STANDARDISATION, INTERGRATION AND UNIFORMITY (SIU), OF RAMS DATA

Siphesihle Mkhabela
Office Manager: Asset Management VNA Consulting

Msondezi Futshane
Chief Director: Road Engineering Standards Department of Transport

***Abstract*— Road authorities are responsible for ensuring optimal return on public investment in road infrastructure through the utilisation of Road Asset Management Systems (RAMS), an integrated tool used by decision makers to ensure optimal performance of the road network by generating advanced road maintenance strategies.**

RAMS follows a systematic and cost-effective process of operating, maintaining, upgrading and disposing of road assets. Whilst most road agencies consider pavement maintenance as the focus of their Operational Expenditure (OPEX), the subject of safety is often downplayed. Items addressed during the design phase such as horizontal curvature radius and super elevation, may have since become inadequate. Even existing road furniture may not meet technical and safety standards.

Although RAMS is practiced nationally, there are vast differences in the process which road authorities approach data collection, reporting of asset condition and the overall management of their assets. This degree of variance in the maturity of the RAMS has prompted the National Department of Transport (NDoT) to address the Standardisation, Integration and Uniformity (SIU) of road sector asset management to assist road authorities with the transition into a "National Template for RAMS"

A comprehensive standardised RAMS framework will require significant efforts and the importance of accurate methodologies of data collection, training and institutional development is the core focus of the SIU. This paper aims to illustrate a structured way forward in improving the overall performance of RAMS in South Africa, taking cognisance of both safety and pavement performance.

I. INTRODUCTION

Roads in South Africa are one of the major modes of transport, and the economic growth of the country relies on a robust road network. The significant investment in infrastructure assets allows the road networks to provide suitable service levels and therefore drives socio-economic growth.

South African Road Authorities are faced with a number of challenges when managing their infrastructure assets, namely, the rapid increasing usage on the road assets, the demand from the public for safety and reliability, the deterioration of these roads over time as a result of prolonged underinvestment and the fact that road funding is insufficient to be able to cover the backlog and bring the roads into a functional level of service. This makes Road asset management an essential practice that offers a huge benefit to road authorities and South Africa as a whole.

ISO 55000 defines asset management as: 'a set of coordinated activities that an organization uses to realise value from assets in the delivery of its outcomes or objectives. Realisation of value requires the achievements of a balance of costs, risks and benefits, often over different timescales'

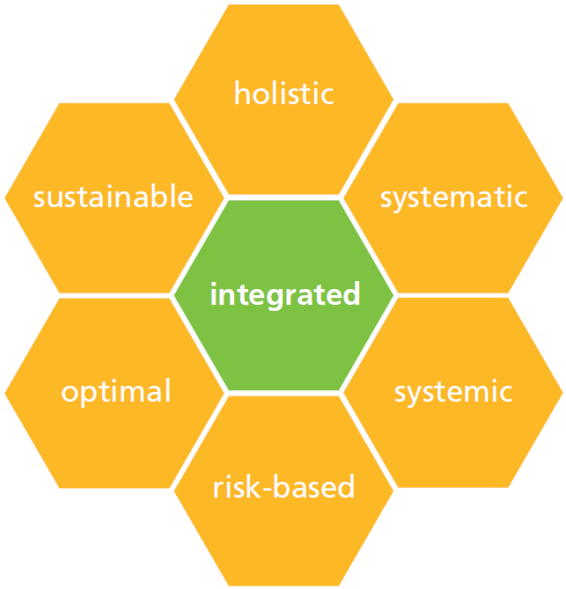

Fig. 1. Key principles and attributes of asset management
*Source PAS 55

There are many reasons to continually collect road condition data. These include, but are not limited to:

- Determining the baseline condition of the network,
- Assist road authorities in determining optimum maintenance strategies,
- Measuring performance,
- Monitoring the change in network condition over time,
- Maintaining inventory assets, and
- Assist the National Treasury in determining budget allocations

One of the most fundamental aspects of Road Asset Management is knowing your assets thus data collection is a very important component of a fully functional Road Asset Management System. The way in which road authorities go about to collect, manage, and analyse their road asset data is important because all road asset management data ideally needs to go into a National repository and with new advances in technology, such as automated data collection equipment, distributed databases, and spatial technologies, data integration And uniformity is crucial.

