KEY PERFORMANCE INDICATORS FOR ROAD INFRASTRUCTURE ASSET MANAGEMENT BY A ROADS AGENCY IN A LARGE LOCAL AUTHORITY

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The Johannesburg Roads Agency (JRA) is the road infrastructure agent of the Greater Johannesburg Metropolitan Council (GJMC). The road infrastructure in Greater Johannesburg represents an asset value in the region of R 5.4 billion. JRA as curator or custodian of GJMC will maintain, improve and manage this valuable infrastructure asset. Ultimately the contract between JRA and GJMC would need to reflect the condition and value of this asset being managed by JRA. Roads related concepts like Visual Condition Index (VCI) and Remaining Pavement Life (RPL) have been developed in the past by engineers for road asset management. These performance indicators are primarily technical in nature and do not clearly or directly reflect asset value in monetary terms. Their exclusive use may make the management of the required new type contractual relationship troublesome. These technical performance indicators were historically developed for a different paradigm where the client body does the management, planning and execution of work with own work force and with diffused checks on performance. A more specific set of KPIs needed to be developed which can be used in this new contractual relationship between JRA and GJMC to measure the curatorship performance and productivity more effectively. This paper gives an overview of the description of appropriate KPIs and indicate the way for the further customisation thereof.

1. INTRODUCTION AND BACKGROUND

The Johannesburg Roads Agency (JRA) is the road infrastructure agent of the Greater Johannesburg Metropolitan Council (GJMC) from 1 January 2001 (JRA, 2000). An Advisory Board has been established and will represent the interests of the GJMC and the public. The JRA will be in a contractual relationship as “curator” or custodian of the Greater Johannesburg road infrastructure system. The curatorship of the Johannesburg road infrastructure is a contractual business relationship of considerable monetary dimension as described by Heggie and Vickers (1998).

> “*The road sector is big business. Many main road agencies are among the Fortune Global 500. The Japan Highway Public Corporation manages assets ($216 billion) roughly equal in value to those of General Motors and Sumitomo Life Insurance, the U.K. Highways Agency ($80 billion) is in the same league as IBM and AT&T, while a relatively small road agency like the Roads Department in South Africa ($7.3 billion) is in the same league as Northwest Airlines and Fuji Electric. On the revenue side, some of the larger road funds and toll road operators also rank among the Global 500. The Japan Road Improvement Special Account has roughly the same turnover ($30 billion per year) as Nippon Steel and Pepsico, while the U.S. Federal Highway Trust Fund ($21 billion per year) and Japan Highway Public Corporation ($17 billion per year) are in the same league as Dow Chemical, Lyonnaise de Eau, and Chibu Electric power.*”

The road infrastructure in Greater Johannesburg represents an asset value in the region of R 5.4 billion of the road pavement layers alone (Judd, 2000). The traditional road authority sees the provision of road infrastructure and maintenance as a social responsibility. In such a traditional scenario there is in most cases little use of the asset value of the road infrastructure in the measurement of service delivery, and limited use of the business value attached. (Horak and van Wijk, 1998). A total paradigm shift is needed when such services are contracted out like in the case of when dealing with a roads agency. JRA as agent or custodian of GJMC roads infrastructure will have to maintain, improve and manage this valuable infrastructure asset. Ultimately the contract between JRA and GJMC would need to reflect the condition and value of this asset being managed by JRA.

Roads related performance indicator concepts like Visual Condition Index (VCI) and Remaining Pavement Life (RPL) have been developed by engineers in the past for road asset management (Judd, 2000). Typically asset management systems like Pavement Management Systems (PMSs), Geographic Information Systems (GISs) and Maintenance Management Systems (MMSs) are used to manage and maintain roads and to derive the aforementioned performance indicators (Horak and Agaienz, 1995). The associated performance indicators are primarily technical in nature and do not clearly and directly reflect asset value in monetary terms. Their exclusive use may make the management of the required new type contractual relationship troublesome. These technical performance indicators were historically developed for a different paradigm where the client body does the management, planning and execution of work with own forces and with diffused checks on performance (Heggie and Vickers, 1999).

