? For example, should they be to:

- Policy 1: Fix worst roads first
- Policy 2: Conduct maintenance according to a priority index?
- Policy 3: Conduct maintenance to maximize pavement condition?
- Policy 4: Conduct maintenance to minimize total transport costs?

An asset management system has the capability through the use of optimization techniques to evaluate the consequences of each policy in terms of their impact on such parameters as overall network condition, long-term changes in the networks's asset value, total transport costs or vehicle operating costs. Such an analysis was carried out by the Gauteng Department of Transport (6) to investigate the long-term consequences of the above maintenance policies and budget levels on their paved road network. The outcome of this analysis makes interesting reading as illustrated by Figures 4, 5 and 6 which are discussed below.

Figure 4 illustrates the overall decrease in network condition after 10 years for each of the four policy objectives evaluated. For each road class, the network condition was calculated based on the weighted condition and length of each road segment. The graph illustrates that the worst first policy clearly resulted in the greatest decrease in road condition.

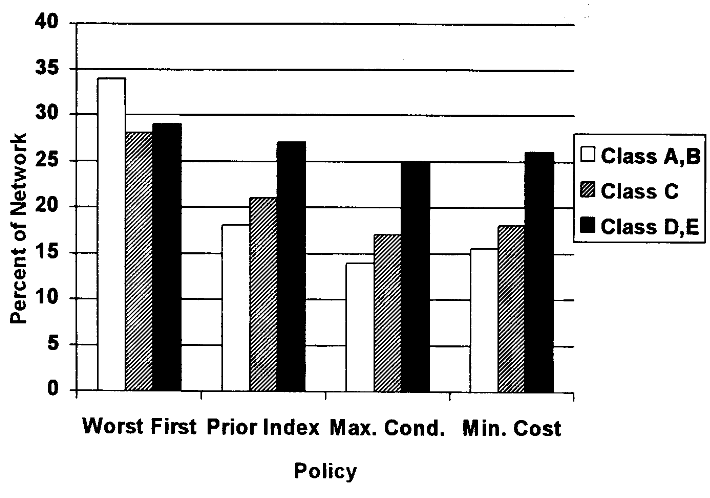

Figure 4 – Decrease in Network Condition

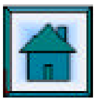
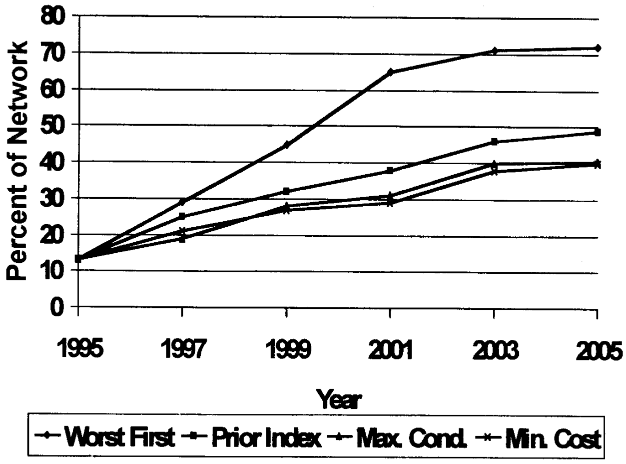

Figure 5 – Percent of Network in Backlog Condition

Figure 5 illustrates the long-term network condition in terms of the effect each policy had on the anticipated backlog. As shown in the graph, the largest backlog, defined as the percentage of the network in poor to very poor condition, occurs when the worst-first policy is pursued.

Figure 6 illustrates the results of the analysis in terms of loss of asset value over 10 years, per road class. In this example, the asset value is representative of the residual value at any given time. The graph illustrates that the largest loss in asset value occurs under the worst-first scenario.

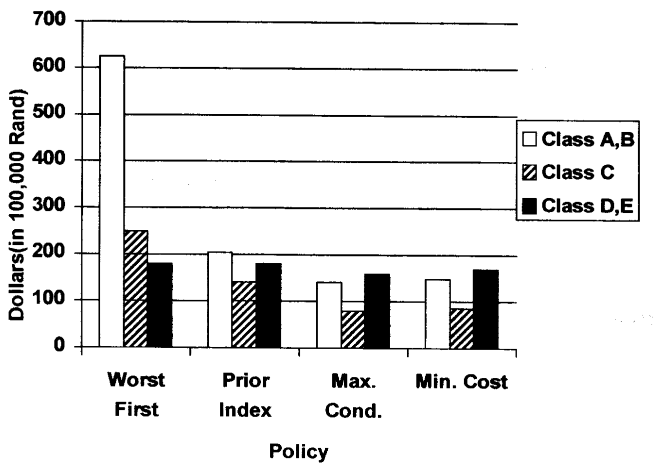

Figure 6 – Loss in Asset Value

What Figures 4 – 6 clearly illustrate is that the policy objective used in selecting maintenance strategies has widely varying long-term performance and cost implications on a road network and its users. It is therefore essential that a roads agency selects a long-term policy objective and structures its maintenance policy to achieve its objective. From the output of the various analyses illustrated above, it appears that policy 3 should be followed if it is the road agency's objective to preserve the road network. If on the other hand, the agency strives to minimize transport costs to society, then it should pursue Policy 4.

