eThekwini Metropolitan Municipality's integrated approach to pavement asset management

Johan Viktor
Technical Director
Road Asset Management Systems
Aurecon South Africa (Pty) Ltd
johan.viktor@aurecongroup.com

Shaun Moodley
Chief Civil Engineering Technologist
Pavement Management Division
eThekwini Metropolitan Municipality
moodleyshaun@durban.gov.za

INTRODUCTION

Recent asset management legislation has holistically incorporated a host of previously stand-alone principles such as "life cycle cost analysis" and "remaining useful life". Some of the issues responsible for the rapidly deteriorating condition of municipal road networks are the lack of capacity, skilled resources and funding to efficiently and effectively manage road networks. Other contributory factors are the lack of reliable condition data and proper Pavement Management Systems (PMS) to budget for and optimise expenditure of available maintenance funds. eThekwini Metropolitan Municipality has, for almost a decade now, used its PMS to achieve arguably one of the best paved metropolitan road networks in the country.

eThekwini's PMS Division is managed by a small complement of professionals, while technical support is provided by Aurecon. The PMS is organisationally located within the Pavement and Geotechnical Engineering Branch of the Roads Provision Department. It is the primary source of all road-related information within the municipality, assisting various entities as shown in Figure 1.

PAVEMENT MANAGEMENT AT eTHEKWINI

The Roads Provision Department implemented a PMS in 2003, commonly known as the eROADS (eThekwini Road Optimisation Analysis Decision Support) system. eROADS is underpinned by an asset management software application dTIMS™ CT provided by Deighton Associates Limited of Canada and configured for use in strategic analysis of pavement networks by Aurecon. The eROADS system is capable of the following broadly defined functions:

- Ensures accurate and reliable location referencing of road data.
- Provides easy access to accurate road network inventory information.