This curatorship of the road infrastructure system will have to be managed contractually and monitored via preset Key Performance Indicators (KPIs). These KPIs will need to be objective and easily measurable. The KPIs thus developed must in essence reflect the interests of the three main role-players/stake-holders:

- The JRA as agent with contractual obligations.
- The client GJMC represented by the roads advisory board.
- The public represented by the advisory board

This paper is designed to deal with the conceptual aspects of KPIs for road asset management. A more inclusive set of KPIs needs to be developed which can be used in this enhanced or broader contractual relationship between JRA and GJMC to measure the curatorship performance and productivity more effectively and efficiently.

2. KEY PERFORMANCE INDICATORS - GENERAL

Key performance indicators (KPIs) are designed to be objective measures of performance for a road authority. There are three aspects that need to be addressed in asset management KPIs for roads:

- Performance – which are functionally related such as measuring skid resistance, rutting, texture, and roughness,
- Visual appearance – including number, degree and extent of defects
- Structural –which include determination and calculation of remaining life

However, KPIs do not just cover asset condition, but should in an outsourcing situation expand to include broader non-technical measures of performance (Austroads,1999) , such as:

- Speed of repair response to road defects,
- Compliance with inspection plans,
- Road safety,
- Smoothness of ride,

- Long term Injury Rate
- Traffic management and disruption,
- Environmental impact.
- Corridor vegetation control
- Customer relations
- Timeliness of response to complaints, etc.
- Travel time
- User satisfaction
- Etc.

It may be appropriate to include some or all of these elements in the KPIs to measure curatorship performance and productivity. However this paper focuses on the development of asset management KPIs. Operational measures of productivity will not be covered in this paper. Operational KPIs typically measure how well the road authority is doing in its routine task of keeping the road functional. It typically relates to questions such as: Are the potholes being patched, and how long does it take to patch them? (Otto and Ariaratnam, 1999)

Good performance by a road authority is to keep the road performing well and its appearance good, without diminishing the value of the structure or reducing the average remaining life. Western Australia typically use a concept of "fit for purpose" as basic descriptor of the road asset in their long term rehabilitation and routine maintenance contracts (Logue and Avery, 1998).

3. LIMITATIONS OF VISUAL APPEARANCE BASED KPIs

Visual condition derived KPIs give a simple visual measure of how well the road authority is doing its task of maintaining the road network as related to mainly functional aspects of the road. The visual survey based KPI used mostly is the Visual Condition Index (VCI) and is well established in its use in SA. It does have certain shortcomings if intended for use in a contractual monitoring situation, though. Typically the cost of keeping the performance and appearance of roads in a good condition is typically much lower than any structural work that may be needed. In addition, the structure is hidden from the public eye. The temptation in a political environment like a local authority can easily be to reduce maintenance costs by postponing structural work and only performing superficial visual maintenance with a limited budget. This can make the performance of the road authority look good in the short to medium term (more work seems to be done for less money). In the medium to long term, the extent of the lurking disaster becomes apparent in due course because no government can afford to do the massive catch-up spending that such an under-maintenance situation eventually demands. This situation is often referred to as "consuming the asset".

VCI as KPI does not adequately address important role-players perceptions in the urban environment, such as those of the client and rate payers. Typically, it does not address the important urban ancillary assets and appearance of footpaths, kerbs, litter, drainage, storm water inlets, signs and vegetation control. These ancillary assets are perceived by the urban rate payer and road user as part of the road asset facility and its condition as a complete unit or package provided by the road authority. It may be necessary to improve or expand the traditional VCI to take some of the most important urban total road reserve issues into account to make VCI meaningful to the clients.

Typically Johannesburg in the past developed a Verge and Footways Management System (VFMS) which caters for some aspects of the road reserve assets. It does not cover all features in the road reserve though. (Horak and Agaienz, 1995) Even though it is complicated to include these other road reserve asset features in a combined visual index, it is argued that it is necessary to ensure the road user and tax payer perspective are incorporated. This will ensure political support and transparent involvement of the road user in such a new paradigm of contractual relationship between JRA and the main client, GJMC and indirectly the rate payers. (Olivier et al, 1998) Even though such combined VCI has not been developed yet, it is argued that the traditional VCI can be used as a starting point and to improve it over time in an evolutionary fashion.