These strides in realizing and embracing technology in RAMS have enabled data collection to not only be fast, but to be less subjective and more accurate. It is vital though, that even with all the advances in technology, to introduce and adopt integration procedures to support the comprehensive analyses and evaluation processes needed for Asset Management. Integration can be deemed the heart of a Road Asset Management System.

The focus of the investigation discussed in this paper is to present the extent at which South African Provincial and Municipal Transport Departments are complying to National requirements for the collection of road asset data.

In addition, there are discussions regarding data management, standardization of data formatting, required software applications, proposed amendments to the TMH 18 and DoRA requirements, digital imaging and a RAMS learning institution. This paper presents recommendations for the NDoT to consider in order to drive forward Road Sector Asset Management in South Africa.

II. BACKGROUND

Road infrastructure is a key national asset, critical for the free movement of people and goods which directly influences the economic development of the country. It is necessary for road assets to be managed efficiently and effectively in order to achieve Return on Investment (ROI) which is a performance measure, used to evaluate the efficiency of an investment. The National Department of Transport (NDoT) has identified challenges associated with, the lack of uniformity with respect to RAMS data submitted by the provincial and municipal road authorities over the past few years.

The Division of Revenue Act (DoRA) requires Provincial and Municipal road authorities to submit updated road inventory, condition and traffic data annually. NDoT is tasked with being the Authority to oversee the proper allocation of maintenance grants, therefore it is imperative that the process of distribution of funds is well informed. The roads maintenance activities performed with this grant differ slightly from province to province, but generally include routine road maintenance, resealing, light rehabilitation, blading of gravel roads and pothole patching.

As previously mentioned, provincial road maintenance is primarily funded by the provincial budget allocations through the PRMG and it is very important to note that this grant has been reported to account for roughly half of provincial road maintenance expenditure.

This has proven over the years to be an increasingly difficult task mainly because of the limited resources to be able to handle the logistics of all the data and more importantly the lack of standardization when it comes to the collection, formatting and even the method of submitting of all this data.

The data collected is intended to be uploaded into a national repository, or central database, intended to facilitate the viewing of geographically linked road data for all road authorities in the country. It is a requirement that the data be submitted as per the Technical Methods for Highways 18 – Road Asset Data Electronic Exchange Formats, commonly referred to as the TMH 18 format.

III. SCOPE OF THE SIU

In August 2016, NDoT appointed VNA Consulting, for the Standardisation, Integration and Uniformity (SIU) of the Road Sector Asset Management in South Africa. The general scope of the SIU is summarised below into 3 main categories:

1. The analysis of Provincial and Municipal Data Analysis

Before any sort of system that's aimed at integration could developed and introduced, the first point of departure was gaining a clear understanding the current state of the data and each road authorities' approach to data collection for RAMS.

This analysis would involve looking at each submitted data file from each road authority. There are 11 data files that are required, each with a specific file extension, as summarized in Table 1 below.

Table 1 Summary of road condition data files outlined in Draft TMH 18

File Name	Format
Network definition	.net
Road Geometry	.kml .kmz
Road Classification	.rcl
Lane configuration	.lan
Traffic Link Volume	.adt
Visual Condition - Flexible Pavement Visual Condition - Concrete Pavement Visual Condition - Block Pavement Visual Condition - Unsurfaced Pavement	.vcf .vcc .vcb .vcu
Combined Instrument Data File	.cid
Normalised Deflection Bowl Data	.fwd

** Source: TMH 18 Draft Version 4 10/2012*

2. The development of an integrated System for the storage and analysis of Provincial and Municipal RAMS Data sets

3. The development of a RAMS Academy

IV. METHODOLOGY

The 2016 data submission from all provincial and municipal road authorities to the NDoT was used as the benchmark for a desktop level analysis. The primary intention of this analysis was to:

- Determine what information was, and was not, provided to the NDoT by the various road authorities
- Determine the reported extent of the provincial and municipal networks
- Summarise the condition of the road networks
- Summarise the reported traffic information (AADT)
- Determine a baseline dataset for future analysis
- Identify challenges in the process and propose recommendations.