4.3 Programme Level Application

At programme level, the challenges faced by the roads agency is to ensure that the most economical maintenance or road improvement options are applied to individual road sections in accordance with the chosen strategy adopted from the strategic level analysis and subject to technical and local constraints. Numerous strategies are available, each with differing life cycle costs and, ultimately, differing economic returns on the investment. For example, as illustrated in Figure 7, one strategy might be to reseal quite frequently whilst the road is in relatively good condition, while another strategy might be to apply a thin overlay when the road is in relatively poor condition. These alternative strategies would be influenced by the type of road, traffic volumes, available budgets, etc. In contrast, Policy 1 should be avoided at all costs!

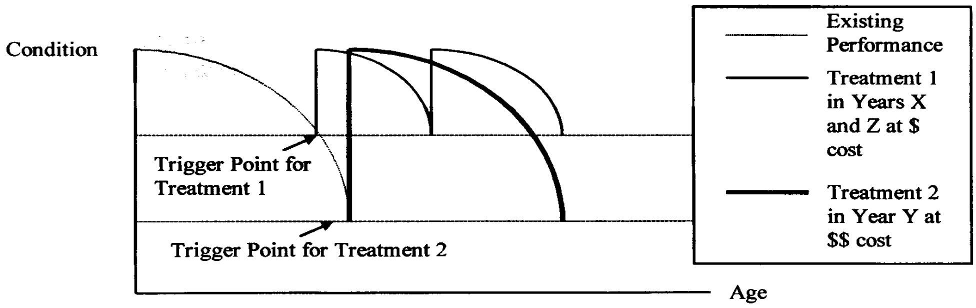

Figure 7 - Alternative Feasible Maintenance Options

To select the best strategy at programme level, optimization techniques can again be used to determine the strategy that gives the best economic return for a specified budget (7). Such a technique allows all strategies for each network element to be plotted on an "economic efficiency frontier" as illustrated in Figure 8. The most cost-effective strategies are the ones that lie on the efficiency frontier. For example, in Figure 8, Strategy 3 and Strategy 6 have approximately the same cost , but strategy 6 has almost twice the benefits. The strategy at the top of the list provides the most benefits per dollar spent. If the budget allows, this strategy should be selected, otherwise the next one down on the efficiency frontier should be selected (Strategy 4).

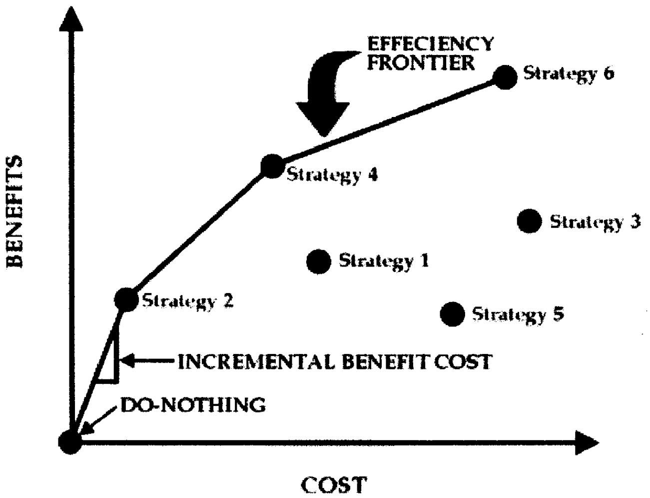

Figure 8 - Economic Efficiency Frontier

Project Level Application

At project level, the roads agency is concerned with the detailed evaluation of one or more road projects or investment options. Road sections with user-specified treatments are analysed over a specified design period to estimate the engineering or economic viability of the project. This would normally entail performing a life cycle analysis of pavement performance, maintenance and/or improvement effects together with estimates of road user costs as a basis for choosing the most appropriate design.

5. SUMMARY

Increased demands for economic efficiency in the use of scarce public funds has engendered a need for roads agencies in the SADC region to resort to the use of appropriately designed road asset management systems. Such systems offer the necessary flexibility to undertake various aspects of road infrastructure asset management in a structured, comprehensive and cost-effective manner.

The modular, integrated framework proposed for asset management systems is based on a strategy developed within the SATCC-TU. It provides the flexibility to match the varied structure of roads agencies in the SADC region and permits a gradual or phased introduction of Decision Support Systems to match the resources of the roads agencies.

Asset management systems can typically be operated at three management levels, namely strategic, programme and project levels. Each of these levels of application represent successive levels of decision making ranging from policy/executive to programme analysis to project implementation..

The optimization techniques available in modern-day asset management systems offer a powerful tool that can be used for policy making. By utilizing such techniques with performance prediction models, the roads agency possesses a tool with the ability to evaluate the long-term impacts of their decisions, and will allow them to fully understand the true cost of their choices.

The successful operation of an asset management system in any roads agency will require top management support, adequate staffing resources and sustainable funding. However, these requirements are probably a small price to pay for the use of a tool which is increasingly becoming the nerve center of most road agency operations.

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