4. THE ROAD ASSET VALUE

4.1 The broader concept of road asset value

The road infrastructure in the urban environment has asset value which could be defined as being made up as follows:

1. The road reserve or right of way (as defined typically by the township planning scheme).
2. The road foundation or bed which can be defined as the in situ subgrade and related earthworks formation works as basis of the road pavement structure built on top of it.
3. The pavement structural layers on top of the prepared subgrade.
4. The road surfacing. This is invariably an asphalt layer with limited concrete or block paving in the Greater Johannesburg urban environment.
5. Bridges, culverts and other structures forming part of the road to carry traffic over streams, other roads and services.
6. Footways and road reserve landscaping features on the sides of the paved surface used mostly by pedestrians, bicycles, etc. Kerbing should be included in this group, but as it also has a strong stormwater linkage.
7. Stormwater facilities (Stormwater inlets and underground stormwater pipes and open side channels).
8. Underground utilities buried in the road reserve. This may include sewerage, water mains, gas, electricity, optical fiber and communication cables.

The road infrastructure asset elements are described in more detail in the Appendix.

Asset elements 1 through 4 are classically directly seen as elements of the concept of a paved road. Their features and performance are seldom described in monetary terms, but typically in physical appearance or technical terms. In the rural situation the surfacing layer is often seen as part of the structural layers, but in the urban area the surfacing is an integral part of the surface storm water drainage system. This difference in use and related deterioration is even more pronounced in the lower order urban streets, the tertiary and even basic access streets where environmental effects may have a stronger detrimental effect on the road condition than traffic.

Asset elements 5 to 8 (mentioned before) are traditionally regarded as not directly part of the paved road infrastructure. They have their own asset management systems like the Bridge Management System (BMS), Footway and Verge Management System (FVMS) and Stormwater Management System (SWMS). These asset elements are however part of the broader concept of a road infrastructure system in the urban environment. Their traditional separation from the road infrastructure system is done mostly for operational discipline focus and institutional operational benefit.

The development of a roads asset KPI (or set of KPIs) is an important measure of the road authority's performance in conserving or preserving the road asset and preventing "consuming the asset".Activities regarding the upkeep, rehabilitation and installation actions of these asset elements have a direct influence on the value and use of the paved road system in the urban environment. Typically the road-using public do not compartmentalise their experience of road infrastructure usage. They typically experience driving over a culvert as part of a road they are traveling on and don't see it as a separate facility. The storm water system in the urban area is further typically integrated with the road system and not divorced as in the case of rural roads.

4.2 Simplification of Road Infrastructure Asset Elements

The various elements described above still provide a rather complex situation and therefore need further consolidation. The road infrastructure is traditionally described in terms of road type and importance of roads. The current road classification used in GJMC is shown in the table to follow, as well as the suggested clustering of these road types and asset elements. It is suggested that asset value of the road infrastructure system also be simplified as shown in the Table I to follow:

Table I: Clustering of Road Types and Asset Elements

Road type	Road Type Cluster	Asset elements clustering		
		Road reserve and foundation	**Structural layers**	**Surfacing**
Motorways (M1 & M2)	**Major routes**	Cluster road bed, kerbing, road reserve, footway, stormwater inlets, stormwater pipes, bridges, culverts and verge facilities all inclusive	Like in the case of rural roads the surfacing can be seen as part of the structural layers. Initial value should be determined from as built information or replacement value determination.	
Metropolitan Routes				
Primary roads	**Urban streets**	Cluster road bed, kerbing, road reserve, footway, stormwater inlets, stormwater pipes, bridges, culverts and verge facilities all inclusive	The structural layers are seen as separate from the surfacing as these roads normally suffer more from environmental factors and utility maintenance activities than traffic loading.	Surfacing is seen as a separate asset element for these roads as they have a stronger preservation effect on the structural layers it protects form environment al effects.
Secondary roads				
Tertiary roads				
Gravel roads	**Gravel streets**	Cluster road bed, road reserve, footway, stormwater side drains, bridges, culverts and verge facilities all inclusive.	Combine the gravel surfacing and structural layers. The Gravel Road Management System (GRMS) should determine regraveling and blading intervals.	