The methodology for this exercise had to be split into the three stages listed below:

- Stage 1: Data management - sorting out the data, applying correct naming conventions, inspecting duplicate datasets.
- Stage 2: Data Register - Using table 1 above to tick off whether or not a file was submitted.
- Stage 3: Data Analysis for Compliance – checking the data sets against TMH and DoRA compliance.

STAGE 1 DATA MANAGEMENT

Due to the huge amounts of data involved in RAMS, good data management becomes one of the important foundations when establishing an integrated system. With this in mind, when the datasets were received from the Provinces and Municipalities, and before any detailed analysis could be undertaken, the data was first examined with respect to the file naming conventions as well as the structure in which the data was stored.

- Unpacking the data from the various methods of submission e.g. CD drives, drop box links, emailed zip folders etc. These data sets were saved onto a server.

- The variances in the submitted data sets made a bulk conversion process or even uploading into a centralized database impossible. With the exception of the road geometry data, each file had to be manually opened, converted and thereafter saved in the ".xlsx" format in order to be viewed and analysed at a later stage.

  This was a long tedious task as the data submissions differ from one road authority to the next due to the fact that some road authorities had deviated with respect to file formats, file naming and data formats.

- The master folders of the original dataset were labelled RRAMS and PRAMS, however it was within these folders where the logical order had substantial room for improvement. For example, there were instances whereby files had been unnecessarily stored, a) within compressed folders, and b) up to six folders deep. The structure itself was not uniform which makes file retrieval a time-consuming process.

  Upon conversion of the files as described above, each file was stored in a new location within a re-ordered filing structure as illustrated below:

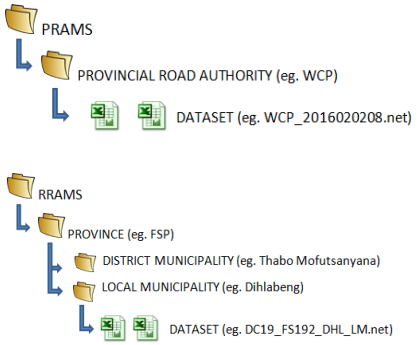

Fig. 2. Re-ordered filing structure

This structure was selected for the purposes of this exercise only because of the non-uniformity of the data and it is not a recommended approach in the long term.

STAGE 2 DATA REGISTER

- A register of the data was created and the analysis was subsequently undertaken using the Road Classification, Visual Condition and Traffic Link Volume files to respectively summarise the extent, condition and traffic of the road networks where possible.
- The purpose of the data register was purely to indicate whether the data file had been submitted or not and was not really an indication of compliance in terms of the validity of the data.

It was clear by this step that a detailed analysis into the validity of the data its self was going to be a futile exercise because although the there was data submitted by a number of road authorities, the huge formatting and non-uniformity issues that were noted thus far had to take president for this analysis.

STAGE 3 DATA ANALYSIS FOR COMPLIANCE

As mentioned above, due to the inconsistencies of the data as a whole, performing an in-depth analysis of all the data sets' validity and correctness was decided against.

At this stage it was rather decided that a partial desktop analysis would be performed in order to ascertain the very basic requirement as per Table 1 above. This involved opening the extent, condition and traffic files of all road authorities and extracting all relevant statistics and off-course, assessing compliance.

- The road classification file for each province and municipality was opened to check that TMH 18 was used as a format for the file then extracting the network extent from the file categorized per surface type.
- The road condition and traffic files were then opened per road authority and again TMH 18 compliance was assessed before extracting conditions and traffic from the files respectively.

V. ANALYSIS

The summaries of the analysis presented in this paper are a revision of the initial analysis done in 2016. Although certain discrepancies may have been clarified in the Provincial and Municipal bilateral meetings, the source of the data presented below is still based on latest datasets (including revised submissions).