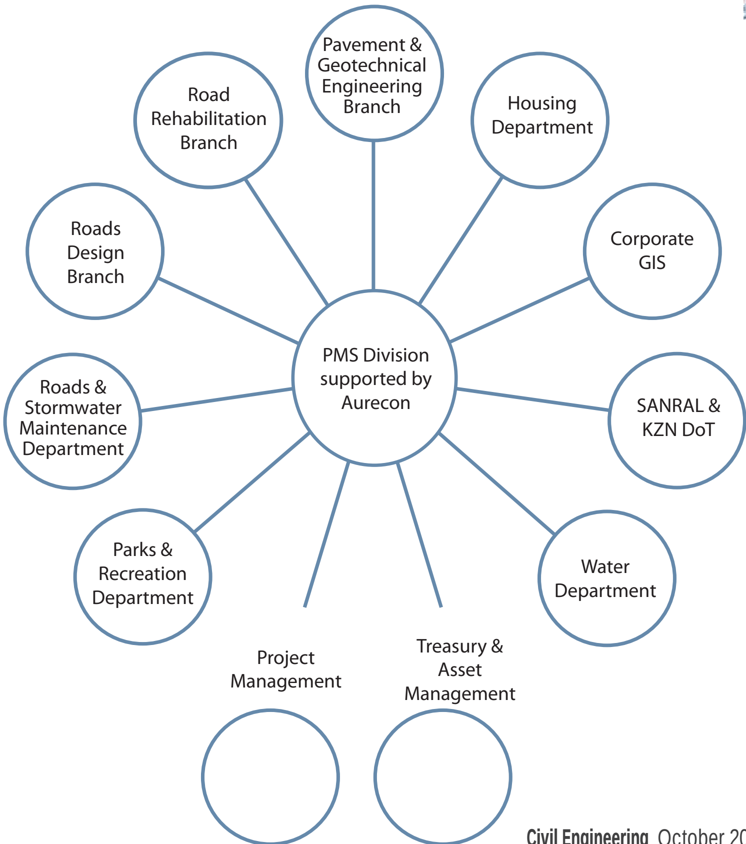


Figure 1: Relationship between the PMS Division and other entities

- Regularly quantifies and reports on the condition of the road network on a network, sub-network and road segment level basis (historic trends and current status quo).
- Allows for integration with the Geographic Information System for presentation of data.
- Provides a basis for allocating funds among different sub-networks through life cycle costing and optimisation.
- Assists in the selection of viable alternative maintenance strategies for each road section in the network and determines life cycle effects of these in terms of: future network conditions, future maintenance requirements and budgetary needs, future road network rehabilitation backlogs, and future asset values of the road network.
- Assists in the selection of the best preventive maintenance and rehabilitation strategies for each road section while taking into account imposed budgetary and resource constraints, now and in the future.
- Assists in identifying the budgetary requirements for implementing the ideal preventive maintenance and rehabilitation strategy for each road section, now and in the future.
- dTIMS^{TM} CT ensures that decision support is available at Level 4 to 5 in terms of the classification of the decision support levels shown in Table 1. Decision support at lower levels will not be sufficient to manage the maintenance of the extensive eThekwini pavement network effectively. Specifically, Life Cycle Cost Analysis (LCCA) and optimisation of investments under constraints are the tools required for effective pavement management.

Table 1 Classification of decision support levels for Pavement Management Systems (Robertson 2004)

Decision support level	Dominant characteristic
1	Basic asset data, rule-based work allocation
2	Project and network level assessment, geographic reference
3	Life cycle cost analysis of agency impacts
4	Life cycle cost analysis of agency and user impacts, economic prioritisation
5	Optimum investments within constraints, sensitivity analysis
6	Economic, social, environmental multi-criteria assessment, risk analysis

Table 2 Surveyed road network length by surface type (2011)

	Pavement type	eThekwini length (km)	SANRAL & KZN length (km)	Total length (km)
2011 Survey data	Block	57	0	57
	Concrete	143	70	213
	Flexible	6 046	1 365	7 411
	Other	6	0	6
	TOTAL (km)	**6 252**	**1 435**	**7 687**

Table 3 Functional road classification

Functional category	Description
UA	Trunk roads, primary distributors, freeways, major arterials and bypasses used for primary urban distribution and linking urban districts/sectors
UB	District and local distributors, minor arterials and collectors, industrial and CBD roads, goods loading areas and bus routes used for district distribution and to link communities
UC	Urban access collectors used for local distribution and to link neighbourhoods
UD	Local access roads (residential): loops, access ways, access courts, access strips and cul-de-sacs

Figure 2: Training of visual condition assessors and assistants

eTHEKWINI'S ROAD NETWORK

The paved road network within the eThekwini Municipality consists of roads belonging to the municipality, SANRAL, the KwaZulu-Natal Provincial Department of Transport, as well as private entities such as Transnet and private residential developments. The extent of the network surveyed in 2011 is shown in Table 2.

Since implementation of the PMS the eThekwini road network is classified based on a functional hierarchy as described in Table 3.

The majority of the paved road network (49%) consists of UD roads that provide mobility and access in a local residential context. UA roads make up only 1% of the network while UB and UC roads constitute 27% and 23% of the road network respectively.

VISUAL ASSESSMENTS

A fundamental aspect of the PMS is the network level visual condition inspections done every two years in accordance with well-defined standards based on the TMH9: 1992 and Draft UTG12: 1996 visual condition assessment standards. The eThekwini standards cater for flexible road pavements, jointed concrete pavements, segmented block pavements, and non-standard or unclassified pavements, while the SANRAL Manual M3-1 (1998) is used for visual assessment of continuously reinforced concrete pavements.

Paved roads are segmented into smaller segments of 500 m which are rated in terms of the various distresses occurring on them. The degree (seriousness) and extent (occurrence) of each distress are recorded. The distresses include surfacing defects, structural defects and functional aspects.

Since its inception in 2003, the PMS has embraced the principles of capacity building and skills transfer by training and accrediting in excess of one hundred visual condition assessors and assistants from the private sector. To date, the selection of survey teams has been based on an Expression of Interest, followed by a pre-tender training, calibration and testing session with specific, defined criteria for acceptance of staff offered as assessors and assistants. This happens together with continuous follow-up and re-calibrations, as needed from the quality control part of the Quality Management Plan (QMP) for visual condition assessments. The quality acceptance procedure is based on re-assessment of a random 10% of the road network of each assessment team to confirm the quality of the production condition assessments. This forms the quality acceptance part of the QMP. The QMP ensures that only acceptable data is imported to the PMS for analysis.