4.3 Calculation of Asset Replacement Value

The road infrastructure as an asset is basically "expended" by using it like a consumable. The expending of a road is mainly caused by the road user travelling on it. The environment and human interference, in various destructive ways, described in the Appendix, also contribute to a general deterioration of the condition of the road network over time. The value of the asset therefore diminishes over time due to use.

The current value of the road asset can therefore be determined by the current condition. The JRA, as agent and curator will be contractually bound to preserve or improve the condition of the road infrastructure via new construction, preventative maintenance, normal maintenance actions, rehabilitation and reconstruction. The appropriate KPI is one of residual or changing asset value.

In determining the residual or changing value of the road asset at least three viable approaches can be suggested. They are briefly described and developed in the sections to follow.

a) Residual asset value (equivalent overlay concept to restore pavement life)

In New Zealand, Transit (their road agency) measure their residual asset value by measuring how much is needed to restore it. They refer to a “normalised” or “equivalent overlay material” rehabilitation procedure of “total tonnage of gravel overlay required to restore the pavement to an agreed design life”. Deflection measurements on the road network is used as basis of this simplified calculation. Only maximum deflection and radius of curvature are used as indicators. The technical basis of this measure is:

- The cost of the pavement overlays is equivalent to the cost of rehabilitation;
- The agreed design life is equivalent to the concept of “as new” in the value definition;
- The cost of placement of overlays is a constant in this application;
- Established procedures are available to convert deflection and curvature measurements to overlay thickness;
- Calibration of the measure to account for future changes in measurement technology or design procedures are relatively simple; and
- The concept is intuitive and technically sound

This approach can be converted to SA practice by converting to asphalt mix overlay instead of gravel as the latter can be confused with gravel streets. A better use of deflection bowl information is possible by typically using deflection basin parameters, such as Surface Layer Index (SLI), Middle Layer Index (MLI) and Lower Layer Index (LLI) and their remaining life relationships for various types of roads. The concept of Odemark’s Equivalent Layer Thickness (ELT) (Horak, Maree and van Wijk,1989). Theory can additionally be used in similar fashion to the gravel overlay method described above. The assumption is that deflection measurements will need to be done on all roads. Cost limitations may temper this need to a hybrid approach for the lower level roads. It is standard practice nowadays to do deflection surveys with the Falling Weight Deflectometer (FWD), but the Transportek Deflectometer (previously known as the La Croix) can also be used even though confidence in the structural evaluations may be lower.

This “overlay to restore pavement life” approach makes virtually exclusive use of deflection measurements. It is basically a structural evaluation which could be supplemented by other means. It is suggested that if it be accepted, that the following approach be followed as summarised in Table II.

Table II: Suggested Deflection Survey Methodology

Road clustering*	Survey methodology
Major Routes	FWD typically at 200m intervals per lane plus visual surveys
Urban streets	Deflectograph on the primary streets only or FWD with statistical sampling per length of road type. In both cases use other instruments like the DCP to supplement information where measurement methodology is applicable. Visual surveys are standard.
Gravel streets	Visual surveys, DCP, material sampling and profiling.

- As described in Table I.

b) PMS inventory and condition related asset value

This approach determines a financial asset value by using PMS information to calculate asset value. Typically a road in a Very Good condition has a value equivalent to the actual replacement value. A road in a condition less than Very Good has a value equivalent to the replacement value less the cost to improve the road to a Very Good condition and is assumed to be a percentage of the replacement cost.

This simplified approach make a lot of assumptions which may be flawed and is the reason for this KPI being unsatisfactory to use on its own in a contractual situation where performance must be measured. One of the assumptions is that visual condition surveys alone can be used for this approach. The major problem is however that fresh road surfacings can mask or obscure real structural problems, with significant impact on repairs and maintenance needs. The maintenance neglect of the recent past may help to obscure or confuse asset preservation with pure operational maintenance aspects. Typically a pothole in a basic access street may have forced an overlay versus a preventative maintenance overlay of a structurally worse access street, but without a pothole at present.