A. Data Register

As mentioned previously, prior to any analysis of the data, a register was created to determine what information was, and was not, available. The register graphically presented below is purely an indication of whether or not the data file was submitted. It is important to note that the register does not consider whether the information contained within the file was credible or not. Additionally, some road authorities may not have concrete or block pavements hence no submission is necessary.

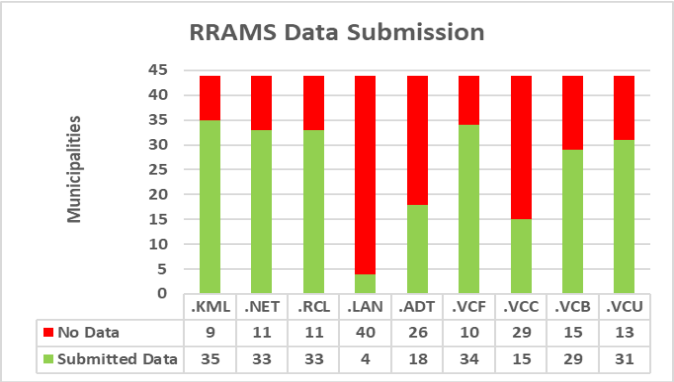

Fig. 3. RRAMS data submition register graph

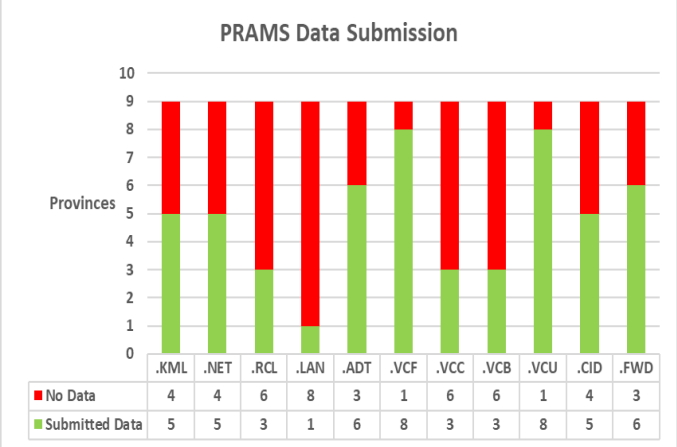

Fig. 4. PRAMS data submition register graph

B. Extent

Data from the Road Classification (. rcl) files were used to summarise the extent of each department road network. It was categorised by surface type, namely Paved and Unpaved, whereby Paved includes flexible, concrete, block, seal, etc. and Unpaved includes gravel, earth, track, etc.

The table below show the combined summary of the extent data received from the road authorities.

Table 2 Overall summary of reported extent data

OVERALL	Paved	Unpaved	Unclassified	Total
TOTAL (Combined)	58 895	187 014	27 597	273 506

C. Condition

Data from the Visual Condition (.vcf,. vcc, .vcb and .vcu) files was used to summarise the condition of the network based on the five point condition category scale, which ranges from very poor (0%) to very good (100%).

The data is illustrated in the table and graph below to give a snapshot of the condition of the network. Once again, it must be noted that this is only based on the information provided and does not take cognisance of missing information.

Table 3 Overall summary of reported condition data

OVERALL CONDITION (Km's)	Flexible	Concrete	Block	Unpaved	Total
Very Poor	7 393	64	16	76 067	83 540
Poor	17 079	10	30	84 591	101 710
Fair	33 787	0	637	35 239	69 663
Good	27 515	2	1 815	8 066	37 398
Very Good	7 335	3	1 715	2 757	11 810
Total	93 109	80	4 212	206 720	304 121