Figure 3: Visual condition assessment team at work

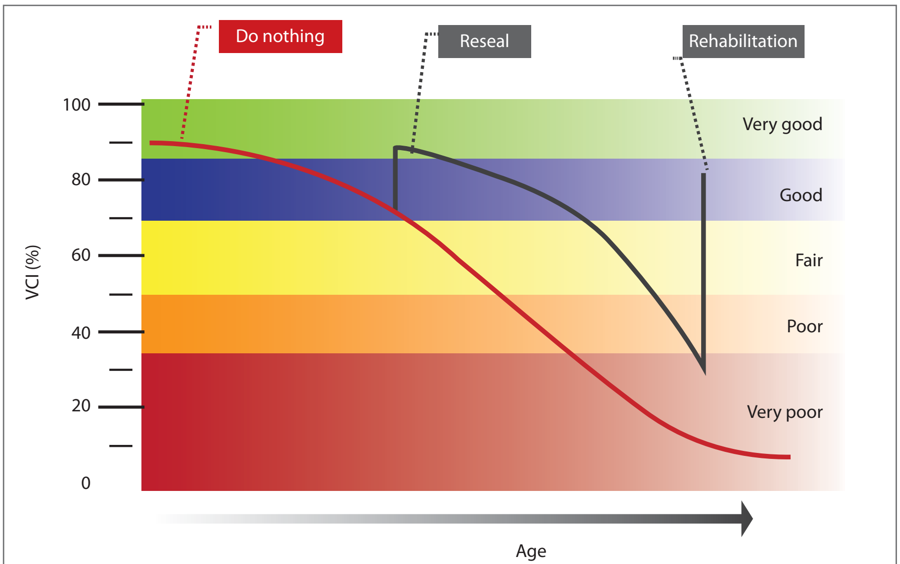


Figure 4: Road deterioration and Visual Condition Index (VCI) categories

The road network is divided into a number of inspection areas, depending on the number of appointed teams (each team consisting of two people, i.e. an approved assessor, and a driver (the assistant). Typically 15 teams are used, and progress per team per day is approximately 10 to 15 km.

Visual condition assessments are captured on the road on tablet notebooks in pre-prepared forms using the Mobicap software. At the start of the segment the form for the relevant visual assessment segment is displayed on confirmation from the assessor that his location as shown on the GIS map on the tablet, from the linked GPS, is correct, as well as the road type. This ensures data capturing against the correct segment. The forms also contain all possible validation procedures during and at the finalisation stage of data capturing of each individual segment's visual data. The purpose is to achieve complete and cross-checked data per visual segment before the assessor physically leaves the relevant segment.

Capturing the visual assessment data directly on the tablets also provides an additional advantage: assessment teams are monitored weekly regarding progress as they submit the data to a central repository. Weekly and cumulative progress per team is available in tabular format and spatially on the GIS. This allows contingency plans to be made should a team default on the required progress.

The network level visual inspections were conducted successfully by trained assessors on the paved road network in 2003, 2005, 2007, 2009 and 2011.

PROCESSING OF VISUAL CONDITION DATA

The surfacing, structural and functional distresses recorded are used to calculate a composite Visual Condition Index (VCI) for each paved road segment (TRH 22 1994: 125-126). The VCI is a percentage index ranging between 0 and 100, where 0 represents a road segment in very poor condition and 100 represents a road segment in very good condition. It is generally accepted that the condition of a road deteriorates with time as shown in Figure 4. The figure also shows the categorisation of the VCI in five condition categories.

PERFORMANCE TARGETS FOR PAVED NETWORK

In order to ensure that the municipal road network delivers an acceptable level of service, the following performance targets have been set (the PMS is ideally suited to determine the future budget needs for achieving and maintaining the performance targets through its LCCA component):

- No roads in any of the UA to UD categories may deteriorate below a VCI of 30.
- No UA and UB roads may deteriorate below a VCI of 50.
- Less than 10% of UC and UD roads may deteriorate below a VCI of 50.
- The average VCI of the entire network must remain greater than 70.