However this is a simple KPI which is a good measure of the visual appearance. It may be used in combination with the residual life approach to have two KPIs for asset management. This is the most desirable situation for the major roads, but the amount of work required to maintain such a KPI system may preclude the use of this combined approach for the less important roads. The PMS based simplified approach may be used on its own for the less important roads provided reliance is placed on structural evaluation coupled with visual surveys of the condition of roads, though. It is therefore a matter of level of acceptable risk or confidence in the results from the surveys which will require various levels of structural evaluation as basis for the calculations. The same approach suggested in Table II would therefore be suggested to handle this aspect.

c) The South African Roads Agency Ltd (SANRAL) approach

The financial method to determine replacement value is to use depreciation (such as straight line) over the life period determined. However, road engineers know that this is not a true reflection of the deterioration of road structural layers and tend to use structural deterioration curves based on PMS condition data. The replacement value of the road foundation (bed) and the structural layers is calculated by the South African National Roads Agency (Ltd) (SANRAL) (Kannemeyer, 2000) using a mixture of financial straight line depreciation and engineering deterioration trends as shown in figure 1 below. The depreciation period for the road bed in this case is 50 years and for the structural layers 25 years.

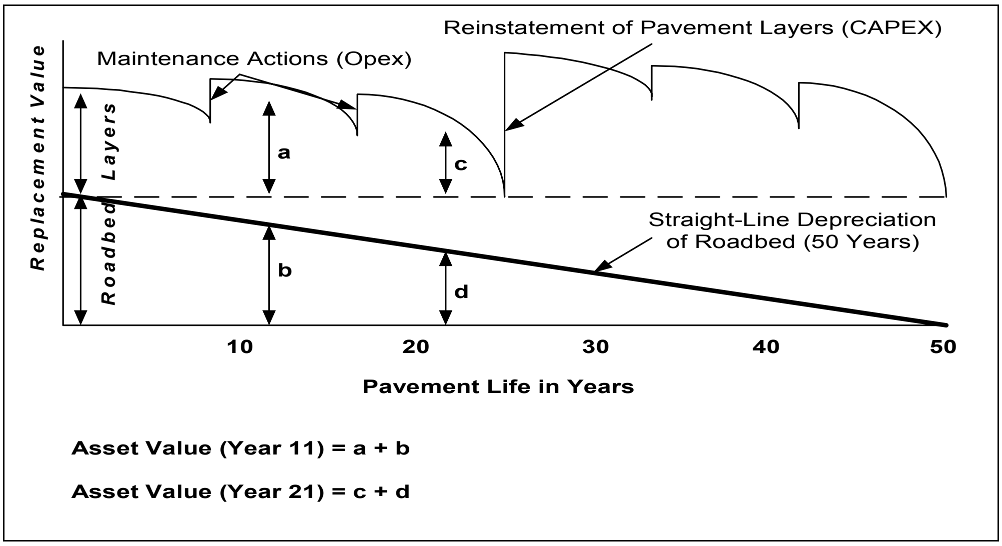

Figure 1: SANRAL method of road asset value calculation.

The replacement value would need periodic inflationary adjustment. Figure 2 conceptually indicate how this is done by SANRAL(Kannemeyer, 2000). There are a number of issues that this approach raises including reconciling the differences between the accounting and the engineering approaches. In addition, different to a rural road situation, in the urban environment the road or street asset value is directly and indirectly influenced by the other peripheral road asset elements described before. It is therefore suggested that a secondary adjustment would be needed to the primary asset replacement value described above. This is conceptually shown in the three tables to follow.