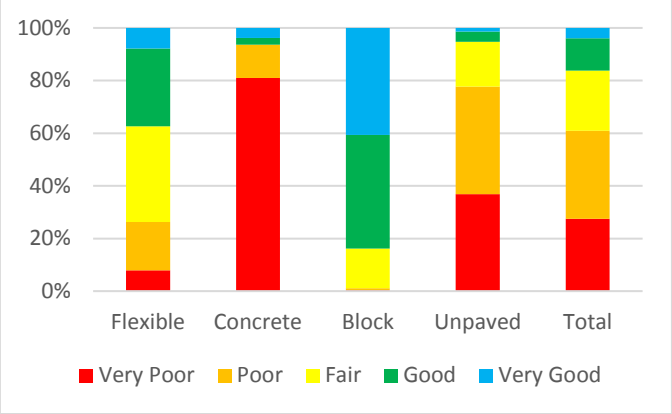

Fig. 5. Graph summarising condition data

D. Traffic

The Traffic Link Volume (.adt) files were used to summarise AADT information where available. The table below shows the length of network carrying each of the four categories of traffic.

Table 4 Overall summary of reported traffic data

OVERALL (AADT – Km's)	< 100	100 - 500	500 - 1000	> 1000
	59 857	16 135	3 860	13 313
	93 165			

E. Comparison

For the National RAMS repository to be a functional system that can assist not only the Department of Transport but also other government departments such as Treasury and even researchers with valuable updated information on the countries road networks, it needs to be integrated and loaded with uniform information. One of the fundamental steps in order to achieve this is for road authorities to continually update their data and get to a stage where their data not only meets the requirements of the DoRA, but dataset are aligned with each other, for example the proclaimed extent must match the extent submitted in the network definition and road classification files, and all other condition, instrument and traffic data must match the overall extent.

The graph below shows the discrepancy between the reported extent, the condition and the traffic, this ideally should be more or less the same value in terms of length.

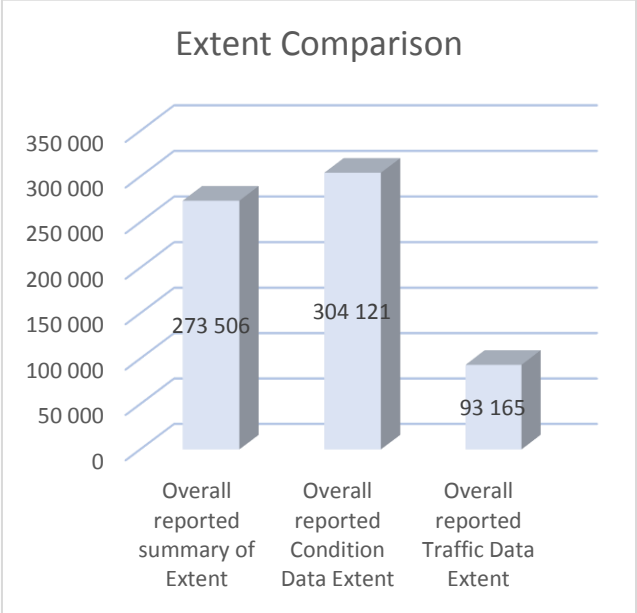

Fig. 6. Graph comparing extents of data

VI. ACCOUNT OF FINDINGS

The filing structure in which the information had been presented is not suitable for analysis of data at this level. It is crucial that a well-defined and logical order of data storage is implemented to facilitate easier and more efficient management of data.

There is a considerable amount of data that was either not submitted or got corrupted during the submission which in the context of this paper can be considered as missing data. Apart from the one province and 12 District Municipalities where no information whatsoever was submitted, the remaining authorities have submitted partially complete datasets.

There is a substantial amount of non-uniformity in the data submission as well as the file naming conventions. For example:

- In some cases, on the RRAMS, datasets are submitted for each Local Municipality within the District, whereas in other cases one dataset was submitted by the District Municipality.
- The file naming conventions are not uniform. Whilst a naming convention is specified in TMH 18, it is recommended that the Department specify that all road authorities comply by adopting the proposed naming convention or propose a simplistic alternative. Either option should result in a standardised naming convention for ease of data management.
- Data submissions must comply with the fields specified in TMH 18 to avoid rejection into the repository. A large

number of files do not correspond with TMH 18 headers. Road authorities are to comply in this regard. The Department should further specify to authorities which fields are mandatory and which are optional.