Since 2003 the average condition of eThekwini's surfaced roads fluctuated between 76% and 80% (See Figure 5).

The condition distribution in 2011 is shown in Figure 6. Note that less than 5% of the network is in the very poor and poor condition categories, indicating a healthy situation compared to the internationally accepted maximum of 10% which is also recommended by RISFSA (2005).

The paved road network is probably eThekwini's most expensive asset. Maintaining it in a good condition is vitally important to the city's economic growth, quality of life and its overall sustainability.

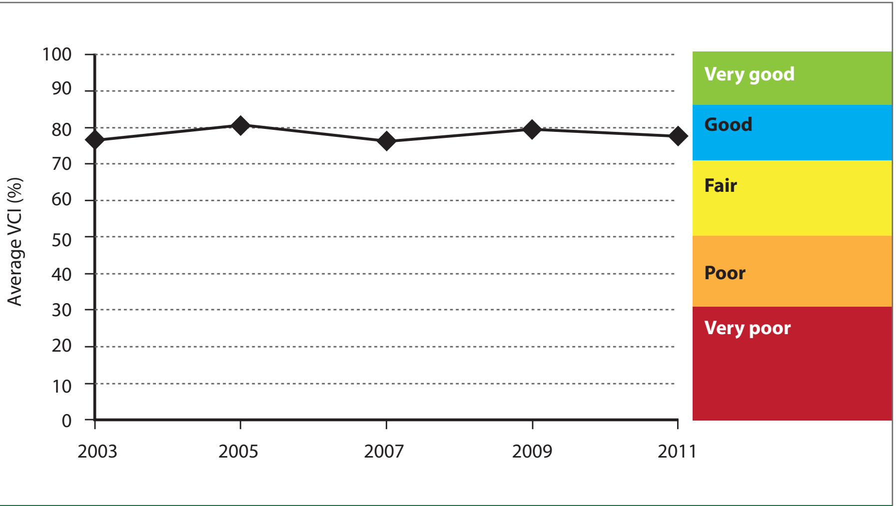


Figure 5: Average VCI for paved roads (2003 – 2011)

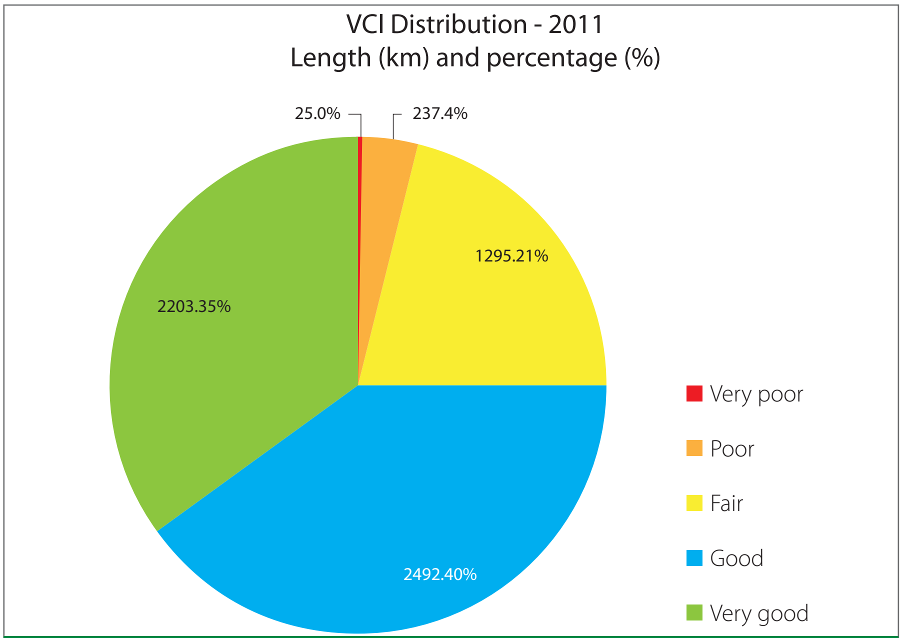
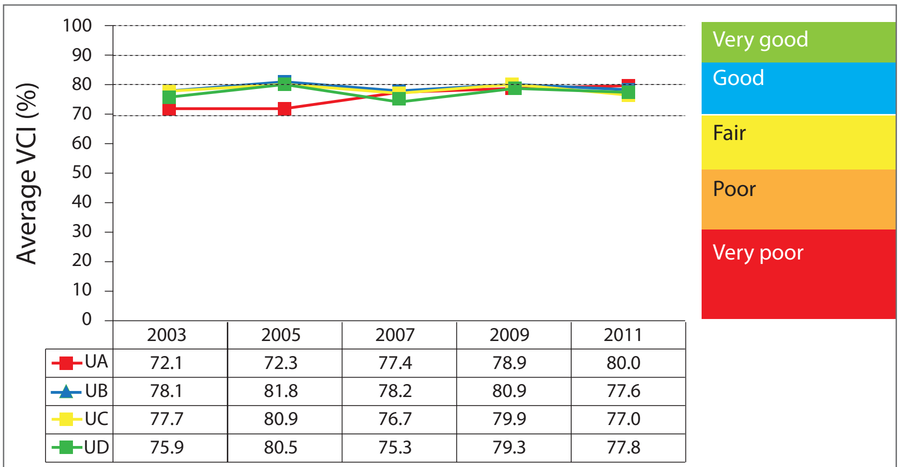