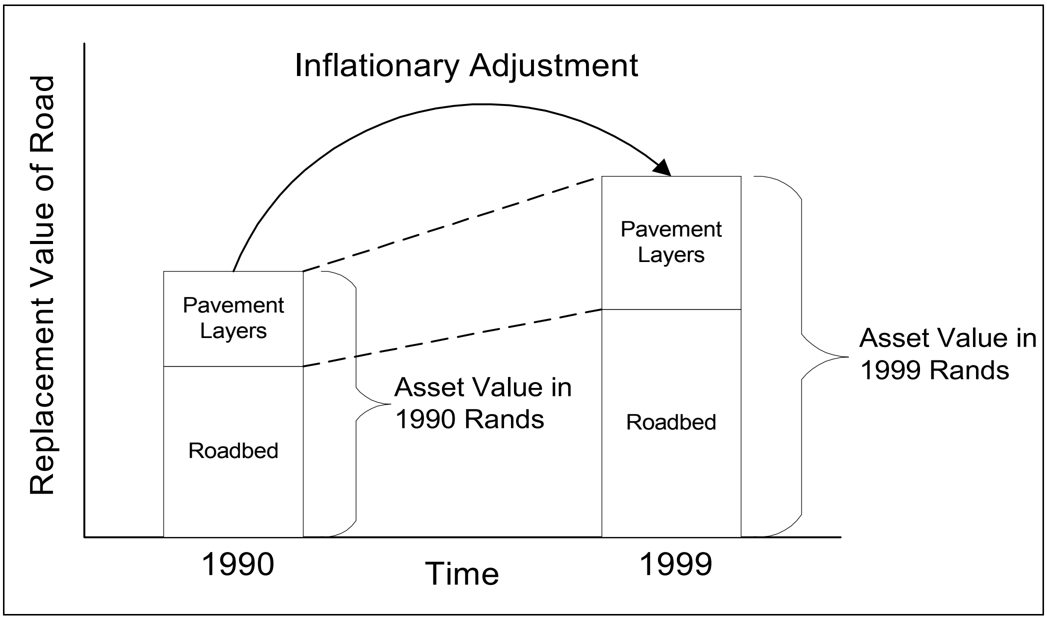

Figure 2: Inflationary adjustment to replacement value

Table III: Asset Cluster Element of Road foundation and road reserve

Primary asset value determination	Secondary adjustment of asset value	Final asset value
• Value of asset is determined by valuers relating it to structural elements and property valuations • Bridge and culvert structures should be seen as part of this asset value grouping • Inventory recorded in GIS , PMS and BMS • Assign present value/worth to it • Adjust value over time based on property values in township at regular intervals.	• Adjust value upwards in case of typical urban renewal schemes • Adjust value downwards in the case of road closure or pedestrianisation, etc.	• This value will be written off over a 50-year period.

Table IV: Asset Cluster Element of Structural layers

Primary asset value determination	Secondary adjustment of asset value	Final asset value
• Inventory of present day replacement value of structural layers determines initial value. • PMS determined visual and instrument structural evaluation determines present condition. This is expressed in VCI or RPL terms. • Bridge and culvert condition assessment via the BMS must be factored in a combined VCI or RPL	• Depreciate based on condition index and/or structural evaluation. • Depreciate street sections based on destructive interference of utilities, storm water or malfunctioning bridges and culverts. • Appreciate in case of maintenance, rehab, reworking or new construction and improvement works.	• Present day adjustment of value based on primary asset value and time related condition adjustments.

Table V: Asset Cluster Element of Surfacing

Primary asset value determination	Secondary adjustment of asset value	Final asset value
• As built construction cost information	• Depreciate in the case of maintenance related malfunctioning of typically storm water inlets. • Inflate or deflate value based on other maintenance and resurfacing actions	• Present day adjustment of value based on primary asset value and time related condition adjustments.

Note: *Gravel streets are handled as described previously*

5. CAUTIONARY NOTES

It is clear that if an asset value is used as KPI that the deterioration of the road infrastructure over time needs to be defined and described in specific terms to lower the risk of an accurate overall asset value. It is clear that the level and sophistication of the PMS selected for use by the JRA will have a crucial role and effect on the level of objectivity obtainable. This risk associated with the level of PMS used is demonstrated conceptually in Figure 3. Before the tolerances of a KPI are selected, the level of PMS would need to be addressed first. The tolerances need to be fixed rather rigorously as this will be used in a contractual situation. Therefore the sensitivity and limits need to be determined beforehand.