Many authorities have not included the lane definition file as part of this submission.

The analysis in terms of extent, condition and traffic was undertaken on the submitted data only and cannot be considered a true overall reflection due to missing information. Notwithstanding, the information is summarised as follows:

- Extent data shows the proclaimed network to be 273 506 km in length comprising of 58 895km paved, 187 014 km unpaved and 27 597 km are not classified. This is a far cry from the ~600 000km proclaimed provincial and municipal network length. This extent is also much less than the extent extracted from the visual assessment.
- From the analysis of the condition data, the percentage of roads in poor and very poor condition is at 61%. This is approximately 185 250 km.
- Traffic data was only reported for 93 165km.

This analysis proved extremely challenging as data could not be understood easily and varying degrees of interpretation was required.

VII. RECOMMENDATIONS

The NDoT should not rely on 3rd party assistance for the analysis of data. This should be done in-house and so the department must invest in appropriate hardware and software to undertake future analysis. In an age where we are heavily reliant on computer technology, manual analysis is considered counterproductive as it is time consuming (hence costly), and open to misinterpretation of the data.

Due to the THM18 data submission requirements document being in a draft format, the NDoT should propose minimum mandatory fields which must be completed in the data submissions.

Digital Images could form the basis of visual assessment and can be collected simultaneously with profile measurements. The time taken to go to site and verify the maintenance strategies can be reduced and even eliminated

There is definitely a need to confirm the veracity of some of the datasets. A question of how roads have been prioritised has been raised and will be addressed as part of the forthcoming data analysis. As the head, it is ultimately the NDoT that should be directing provinces as to how budgets must be allocated. It is the NDoT that should have the wholistic perspective of the condition of the entire road network (based on the data collection) which will guide strategic budget allocations.
The technology exists to quickly and effectively verify measurements.

A. Data Management

One of the most important components of any RAMS is the collection of data. Large volumes of data require careful management, storage, quality control, processing and presentation. The purpose of the TMH 18-Road Asset Data Electronic Exchange Formats document is to facilitate efficient data management by ensuring uniformity in the format of the data submitted by various road authorities. This information can therefore be uploaded onto a central repository hosted by the NDoT, where analysis, statistics and data search functions can be done easily and quickly.

At present, the NDoT does not have an appropriate software application, or program, to store and analyse the vast amounts of data it receives annually. Instead, the NDoT relies on assistance from external professional service providers, such as VNA, to review and report on the data submissions. This is presently achieved by manually analysing the contents of each and every file.

For this exercise, manual analysis is not the recommended approach. To put it into perspective, the flexible condition file (.vcf) has 86 fields, or columns of data, while the combined instrument data file (.cid) can easily exceed 100 000 lines, or rows, of information depending on the network size. If all authorities submit complete datasets, it would mean perusing through an excess of 500 files, which make analysis by manual methods impractical. At this level of analysis, a manual approach can be considered counterproductive.

Instead, the NDoT needs to invest in suitable software capable of importing, storing and analysing the annual data submissions. Whilst there are competitive alternatives in the market, the decision of which software package to use should not be taken lightly. Some factors to consider are:

- Does the supplier understand the needs of the NDoT?
- How easily can source code be changed to cater for changes in the data submission requirements (taking cognisance that TMH 18 is still to be finalised)
- Is the system efficient and easy to use?
- Can the system work over a network?
- Does the system link seamlessly with a GIS?
- How flexible is the reporting?
- How secure is the system?
- Will human and financial resources (licenses) be continually available?

Hardware requirements are also fundamental, although much easier to procure and maintain. As a start point, a standalone server with sufficient storage to host the database and with local area network access.

B. Central Data Repository

The Central Data Repository (CDR) will be a web-based system to upload, store, analyze and manage all provincial and municipal (DoRA stipulated) RAMS Data from a central database.