Figure 6: Condition distribution of paved roads (2011)



	2003	2005	2007	2009	2011
UA	72.1	72.3	77.4	78.9	80.0
UB	78.1	81.8	78.2	80.9	77.6
UC	77.7	80.9	76.7	79.9	77.0
UD	75.9	80.5	75.3	79.3	77.8

Figure 7: Average VCI for paved roads per road category (2003 to 2011)

THE PMS AS A STRATEGIC PLANNING TOOL

In an environment of decreasing budgets and increasing demands, the PMS has proved to be an invaluable strategic tool, used to make cost-effective decisions on pavement management issues. The eROADS system optimises the information from the network level surveys taking into account pavement condition, predicted deterioration and treatment costs to produce a prioritised list of rehabilitation and seal projects across the entire municipal network, such that the most economically viable treatment is undertaken, given the budgetary constraints for road maintenance. The optimisation process is therefore not a simple "worst first" scenario, but evaluates the merits of a range of possible treatments, each time taking into account the predicted future deterioration of the road in accordance with the HDM-4 World Bank Road Deterioration models. This iterative process is undertaken for every road in the municipal network to produce a multi-year Maintenance and Rehabilitation (M&R) programme.

Based on the strategic level maintenance needs analysis, the Roads Provision Department has successfully influenced Council to increase its funding allocation for pavement preservation and rehabilitation.

The 2007 Strategic Maintenance Needs Analysis indicated a funding level need of approximately R300 million for preventive maintenance and rehabilitation to counter further deterioration and to improve the condition of the network. The municipality subsequently increased the preventive maintenance and rehabilitation funding level from R80 million to more than R300 million for 2008/9. This investment resulted in an increase in the overall condition of the network from 2007 to 2009, due to increased portions of