The costs of maintenance neglect over the past few years ideally also need to be calculated as it may pull an asset related KPI into the operational and productivity level and mix concepts. Typically a PMS under ideal circumstances focuses on preventative maintenance and asset preservation. When maintenance backlogs exist, maintenance activities drift into operational routine and even emergency stopgap measures. This invariably lowers the general current value of the road infrastructure asset. Typically resurfacings done under such circumstances tend to temporarily mask structural problems. An attempt should therefore be made to quantify this cost of neglect via a proper commissioning survey and baseline analysis.

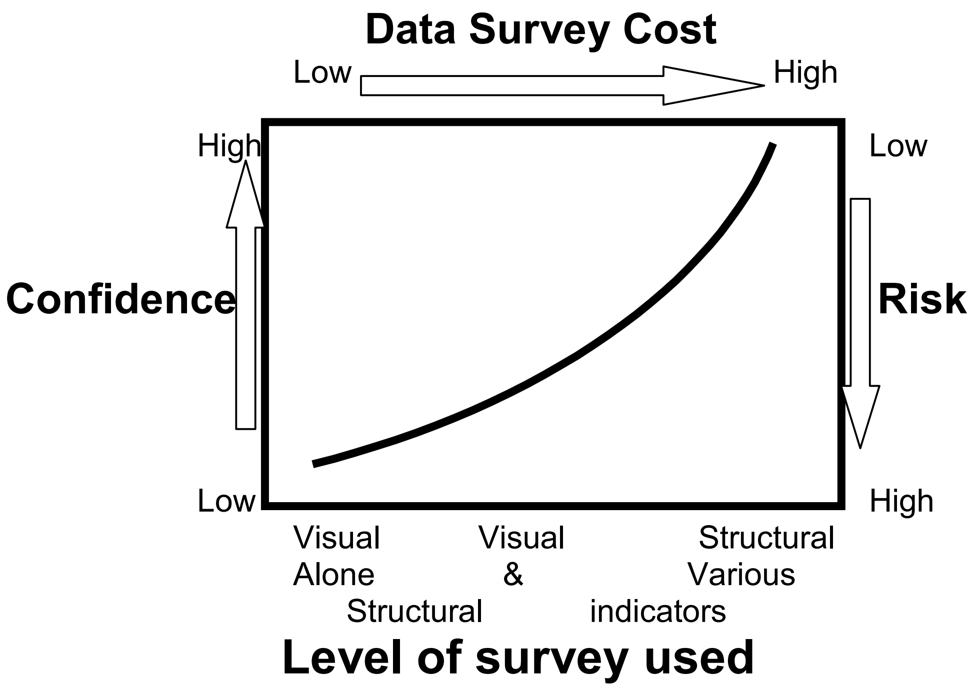

FIGURE 3. Conceptual risk, confidence and cost of asset survey level

There are certain purely routine maintenance activities, normally associated with operational type KPIs, which can have a direct impact on the asset value determination or residual value. Typically the operational activity of storm water inlet cleaning can accelerate traffic related deterioration of a street in the urban environment more than on a rural road. It is therefore important that the operational KPIs are also determined in parallel with the asset value KPIs in order to create linkages .

The impact of the condition and functioning of the peripheral road asset elements cannot be denied and would need proper quantification. Typically such separate asset management systems (BMS, SWMS and FVMS) are not fully functional and have typically not been integrated yet via a GIS. These systems will probably operate independently for the time being. Nevertheless the output from these systems would need to be converted and factored or weighted into the primary functional system outputs, the PMS. This can probably be handled via a phased approach of upgrading and increase in accuracy. Typically a gut feel link can be established which can be upgraded via further development and research in due course.

The ability of the JRA to maintain the road network to an agreed condition or maintain it to an agreed asset value is directly dependant on a guaranteed road operational budget. It is imperative that a sensitivity analysis be done on the road network for various budget scenarios to indicate the impact on the road network over time. Most of the better model PMSs can do such a sensitivity analysis. Based on this analysis a budget value should be agreed and guaranteed by the GJMC in order to ensure the JRA would be in a position to fulfil its contractual obligations. Any savings that JRA register should typically be reinvested in the upgrading of the road network and encouraged by the GJMC to ensure commitment to asset improvement.