The Central Repository will be the largest host Road Asset Management Data and will provide the easiest way to access, store, manage and distribute RAMS Data on a National transparent platform. It will also start to develop a National, Provincial and Municipal historical database that can be used as a potential research tool for better understanding of RAMS trends.

The first step in enabling this central data repository will be to create a network of distributed databases that each contain the virtual representations of each road authority and are associated with the respective data sets. Each virtual representation will have a unique identifier and the road authorities will be able to access this through the user interface.

The main components that make up the proposed repository are as follows:

- User interface - This is essentially the interface that will be visible to the users, which will most likely be comprised of a data uploading tool, a data view tool as well as the ability to view data from other users on a controlled National data view tool. The relationships between one virtual representation and another (e.g. Limpopo and Western Cape) will be protected by rules that govern which information will be visible for other users to view.
- SQL database - The database is basically to ensure the safe storage of the vast amount of data that will be housed in the repository. This database will also ideally have the added functionality to check the data for certain errors as well as calculate and analyse important indices to assist decision making in the management tool.
- Management tool - This tool will most likely be a replica of the user interface with specific added management functions. This tool will be able to create useful summaries and reports for the management of data on a National platform.

The NDoT will use this repository to standardize and evaluate data for Prioritization of projects ranging from road safety to capacity improvement and pavement management

The Hawkeye insight can be described as a powerful data storage, integration and analysis tool. It is a web-based repository tool that is able to store, imagery, deflections, profiler data and network definition data. This can all be integrated onto the insight database allowing the user to have a snapshot view of the road information.

This essentially means that you can select a segment of your network on the insight tool, and very simply be able to view all pertinent data such as rutting, deflections, road class, images etc., depending on the range of data uploaded.

Historical data of the road network can also be stored onto the database allowing road authorities to easily evaluate the networks pavement deterioration over time as well as track improvements from yearly maintenance improvements.

C. Digital Imaging

The visual condition assessment is a mandatory requirement for network level analysis. However, visual condition assessments are by their nature subjective which results in inconsistencies in rating pavement defects. How a defect is rated depends largely on the experience of the assessor. Field assessments can become laborious and assessors frequently have to deal with challenges such as traffic and weather. Fatigue, which usually sets in towards the end of the day, has been proven to have a negative effect on the quality of the assessments. Measuring defects using instrumentation reduces and in some cases, removes the subjectivity that is inherent in visual condition assessments. This is one of the reasons why profile measurements are a requirement in the DoRA.

A solution to overcome these challenges is to explore the concept of digital imaging as part of the data collection process. Digital Images are a useful tool for rating pavement distresses, safety assessments and logging roadside assets. Imaging options range from basic frame imaging to more sophisticated 3D laser scanning which incorporates automated distress identification and quantification.

Imaging systems can easily be incorporated into digital laser profilers thus eliminating the need for additional or separate imaging surveys to be undertaken as profiles and images can be collected with one vehicle in a single pass resulting in synchronised images and profile data.

D. RAMS Academy

The main purpose of setting up the RAMS Academy is to impart the necessary knowledge and skills to relevant employees of road authorities to enable them successfully implement and manage RAMS within their organizations. The Academy will provide a single point of training thereby ensuring consistency and quality.

The RAMS Academy will aim to develop and deliver courses to road authority staff involved in the implementation and management of RAMS. It will be the objective of the RAMS Academy to transfer knowledge and skills and to develop a professional attitude in the trainees. Courses will be developed to match skills areas identified in TMH22 as well as in consultation with the Department of Transport, road authorities and the road transport industry as a whole.

VIII. CONCLUSIONS

It is clear that there is a large degree of non-conformity amongst the provincial and municipal road authorities. The level of this varies, depending on the maturity of the internal systems within the authority. This does however enforce the need to create a national standard for RAMS.

As road asset data has been collected at different times by different units using different methods stored in varying formats and media, there is a need for data integration to support uniformity. Data integration is essential to transform the data into information that is able to support decision making at the various management levels. Road authorities must organize the available data into suitable formats for applications at the different organizational levels of decision making. This venture presents a significant challenge because of the difficulty of data integration.

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