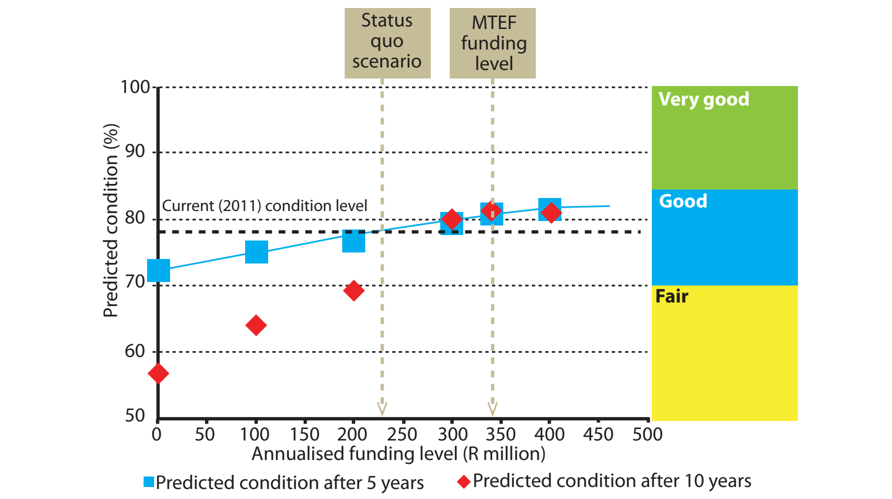


Figure 8: Predicted condition five and ten years from 2011 versus annual funding level