6. CONCLUSIONS

It is recommended that :

1. A clustering of road asset element and road category be used to describe the road asset elements in cluster groupings as shown in Table I to achieve a level of simplification which will support the efficiency of the road asset management.
2. A visual survey based asset condition assessment method alone cannot be used to determine objective and effective KPIs for road asset management. A mix of visual assessment enhanced with various structural assessment methodologies should be applied in relation to the asset element clustering and road class suggested above to manage the risk involved and cost associated as illustrated in Figure 3.
3. A phased approach of asset value determination should be used. It is suggested that the standard practice of using PMS survey methodology be used as departure point and used as absolute minimum survey methodology in line with conclusions made above. Aspects of the "equivalent layer overlay" method should be added to enhance confidence in survey results. The SANRAL based road asset value determination should be seen as the ultimate contractually correct asset KPI. This method should be phased in pending clarification of contractual relations between JRA and GJMC.
4. The influence of the "peripheral" road asset elements (typically FVMS, SWMS and BMS information) should be quantified in a simplified approach and be included in the total road asset value determination. Typically a factor or weight based on condition information from these asset management systems should be multiplied with a road link or sub-network condition rating when such features occur.
5. Operational KPIs should be developed as a priority for the MMS due to the impact on road asset value. It is suggested that a phased approach or Pareto principle be used to determine such operational KPIs. Some of these operational KPIs (typically cleaning efficiency of storm water inlets) should be used via a factor to adjust the road asset condition rating. Expert opinion should be used to determine such factors initially.

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APPENDIX

ROAD INFRASTRUCTURE ASSET ELEMENTS

Asset element	Inventory information source	Expending factors	Typical life-span	Public perspective
Road surfacing	• PMS inventory and condition rating • Surfacing program • MMS • Wayleaves system • GIS	• Traffic • Environment • Trenching of utilities	• Surfacing seals typically 5 to 10 years • Premix overlays typically 10 to 15 years	• Smoothness of ride (riding quality) • Safety (Skid resistance) • Visual impression of lack of potholes and patching
Pavement Structural Layers	• As built information • PMS • GIS	• Traffic • Environment • Trenching of utilities	• 30 to 40 years in urban setting	• Unaware of this element • Rehab , reworking and trenching creates inconvenience
Road Foundation	• GIS • PMS inventory • Town planning records	• Environment • Geological problem areas such as clays, marshes and bad subsurface drainage • Limited traffic effect	• Theoretically 50 years. • Practically for as long as town exists (Jhb already celebrated it's a 100 years of existence)	• Unaware • Rehab , reworking and trenching creates inconvenience
Road Reserve	• GIS • FVMS • Parks management system	• Trenching • Leaking water, sewerage, etc.	• Theoretically 50 years • Practically 10 to 20 years	• Visual impressions of motorists of aesthetics and general cleanliness. • Pedestrian awareness high
Bridges and Culverts	• BMS • PMS • GIS • SWMS	• Traffic • Environment	• Theoretically 25 to 40 years • Practically 50 to 100 years	• Joint problems • Depressions at bridge approaches • Severe problems when bridge or culvert is closed
Stormwater facilities	• SWMS • PMS • GIS	• Inlet blockages due to bad maintenance • Road foundation deformations • Traffic	• Theoretically 25 to 40 years • Reality is 50 years plus	• Unaware in general • When roads are flooded due to various reasons during storms • Wash-aways
Under-ground utilities	• GIS • Wayleave system	• Maintenance and rehab activities • Bursts (e.g. water, gas, sewerage) causes subsidence	• Depending on utility it can vary between 20 and 50 years. Use average value of 40 years.	• Unaware in general • Cause severe frustration when repairs causes traffic inconvenience

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CV of Prof Emile Horak

1. Currently head of the Department of Civil Engineering of the University of Pretoria.
2. Started career at Transportek, CSIR where 14 years were spent in roads and transport related research and management, particularly with accelerated roads testing
3. Was Executive Director of the Roads and Works directorate of Johannesburg City Council as well as Head of service delivery of the Greater Johannesburg Metropolitan Council.
4. Spent time with Murray and Roberts Contractors, Tolcon and Technicon SA.