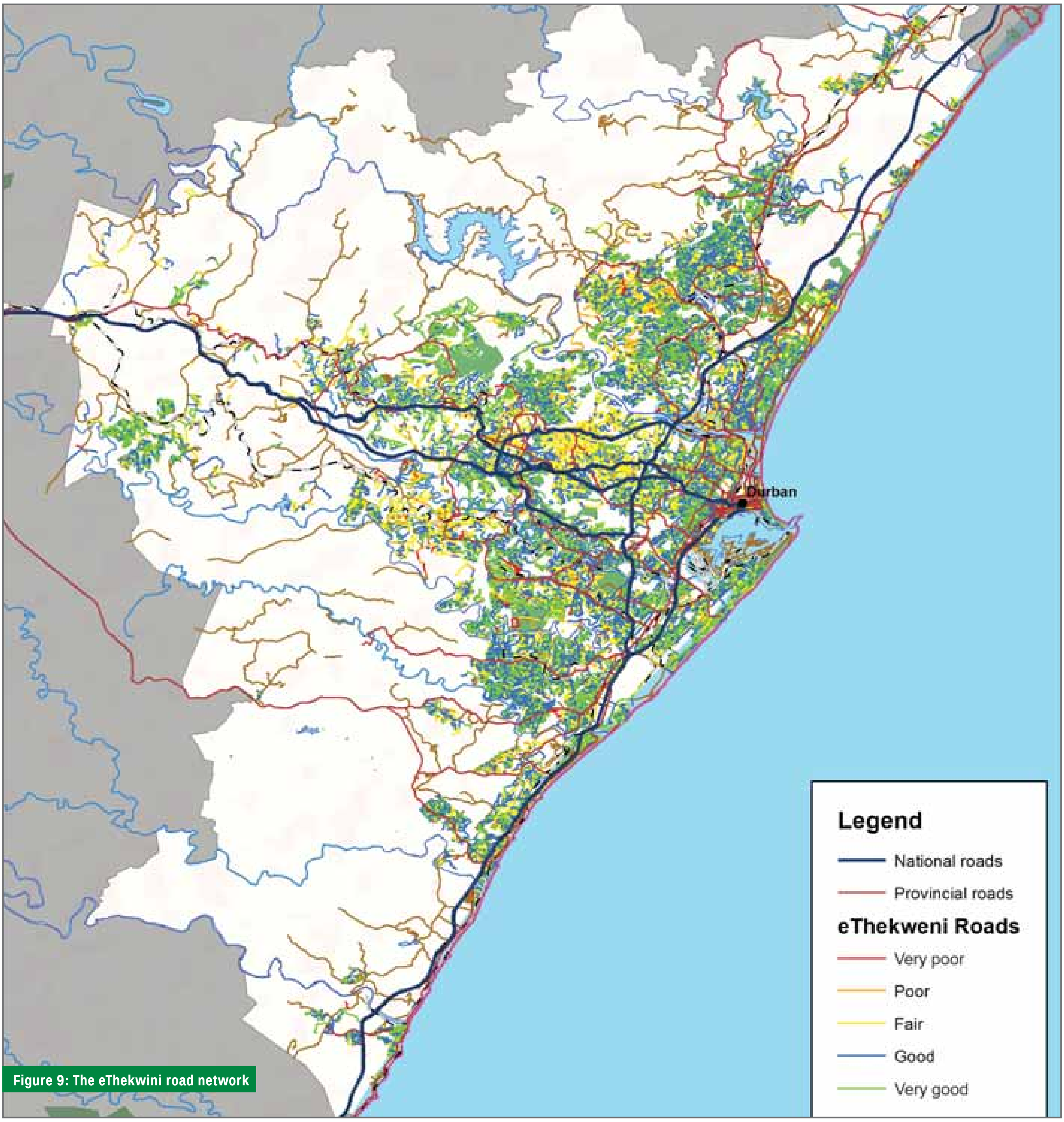


Figure 9: The eThekwini road network

roads in the "good" to "very good" condition categories (Figure 7).

The Strategic Maintenance Needs Analysis of 2009 predicted an improvement in the overall network condition if the Medium-Term Expenditure Framework (MTEF) budget (R424 million) was allocated for preventive maintenance and rehabilitation according to the recommendations of the LCCA. The national bitumen shortage and contractor procurement issues were some of the pitfalls resulting in the recommendations not being fulfilled, hence a slight decrease in the condition in 2011. However, based on the Strategic Maintenance Needs Analysis of 2011, the Roads Provision Department has implemented an intensive re-seal programme to prevent "fair" roads deteriorating into the "poor" condition category. Roads in a "fair" condition have the opportunity to be preserved with cost-effective preventive intervention measures, effectively increasing the life of the pavement by many years. This informed decision-making process would not have been possible without the PMS and its decision support tools.

The strategic analysis is used to determine the consequences of various policy and budget scenarios, and can be expressed as the expected average future condition, expected future backlog (roads in poor and very poor condition), expected condition distribution, etc. Figure 8 shows the expected impact of annual budget levels on the future average condition five and ten years into the future.

PAVEMENT MANAGEMENT IN THE ASSET MANAGEMENT CONTEXT

The PMS is strategically positioned to satisfy National Treasury's regulatory requirements of Generally Recognised Accounting Practice (GRAP) from a road asset management perspective. The PMS provides the information needed of the municipality's asset management system regarding the relevant characteristics of the pavement asset, and their condition and remaining useful lives. The PMS, however, contains substantially more detailed information without which the strategic needs analysis and preparation of multi-year preventive maintenance and rehabilitation plans would not be possible. Currently, the PMS satisfies the decision support needs of the pavement managers of eThekwini, while the information passed on to the asset management system satisfies the accounting requirements. The latter alone is not sufficient for pavement management and satisfies a different need.

PMS AND GIS INTEGRATION

The implementation of the PMS has led to substantial requirements being put on Corporate GIS regarding the spatial integrity of the road centerline map. The PMS uses the dynamic segmentation (also known as linear referencing) capabilities of the GIS to display data and information from the PMS for the linear pavement infrastructure. This requires specific topology rules to be adhered to in the GIS regarding direction of lines, overshoots, undershoots, duplication, etc. To assist Corporate GIS in complying with this, Aurecon developed an Editing Verification Tool (EVT) as a plug-in to verify any changes made to the spatial network, e.g. addition of new roads, splitting of links, etc. The road network identifier information of every link (start and end descriptions, nodes, km positions) is also generated from the GIS, thus ensuring a fully synchronised GIS and PMS.

CONCLUSION

The success of eThekwini's PMS can be attributed to the interaction of three fundamental components: processes, people and technology. eThekwini has developed a *pavement management mindset*, having implemented processes that are geared towards managing the road network at optimal levels. The professionals responsible for the PMS ensure that sufficient budgets are motivated for data collection, system upgrades, skills development and operational support. Adhering to strict quality management procedures for data collection ensures that the strategic analysis of the consequences of budget and policy scenarios is based on sound data. This leads to the development of optimum multi-year preventive maintenance and rehabilitation plans, the implementation of which has had positive effects on the overall pavement conditions. In the long term, eThekwini's R 46.8 billion road pavement asset is in good hands!

NOTE

The list of references is available from the editor. □

Source:
http://www.saice.org.za/downloads/monthly_publications/2012/2012-Civil-Engineering-October/#/0